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DEPARTMENT OF MANAGEMENT SCIENCE AND TECHNOLOGY

Ph.D. Thesis

IT project investments evaluation: A Real Options Perspective

This thesis is submitted for the degree of Doctorate of Philosophy

by

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Στους αγαπημένους μου γονείς Γιώργο και Ευαγγελία,

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STATEMENT OF ORIGINAL AUTHORSHIP

The following papers have been published or have been submitted for publication as a direct or indirect result of the research discussed in this dissertation:

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Dimakopoulou A., Pramatari K. (2012). Trends and Investment Opportunities for RFID in Europe European Survey Results, RFID in Europe Conference, 23-24 May, Leuven, Belgium

Dimakopoulou A. and Pramatari K. (2011). Real Options in RFID investments. RFID conference in Prague, 29th of March, RFID in Europe thematic network.

Pramatari K. and Dimakopoulou A. (2011). Trends and Investment Opportunities for RFID in Europe – European Survey Results, RFID conference in Prague, 30th of March , RFID in Europe thematic network.

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Articles in magazines:

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Dimakopoulou A. and Pramatari K. (2012). RFID investment trends. Results from a European Survey, Logistics and Management, February 2012.

ABSTRACT

Due to the inefficiencies of traditional investment evaluation and adoption approaches to consider managerial flexibility for the assessment of information technologies with high levels of uncertainty and irreversibility, Real Options theory has been acknowledged for its significance and exploited in the IS field as an alternative and dynamic approach. However, there has been very little research on how the use of real options in IT capital budgeting affects managerial behavorial decisions. In addition, although pertinent literature has claimed that Real Option value varies across different IT projects, the majority of the studies have considered IT projects as a homogeneous group. Moreover, in spite that related research proposes the factors that stimulate the recognition and value of technology options, very few studies have empirically examined the significance of these determinants.

To address the above gaps the present doctoral thesis develops a model drawing from Real Options theory, IT innovation firm adoption theories and IS classification frameworks with the aim to study the impact of Real Options on IT investment decision making process. The thesis empirically examines the developed model and applies it to the case of RFID technology. Based on an exploratory phase comprised of three case studies and a confirmatory phase including one pilot and two field studies and through the exploitation of first-generation (e.g. multiple regression, ANOVA) and second-generation statistical methods (i.e. structural equation modeling and confirmatory factor analysis) results show that:

(1) Regarding the evaluation of an IT innovative project, recognition of growth and stage options (embedded in this project) have a significant positive impact on the assessed IT project value of returns and ultimately its adoption; whereas recognition of the option to delay investment has a significant but negative effect; However, the present thesis based on an RFID typology matrix it develops shows that the impact of real options is significant in specific and not all IT project types. In particular, it is shown that: (2) the scope of an IT project (whether it is a family or standalone application) moderates the effect of real options on the perceived project value of returns. This impact is strengthened for IT family applications and lessened for standalone applications (except for the impact of growth options which is strong in both types of projects); (3) the span of an IT project (whether it is internal or supply chain IT project) moderates the impact of real options on the perceived value of an IT project returns. The effect of real options (growth, stage and deferral) is more significant in supply chain than in internal IT projects; (4) the purpose of an IT project (whether it is a strategic or transactional) moderates the impact of real options. The impact of growth and stage options is strengthened for strategic IT projects, whereas for transactional projects is lessened. However, the deferral option has insignificant impact in both types of projects; (5) growth option recognition of an IT project is a result of specific organisational (i.e. organisational learning and innovative capabilities) and technological

parameters (i.e. strategic importance, radicalness and sustainability of the technology investment impact) which have to be considered as significant determinants and sources of growth option value; (6) recognition of growth options mediates the effect of the above organisational and technological parameters on the perceived IT project value of returns.

Overall, the above findings have important contributions to a recent research stream which investigates the behavorial implications of Real Options for the investment evaluation and adoption of innovative information technologies. More specifically, the present thesis extends the very few previous research studies on this field. In addition, it constitutes the first empirical quantitative study which investigates whether the perceived impact of Real Options on IT appraisal differs across the different types of Information Technology projects. In addition, the present study contributes to the IT Real Options field by empirically investigating the parameters which act as sources of the generation and recognition of real options and in particular growth options. This thesis also contributes to the IT innovation adoption research stream by explaining 'how' specific organisational or technological IT innovation determinants affect organisational IT adoption through real options reasoning. Finally, the present study extends the very few previous studies on RFID appraisal and adoption through real options analysis.

The above findings have also important practical implications. Managers are suggested to embed real options reasoning in their investment decisions but be aware of the fact that the significance of real options depends on the type of an IT investment. Real Options exploitation does not seem to add value to all types of IT project investments. In addition, managers can exploit the significant parameters which are found from this thesis that promote the growth option generation and incorporate them in a decision making tool to facilitate IT investment appraisal. In addition, IT suppliers and developers are recommended to design IT products with attributes which can trigger real options generation in order to affect managers' perceptions towards the value and the use of these products. Finally, decision makers of RFID technology can utilise the proposed by this study RFID typology matrix as an important means to support their investment decisions.

ΕΠΙΤΕΛΙΚΗ ΣΥΝΟΨΗ ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ

Η συγκεκριμένη διατριβή εντάσσεται στο ευρύτερο πεδίο της Διοίκησης των Πληροφοριακών Συστημάτων και πιο συγκεκριμένα στα εξής ερευνητικά πεδία: (α) αξιολόγηση επιχειρηματικών επενδύσεων και υιοθέτηση καινοτόμων εφαρμογών πληροφοριακής τεχνολογίας (IT investment evaluation and adoption) και (β) τη μέθοδο αποτίμησης των εμπράγματων δικαιωμάτων (Real options valuation) για την αξιολόγηση ενός επενδυτικού σχεδίου. Η διατριβή αναπτύσσει και ελέγχει εμπειρικά εννοιολογικά μοντέλα για να μελετήσει το ρόλο των εμπράγματων δικαιωμάτων στις αντιλήψεις των διοικητικών στελεχών όταν αξιολογούν μια καινοτόμο τεχνολογική εφαρμογή. Η Τεχνολογία Ραδιοσυχνικής Αναγνώρισης (RFID technology) αξιοποιείται ως το πλαίσιο εφαρμογής των συγκεκριμένων μοντέλων.

Εισαγωγή στο πεδίο της διδακτορικής διατριβής και τα ερευνητικά κενά στη βιβλιογραφία

Η ραγδαία εξέλιξη της τεχνολογίας έχει φέρει στο προσκήνιο μια πληθώρα νέων εφαρμογών πληροφορικής οι οποίες έχουν στόχο να υποστηρίξουν και να προάγουν τις επιχειρηματικές λειτουργίες των οργανισμών. Λόγω του μεγάλου κόστους αυτών των εφαρμογών και λόγω των οικονομικών περιορισμών των οργανισμών είναι πολύ σημαντικό να γίνει κατανοητό και να τεκμηριωθεί από τους επιχειρηματίες το αν αξίζει να επενδύσουν σε αυτές τις τεχνολογίες. Σε περίπτωση που μια τεχνολογία δεν έχει αξιολογηθεί και δεν έχει δικαιολογηθεί επαρκώς η επένδυσή της, τότε αυτό μπορεί να εμποδίσει και να υποσκάψει ακόμη και την επίδοση της ίδιας της εταιρείας (Gunasekaran 2001). Γι αυτό το λόγο έχουν αξιοποιηθεί αρκετές **μέθοδοι αξιολόγησης επενδύσεων**. Μια από τις πλέον εφαρμοσμένες τεχνικές αξιολόγησης αυτών των επενδύσεων είναι οι οικονομικές παραδοσιακές μέθοδοι προεξόφλησης. Παρόλο που αυτές οι τεχνικές έχουν ευρέως χρησιμοποιηθεί και στην πράξη και στη βιβλιογραφία, έχουν κριθεί ως ακατάλληλες και μη επαρκείς στο να λάβουν υπόψη τους το δυναμικό χαρακτήρα και τη διοικητική ευελιξία που προσφέρουν οι νέες τεχνολογικές εφαρμογές, καθώς βασίζονται σε μια εφάπαξ αξιολόγηση και οχι σε μια συνεχή και ευέλικτη διαδικασία αξιολόγησης.

Αυτές οι τεχνολογικές εφαρμογές έχουν χαρακτηριστεί ως εφαρμογές με μεγάλη **αβεβαιότητα (uncertainty)** ως προς το τελικό αποτέλεσμα που επιφέρουν σε έναν οργανισμό. Η αβεβαιότητα μπορεί για παράδειγμα να προέρχεται από τη δυσκολία του να προβλέψει κάποιος θέματα που αφορούν σε αναμενόμενα τεχνικά προβλήματα ή και απαραίτητες οργανωσιακές αλλαγές που απαιτεί μια τεχνολογική εφαρμογή όταν υλοποιείται. Επίσης, λόγω του υψηλού κόστους που εμπεριέχουν οι καινοτόμες τεχνολογικές εφαρμογές έχουν χαρακτηριστεί και ως εφαρμογές με **μη αναστρεψιμότητα (irreversibility) του κεφαλαίου** που έχει αρχικά επενδυθεί. Ο υψηλός βαθμός αβεβαιότητας και κινδύνου αυτών των εφαρμογών μπορεί να μειωθεί με την αξιοποίηση **διοικητικής ευελιξίας (managerial flexibility)** στη λήψη αποφάσεων. "*Η διοικητική ευελιξία είναι η ικανότητα ενός ατόμου/οργανισμού να πραγματοποιήσει μια ενέργεια βάσει μιας νέας κατάστασης, νέας πληροφορίας ή μιας αλλαγής που έχει πραγματοποιηθεί* (R. Kumar 1999)". Για παράδειγμα ένας οργανισμός μπορεί να εγκαταλείψει την περαιτέρω επένδυση σε μια τεχνολογική εφαρμογή η οποία φαίνεται ότι δεν αποδίδει. Στην περίπτωση που υπάρχουν τα χαρακτηριστικά αβεβαιότητας και μη αναστρεψιμότητας του επενδυθέντος κεφαλαίου *το να αγνοηθεί η διοικητική ευελιξία καταλήγει στην υποεκτίμηση μιας επένδυσης* (Fichman 2004) και συνεπώς σε λανθασμένες επιχειρηματικές αποφάσεις. Η βιβλιογραφία έχει υπογραμμίσει την ανάγκη να ερευνηθούν οι επενδύσεις σε τέτοιου είδους εφαρμογές λαμβάνοντας υπόψη τη διοικητική ευελιξία των επενδύσεων.

Όταν ολοκληρωθεί η αξιολόγηση επενδύσεων ακολουθεί η απόφαση για την **υιοθέτηση ή μη αυτών των επενδύσεων (IT innovation adoption)** (Thong 1999). Παρόλο που προηγούμενες έρευνες έχουν προσφέρει μια σημαντική γνώση για τους οργανωσιακούς, τεχνολογικούς και περιβαλλοντικούς παράγοντες που επηρεάζουν την υιοθέτηση αυτών των καινοτόμων τεχνολογικών εφαρμογών (IT innovation firm adoption), η πλειονότητα αυτών δε λαμβάνει υπόψη τη διοικητική ευελιξία ως πιθανό παράγοντα που επηρεάζει τις επιχειρηματικές αποφάσεις. Επίσης προηγούμενες έρευνες *δεν εξηγούν το πώς ακριβώς αυτοί οι παράγοντες επηρεάζουν τις επενδυτικές αποφάσεις και τελικά την υιοθέτηση των τεχνολογικών εφαρμογών (Goswami et al. 2008)*. Γι αυτό το λόγο η ακαδημαϊκή βιβλιογραφία έχει υπογραμμίσει την ανάγκη εύρεσης και εφαρμογής μιας νέας προσέγγισης που θα εξηγεί το πώς αλλά και θα λαμβάνει υπόψη αυτήν την ευελιξία κατά τη διάρκεια των επιχειρηματικών αποφάσεων που σχετίζονται με επενδύσεις σε νέες τεχνολογίες.

Η προσέγγιση η οποία προέρχεται από τον κλάδο των Χρηματοοικονομικών και λαμβάνει υπόψη της αυτή τη διοικητική ευελιξία, είναι η **Μέθοδος των Εμπράγματων Δικαιωμάτων (Real Options)** η οποία εφαρμόζεται σε επενδυτικά προβλήματα που εμφανίζουν υψηλό βαθμό αβεβαιότητας και μη αναστρεψιμότητας του κεφαλαίου, με απώτερο στόχο τη μείωση του ελοχεύοντος κινδύνου. Από τον κλάδο των Χρηματοοικονομικών ένα 'option' είναι *η επιλογή ή το δικαίωμα που έχει κάποιος (και όχι υποχρέωση) να πραγματοποιήσει μια ενέργεια μετά την εμφάνιση κάποιας πληροφορίας*. Η θεωρία των εμπράγματων δικαιωμάτων (Real Options Theory) αναφέρεται σε εμπράγματα δικαιώματα (δηλαδή πάγια στοιχεία) όπως είναι οι επενδύσεις σε τεχνολογίες, επενδύσεις σε συγχωνεύσεις εταιρειών κτλ. κι έτσι επεκτείνει τη θεωρία των χρηματοικονομικών δικαιωμάτων στον πραγματικό κόσμο. Παράδειγμα εμπράγματων δικαιωμάτων αποτελεί το δικαίωμα αναβολής μιας επένδυσης (deferral option) σε μια τεχνολογία για ένα μελλοντικό χρονικό διάστημα, έτσι ώστε μια επιχείρηση να περιμένει να μειωθεί η τιμή αυτής της τεχνολογίας και να επενδύσει σε αυτήν αργότερα μετά από κάποια χρόνια. Άλλο παράδειγμα εμπράγματου δικαιώματος είναι το δικαίωμα ένας οργανισμός να επενδύσει αρχικά σε ένα project με στόχο να μπορεί αυτό το project να αποφέρει μελλοντικές εφαρμογές και να αποτελέσει τη βάση για μελλοντικά παρόμοιου τύπου projects (growth option). Επίσης, η δυνατότητα του να υλοποιήσει κάποιος μια τεχνολογική εφαρμογή σε στάδια (αντί να την εφαρμόσει εφάπαξ) του δίνει τη δυνατότητα να παρακολουθήσει την εξέλιξη αυτής της επένδυσης στο μέλλον και να προχωρήσει σε επόμενα στάδια, μόνο εάν τα πρώτα στάδια της επένδυσης έχουν καρποφορήσει και έχουν αποβεί κερδοφόρα (stage option). Αυτά τα δικαιώματα έχει αποδειχθεί από τη βιβλιογραφία ότι εμπεριέχουν αξία και εκφράζουν τη διοικητική ευελιξία των οργανισμών με στόχο τη μείωση κινδύνων μιας επένδυσης. Ως αποτέλεσμα, αυτά τα δικαιώματα κατά τη διάρκεια της αξιολογήσης επενδύσεων πρέπει να λαμβάνονται υπόψη μια και προσδίδουν κάτι παραπάνω από μια απλή αποτίμηση της επένδυσης. *Αν δε ληφθούν υπόψη τότε η επένδυση κινδυνεύει να υποεκτιμηθεί* (Dos Santos 1991).

Η **θεωρία των εμπράγματων δικαιωμάτων** έχει εφαρμοστεί και **στον κλάδο των Πληροφοριακών Συστημάτων** από το 1990 για την αξιολόγηση επενδύσεων σε τεχνολογικές εφαρμογές όπως δίκτυα τηλεπικοινωνίας, πλατφόρμες ανάπτυξης λογισμικού, επιχειρηματικές εφαρμογές (π.χ. ERP). Παρόλα αυτά, το μεγαλύτερο κομμάτι της βιβλιογραφίας εφαρμόζει τη θεωρία των εμπράγματων δικαιωμάτων αναπτύσσοντας μαθηματικές φόρμουλες από τον κλάδο των χρηματοοικονομικών (option pricing formulas) και κανονιστικά μοντέλα (normative approach). Ένα πάρα πολύ μικρό κομμάτι της βιβλιογραφίας μελετά την προσέγγιση που εξετάζει την επίδραση των εμπράγματων δικαιωμάτων στις αντιλήψεις των διοικητικών στελεχών και τη συμπεριφορά των οργανισμών (intuitive approach). Προηγούμενες σχετικές μελέτες *(Denison 2009; Tiwana et al. 2006)* έχουν υπογραμμίσει την ανάγκη για έρευνα η οποία να εξετάζει το: ***"Πώς η χρήση και αξιοποίηση των εμπράγματων δικαιωμάτων κατά τη διάρκεια αξιολόγησης επενδύσεων και προϋπολογισμού του κεφαλαίου (capital budgeting) επηρεάζει τη συμπεριφορά των διοικητικών στελεχών και τις επενδυτικές τους αποφάσεις".*** Αυτό είναι και το πεδίο αναφοράς της συγκεκριμένης διατριβής. Αυτό το ερευνητικό κενό έχει υπογραμμιστεί όχι μόνο για τεχνολογικές εφαρμογές αλλά γενικότερα για κάθε τύπου έργο.

Μέσα στο πλαίσιο αυτό, έχουν πραγματοποιηθεί πάρα πολύ λίγες μελέτες οι οποίες και έχουν παρουσιάσει ότι τα εμπράγματα δικαιώματα έχουν μια πολύ σημαντική επίδραση στις επενδυτικές επιχειρηματικές αποφάσεις όταν αξιολογούνται τεχνολογικές εφαρμογές. Ωστόσο, οι συγκεκριμένες μελέτες παρουσιάζουν **αντιφατικά αποτελέσματα**. Ενώ για παράδειγμα συγκεκριμένες μελέτες έχουν συμπεράνει ότι το δικαίωμα που μπορεί να έχει ένας οργανισμός να αναβάλει μια τεχνολογική επένδυση για κάποιο μελλοντικό χρονικό διάστημα έχει θετική επίδραση στην πρόθεση του οργανισμού να επενδύσει τελικά σε αυτήν την εφαρμογή, άλλες μελέτες παρουσιάζουν ότι αυτή η επίδραση είναι αρνητική ή ακόμη και μη στατιστικά σημαντική. Αυτά τα αντιφατικά αποτελέσματα στη βιβλιογραφία δημιουργούν το πολύ σημαντικό κίνητρο για περαιτέρω διερεύνηση του φαινομένου και συγκεκριμένα της επίδρασης των εμπράγματων δικαιωμάτων στις επενδυτικές αποφάσεις και στη διαδικασία λήψης αποφάσεων ενός οργανισμού. Για παράδειγμα, η ύπαρξη κάποιων μεταβλητών που δρουν ενδεχομένως ως ρυθμιστικοί παράγοντες (moderators) μπορούν να δημιουργούν αυτές τις αντιφάσεις. Ένα παράδειγμα σημαντικού παράγοντα ο οποίος μπορεί να δρα ως μια παράμετρος που ενδυναμώνει ή μειώνει την επίδραση των εμπράγματων δικαιωμάτων στη συμπεριφορά των διοικητικών στελεχών είναι ο τύπος μιας τεχνολογικής εφαρμογής. Ενώ η βιβλιογραφία (Tiwana et al. 2006; X. Li & Johnson 2002; Wu & Ong 2008) υποστηρίζει ότι η επίδραση των εμπράγματων δικαιωμάτων στις επενδυτικές αποφάσεις των διοικητικών στελεχών είναι μεγαλύτερη και ενδυναμώνεται σε συγκεκριμένους τύπους τεχνολογικών εφαρμογών, εμπειρική έρευνα η οποία να εξετάζει αυτήν την παραδοχή δεν υπάρχει. Παράλληλα, περιορισμένη βιβλιογραφία έχει αφιερωθεί στο να προσδιορίσει τα χαρακτηριστικά των τεχνολογικών εφαρμογών που προάγουν τη δημιουργία των εμπράγματων δικαιωμάτων. Για παράδειγμα, οι Wu & Ong (2008) υποστηρίζουν ότι οι εφαρμογές οι οποίες είναι μικρής κλίμακας (π.χ. τα πληροφοριακά συστήματα τα οποία χρησιμοποιούνται για τις καθημερινές λογιστικές εγγραφές και την αυτοματοποίηση των δραστηριοτήτων του γραφείου) προσφέρουν λιγότερα εμπράγματα δικαιώματα σε μια επιχείρηση σε αντίθεση με αυτά που προσφέρουν οι μεγάλης κλίμακας τεχνολογικές εφαρμογές.

Επιπροσθέτως, οι μελέτες στον κλάδο της εφαρμογής της μεθόδου των εμπράγματων δικαιωμάτων για την αξιολόγηση επενδύσεων σε καινοτόμες τεχνολογίες, εκτός από το ότι έχουν αποδείξει ότι η παρουσία των εμπράγματων δικαιωμάτων σε μια επένδυση επηρεάζει τις επενδυτικές αποφάσεις έχουν προτείνει και συγκεκριμένες **μεταβλητές οι οποίες πυροδοτούν τη δημιουργία και την αναγνώριση αυτών των δικαιωμάτων.** Αυτές οι μεταβλητές είναι είτε απτοί παράγοντες (π.χ. οι ταμειακές ροές της επένδυσης σε μια τεχνολογική εφαρμογή, η μεταβλητότητα των αναμενόμενων εσόδων αυτής της εφαρμογής), είτε "άϋλοι" παράγοντες, όπως η πίεση από τους ανταγωνιστές και οι δυνατότητες ενός οργανισμού να είναι καινοτόμος, να "μαθαίνει" από μια αρχική επένδυση κλπ. Παρόλα αυτά, η πλειονότητα αυτών των μελετών είτε αναπτύσσει θεωρητικά μοντέλα με προτάσεις χωρίς να έχουν ελεγχθεί εμπειρικά, είτε ελέγχει την επίδραση αυτών των παραγόντων χρησιμοποιώντας ποσοτικά μαθηματικά μοντέλα. Εμπειρικές μελέτες οι οποίες να εξετάζουν, βάσει επιχειρηματικών αντιλήψεων, τη σημαντικότητα αυτών των μεταβλητών σχετικά με το εάν επηρεάζουν ή όχι τα διοικητικά στελέχη στο να μπορούν να αναγνωρίσουν την παρουσία των εμπράγματων δικαιωμάτων σε μια τεχνολογική επένδυση είναι πάρα πολύ λίγες εώς ανύπαρκτες.

Ερευνητικό ερώτημα-Αντικείμενο και στόχοι της διατριβής

Βάσει των παραπάνω ερευνητικών κενών, αντικείμενο της παρούσας διδακτορικής διατριβής είναι να μελετήσει το ερευνητικό ερώτημα: "***Πώς τα εμπράγματα δικαιώματα (Real Options) μπορούν να επηρεάσουν τη συμπεριφορά και τις επενδυτικές αποφάσεις των διοικητικών στελεχών όταν αξιολογούν έργα πληροφορικής***;" Το παραπάνω ερώτημα αποτελείται από τα παρακάτω υποερωτήματα:

- *Ποια είναι η επίδραση των εμπράγματων δικαιωμάτων στην αναμενόμενη αξία και την υιοθέτηση ενός έργου πληροφορικής (IT project) όταν αυτό αξιολογείται από διοικητικά στελέχη ως επικείμενη επένδυση;*
- *Ποια είναι η επίδραση του τύπου της εφαρμογής μιας πληροφοριακής τεχνολογίας στην ενδυνάμωση ή στη μείωση της παραπάνω σχέσης (εμπράγματων δικαιωμάτων και συνολικής αξίας ενός έργου πληροφορικής);*
- *Ποιοι είναι οι παράγοντες που πυροδοτούν και επηρεάζουν την παρουσία και δημιουργία εμπράγματων δικαιωμάτων που υπάρχουν σε μια τεχνολογική εφαρμογή;*

Συγκεκριμένα στόχος της διατριβής είναι να ***αναπτύξει θεωρητικά και να επιβεβαιώσει εμπειρικά μοντέλα αξιολόγησης και υιοθέτησης από τις επιχειρήσεις καινοτόμων έργων πληροφορικής. Οι μεταβλητές των συγκεκριμένων μοντέλων προκύπτουν από τη θεωρία των Εμπράγματων Δικαιωμάτων (Real Options Theory), θεωρίες από τον κλάδο υιοθέτησης καινοτόμων εφαρμογών πληροφορικής (IT innovation adoption theories) και τον κλάδο των πληροφοριακών συστημάτων και της κατηγοριοποίησής τους (IT classification).*** Το ερευνητικό αντικείμενο της διατριβής προσδιορίζεται από τους **παρακάτω επιμέρους στόχους**:

- Μελέτη της ***επίδρασης των Εμπράγματων Δικαιωμάτων*** (Real Options) στην επιχειρηματική αξία απόδοσης έργων πληροφορικής που αξιολογούνται ως επενδύσεις από επιχειρηματικά στελέχη
- Προσδιορισμός και ***μελέτη των βασικών προβλεπτικών τεχνολογικών και οργανωσιακών παραγόντων*** που πυροδοτούν και επηρεάζουν τη δημιουργία και αναγνώριση των Εμπράγματων Δικαιωμάτων για την αξιολόγηση έργων πληροφορικής
- Μελέτη και αξιολόγηση του βαθμού επίδρασης των Εμπράγματων Δικαιωμάτων στην επενδυτική αξία ***διαφορετικών τύπων εφαρμογών πληροφοριακής τεχνολογίας***
- Σχεδιασμός και **ανάπτυξη εννοιολογικού ερευνητικού πλαισίου (research framework)** που εξετάζει τα παραπάνω και συγκεκριμένα την επίδραση της χρήσης της μεθόδου των Εμπράγματων δικαιωμάτων στην αξιολόγηση καινοτόμων έργων Πληροφορικής και τις επενδυτικές αποφάσεις
- **Εφαρμογή** και εμπειρική αξιολόγηση του παραπάνω πλαισίου στην περίπτωση αξιολόγησης επενδύσεων σε εφαρμογές της **τεχνολογίας Ραδιοσυχνικής Αναγνώρισης**

Η κατανόηση της επίδρασης των εμπράγματων δικαιωμάτων στη συμπεριφορά και τις επενδυτικές αποφάσεις των διοικητικών στελεχών όταν αξιολογούν ένα επενδυτικό προϊόν, όπως μια τεχνολογική εφαρμογή είναι πολύ σημαντική καθώς επεκτείνει τις ολιγόριθμες εμπειρικές μελέτες οι οποίες έχουν πραγματοποιηθεί σε αυτόν τον τομέα. Ακόμη, σύμφωνα με τη βιβλιογραφία (Lankton & Luft 2008), είναι πολύ σημαντικό το να προσδιορίσουμε τις συνθήκες κάτω από τις οποίες η μέθοδος των εμπράγματων δικαιωμάτων που βασίζεται στην κρίση και την ενστικτώδη αξιολόγηση επενδύσεων από διοικητικά στελέχη λειτουργεί επιτυχώς, μιας και μπορεί τότε αυτή η αξιολόγηση να αντικαταστήσει ή και να συμπληρώσει την κοστοβόρα εναλλακτική που αξιοποιεί ποσοτικά μαθηματικά μοντέλα εμπράγματων δικαιωμάτων.

Επίσης, η μελέτη της επίδρασης των εμπράγματων δικαιωμάτων σε διαφορετικούς τύπους τεχνολογικών εφαρμογών είναι πολύ σημαντική μιας και βάσει της γνώσης μας η συγκεκριμένη διατριβή αποτελεί την πρώτη εμπειρική μελέτη που ερευνά το αν η αξία των εμπράγματων δικαιωμάτων ενδυναμώνεται ή μειώνεται σε διαφορετικούς τύπους τεχνολογικών εφαρμογών. Η κατανόηση αυτή βοηθά τα διοικητικά στελέχη να καταλάβουν το πότε η μέθοδος των εμπράγματων δικαιωμάτων αξίζει να χρησιμοποιηθεί για την αξιολόγηση ενός τεχνολογικού έργου. Γενικότερα, σύμφωνα με τη βιβλιογραφία εάν κάποιος δεν έχει κατανοήσει πότε μια μέθοδος αξιολόγησης ταιριάζει και είναι κατάλληλη με τη διαδικασία τεκμηρίωσης και επιλογής μιας τεχνολογικής εφαρμογής, τότε αυτό μπορεί να προκαλέσει χάσιμο χρόνου, χρημάτων και επένδυσης σε μια μέθοδο αξιολόγησης που δεν είναι η κατάλληλη (Gunasekaran et al. 2006).

Επίσης, το να κατανοήσουμε ποιοί είναι οι παράγοντες οι οποίοι πυροδοτούν τη δημιουργία και αναγνώριση από τα διοικητικά στελέχη των εμπράγματων δικαιωμάτνω σε ένα τεχνολογικό έργο είναι πολύ σημαντικό διότι αυτοί οι παράγοντες μπορούν να παίξουν το ρόλο της πρόβλεψης της συνολικής αξίας ενός τεχνολογικού έργου που αξιολογείται. Επίσης, αυτοί οι παράγοντες μπορούν να παραμετροποιηθούν, να ποσοτικοποιηθούν και να εισαχθούν σε ένα ποσοτικό μοντέλο αξιολόγησης επενδύσεων σε τεχνολογικές εφαρμογές το οποίο βασίζεται στη μέθοδο των εμπράγματων δικαιωμάτων. Με αυτόν τον τρόπο, μπορεί να υποστηριχθεί η διαδικασία λήψης αποφάσεων. Επίσης, το παραπάνω είναι σημαντικό και για τον κλάδο που μελετά την υιοθέτηση εφαρμογών πληροφορικής από τις επιχειρήσεις διότι αναμένεται τα εμπράγματα δικαιώματα να αποτελέσουν μια προσέγγιση η οποία εξηγεί το μηχανισμό κάτω από τον οποίο ένα επιχειρηματικό στέλεχος αποφασίζει να υιοθετήσει μια τεχνολογία βάσει συγκεκριμένων παραγόντων.

Το συγκεκριμένο εννοιολογικό ερευνητικό πλαίσιο της διατριβής **εξετάζεται** για την περίπτωση αξιολόγησης επενδύσεων σε εφαρμογές της **τεχνολογίας αναγνώρισης μέσω ραδιοσυχνοτήτων** (RFID technology). Βασικό της χαρακτηριστικό αυτής της τεχνολογίας είναι η ικανότητα να ταυτοποιεί μοναδικά από απόσταση ένα αντικείμενο στο οποίο έχει επικολληθεί μια ετικέτα αναγνώρισης. Η συγκεκριμένη τεχνολογία έχει ποικίλες εφαρμογές όπως τα αντικλεπτικά συστήματα, τα ηλεκτρονικά διόδια, η ιχνηλασιμότητα και ο ασύρματος εντοπισμός αποσκευών στα αεροδρόμια ή βιβλίων σε χώρους βιβλιοθηκών. Σημαντική είναι η χρήση της συγκεκριμένης τεχνολογίας και στο χώρο της εφοδιαστικής αλυσίδας, όπου είναι δυνατός ο εντοπισμός σε πραγματικό χρόνο αγαθών που βρίσκονται στις αποθήκες των εταιρειών, η ιχνηλασιμότητα των προϊόντων αυτών κατά μήκος όλης της εφοδιαστικής αλυσίδας, η αυτόματη ενημέρωση για τον αριθμό του αποθέματος των προϊόντων στις αποθήκες και η αυτόματη πρόταση για την ανάγκη ανεφοδιασμού.

Η συγκεκριμένη τεχνολογία αποτελεί το πεδίο εφαρμογής της συγκεκριμένης διατριβής για τους εξής λόγους: (1) Η τεχνολογία RFID είναι μια τεχνολογία η οποία έχει χαρακτηριστικά τα οποία αποτελούν τις βασικές προϋποθέσεις για τη μελέτη και εφαρμογή της μεθόδου των εμπράγματων δικαιωμάτων. Πιο συγκεκριμένα η τεχνολογία χαρακτηρίζεται από μεγάλο βαθμό κινδύνου και λόγω του ότι οι αντίστοιχες εφαρμογές αποτελούν συχνά μιας μεγάλης κλίμακας επένδυση έχουν το χαρακτηριστικό της μη αναστρεψιμότητας του αρχικού κεφαλαίου επένδυσης. Παράλληλα όμως, προσφέρει διοικητική ευελιξία ως προς την εφαρμογή της με στόχο να μειώσει αυτόν τον κίνδυνο. Μια επιχείρηση για παράδειγμα έχει τη δυνατότητα να εφαρμόσει την τεχνολογία με πολλούς διαφορετικούς τρόπους βάσει συγκεκριμένων χαρακτηριστικών όπως το επίπεδο επικόλλησης ετικετών στα προϊόντα (σε επίπεδο παλετών ή σε επίπεδο κιβωτίων) ή ακόμη βάσει του αριθμού και της τοποθεσίας των συσκευών αναγνώρισης (RFID readers) αυτών των προϊόντων με στόχο να εντοπίσει το βέλτιστο για τον οργανισμό συνδυασμό. Ακόμη η τεχνολογία RFID είναι καινοτόμα και γι αυτό το λόγο μπορούν να χρησιμοποιηθούν και να ελεγχθούν οι σχετικές θεωρίες για την υιοθέτηση καινοτόμων εφαρμογών (IT adoption theories) από επιχειρήσεις και να εξεταστεί το πώς αυτές μπορούν να αλληλεπιδράσουν με το πεδίο των εμπράγματων δικαιωμάτων. (2) Στη βιβλιογραφία πολύ λίγες μελέτες έχουν διεξαχθεί για να εξετάσουν την επίδραση των εμπράγματων δικαιωμάτων στη συμπεριφορά επενδυτών στην τεχνολογία RFID, παρόλο που έχει υπογραμμιστεί από την ακαδημία (Curtin et al. 2007) η ανάγκη για έρευνα με αυτόν το σκοπό. (3) Τέλος, η συγκεκριμένη τεχνολογία θεωρείται ως η πιο κατάλληλη για να ελεγχθεί μια από τις υποθέσεις της διατριβής σύμφωνα με την οποία στόχος είναι να εξεταστεί το πώς διαφορετικού τύπου εφαρμογές μπορούν να καθορίσουν την αξία που έχουν τα εμπράγματα δικαιώματα πάνω σε μια επενδυτική απόφαση. Η συγκεκριμένη τεχνολογία μπορεί εφαρμοστεί σε μια πληθώρα διαφορετικών τύπων έργου (π.χ. μια εφαρμογή που αναπτύσσεται εσωτερικά μιας επιχείρησης ή μια εφαρμογή που απαιτεί τη συνεργασία με τους προμηθευτές της εταιρείας).

Ερευνητική Μεθοδολογία και βασικά αποτελέσματα

Για την επίτευξη του παραπάνω ερευνητικού στόχου πραγματοποιήθηκε αρχικά μια βιβλιογραφική επισκόπηση (Κεφάλαιο 2) σε τρία ερευνητικά πεδία: "Αξιολόγηση και υιοθέτηση επενδύσεων σε τεχνολογικές εφαρμογές", "Μέθοδος των Εμπράγματων Δικαιωμάτων στην αξιολόγηση πληροφοριακών συστημάτων" και "Αξιολόγηση και υιοθέτηση επενδύσεων στην Τεχνολογία Ραδιοσυχνικής Αναγνώρισης". Αφού υπογραμμίστηκαν τα ερευνητικά κενά που αναφέρθηκαν παραπάνω καθορίστηκαν οι ερευνητικοί στόχοι όπως παρουσιάστηκαν στην προηγούμενη ενότητα. Η μεθοδολογία (όπως αναλυτικά παρουσιάζεται στο Κεφάλαιο 3 της διατριβής) που ακουλουθήθηκε για την κάλυψη των ερευνητικών στόχων βασίστηκε σε μια μεικτή προσέγγιση αποτελούμενη από δύο βασικές φάσεις: **(α)** <u>τη διερευνητική φάση,</u> κατά την οποία πραγματοποιήθηκαν τρεις μελέτες περίπτωσης και **(β)** <u>την επιβεβαιωτική φάση</u> κατά την οποία έτρεξαν μια πιλοτική και δύο κύριες έρευνες. Η πρώτη φάση βασίστηκε σε ποιοτική ανάλυση για την κατανόηση του φαινομένου των εμπράγματων δικαιωμάτων στην αξιολόγηση των επενδύσεων, ενώ η δεύτερη φάση σε ποσοτική έρευνα για να ελεγχθεί στατιστικά η σχετική θεωρία και η σχέση συγκεκριμένων μεταβλητών (Creswell 2003; M. D. Myers 1997).

(α) Διερευνητική Φάση: Τρεις μελέτες περίπτωσης (Κεφάλαιο 4)

Με στόχο να διερευνηθεί το φαινόμενο του πώς τα εμπράγματα δικαιώματα εμφανίζονται κατά τη διάρκεια αξιολόγησης επενδύσεων σε τεχνολογικές εφαρμογές μελετήθηκαν τρεις μελέτες περίπτωσης. Βασικός στόχος αυτών των μελετών ήταν να αποσαφηνιστεί **ποια ακριβώς εμπράγματα δικαιώματα (κατηγορίες δικαιωμάτων)** θα μετρηθούν κατά την επιβεβαιωτική φάση της διατριβής έτσι ώστε να μελετηθεί το ποια είναι η επίδρασή τους στην αξία των εφαρμογών που αξιολογούνται από τα διοικητικά στελέχη. Δεύτερος βασικός στόχος της πραγματοποίησης των μελετών περίπτωσης ήταν να γίνει κατανοητό **πόσοι και ποιοι διαφορετικοί τύποι εφαρμογών της τεχνολογίας RFID** μπορούν να εφαρμοστούν σε έναν οργανισμό. Στόχος ήταν να προκύψει μια συγκεκριμένη τυπολογία και κατηγοριοποίηση, ώστε να μελετηθεί στη συνέχεια το αν η αξία των εμπράγματων δικαιωμάτων ενδυναμώνεται ή μειώνεται ανάλογα με τον τύπο μιας εφαρμογής. Ο σχεδιασμός **πολλαπλών μελετών περίπτωσης (multiple-cases study design)** επιλέχθηκε για τους παραπάνω στόχους και για το ότι τα δεδομένα περισσοτέρων του ενός οργανισμού είναι σύμφωνα με τη βιβλιογραφία πιο εύρωστα (Yin 2009) και ικανά να προστατεύσουν την έρευνα από πιθανή προκατάληψη (bias) του παρατηρητή/ερευνητή (Leonard-Barton 1990).

Ο κάθε οργανισμός από τις τρεις μελέτες περίπτωσης δραστηριοποιείται σε διαφορετικούς κλάδους. **Η πρώτη μελέτη περίπτωσης** αφορά σε μια από τις μεγαλύτερες στην Ελλάδα εταιρείες τηλεπικοινωνιών και πώλησης προϊόντων, όπως κινητά και ηλεκτρονικές συσκευές. Η **δεύτερη μελέτη περίπτωσης** αναφέρεται σε μια αλυσίδα σούπερ-μάρκετ που δραστηριοποιείται στην Ελλάδα. Ενώ η **τελευταία μελέτη περίπτωσης** αφορά σε μια εταιρεία παραγωγής, πώλησης και διανομής αναψυκτικών στην Ελλάδα αλλά και διεθνώς. Κοινό χαρακτηριστικό αυτών των εταιρειών είναι το ότι ήθελαν να αξιολογήσουν την εισαγωγή της τεχνολογίας RFID στον οργανισμό τους. Το βασικό στοιχείο που διαφοροποιεί αυτές τις μελέτες και αντίστοιχα αποτελεί και λόγο επιλογής αυτών των οργανισμών είναι το ότι οι εταιρείες εκπροσωπούν ένα διαφορετικό κομμάτι στην εφοδιαστική αλυσίδα και έχουν διαφορετικό στόχο για την υλοποίηση της συγκεκριμένης τεχνολογίας. Πιο συγκεκριμένα, ο πρώτος οργανισμός είναι κυρίως μια εταιρεία διανομής ήδη παραχθέντων προϊόντων με στόχο να υλοποιήσει εσωτερικά την τεχνολογία και να ικανοποιήσει κυρίως καθημερινές λειτουργίες. Αντίθετα,ο δεύτερος οργανισμός είναι λιανέμπορος με στόχο να υλοποιήσει την τεχνολογία σε ένα συνεργατικό πλαίσιο με τους προμηθευτές με στρατηγικό απώτερο σκοπό. Τέλος, η τρίτη μελέτη περίπτωσης διαφοροποιείται βάσει του ότι αφορά σε έναν παραγωγό αντί λιανέμπορο.

Στο πλαίσιο αποτίμησης του αναμενόμενου οφέλους και κόστους εφαρμογής της τεχνολογίας αξιολογήθηκαν και οι δυνατότητες αυτών των εφαρμογών σχετικά με το αν μπορούν να επιφέρουν εμπράγματα δικαιώματα για κάθε οργανισμό. Συνοπτικά για κάθε έναν οργανισμό πραγματοποιήθηκε **ανάλυση ("within case analysis")** σχετικά με το στόχο και τον τύπο της κάθε εφαρμογής RFID και μια ανάλυση για την αναμενόμενη αξία των εφαρμογών συμπεριλαμβανομένης της καθαράς παρούσας αξίας και της αξίας που προέρχεται από τα εμπράγματα δικαιώματα.

Για τη συλλογή δεδομένων, αφού προσδιορίστηκε ένα συγκεκριμένο πρωτόκολλο (data collection protocol), χρησιμοποιήθηκαν διάφορες μέθοδοι, όπως οι συνεντεύξεις, αρχεία των εταιρειών, ερωτηματολόγια, επιτόπιες παρατηρήσεις των επιχειρηματικών διαδικασιών στους οργανισμούς και η πραγματοποίηση ομάδων εστίασης (focus groups). Βάσει των δεδομένων που συλλέχθηκαν και της σύγκρισης των τριών μελετών (cross-case pattern) προέκυψαν τα παρακάτω κύρια **αποτελέσματα:**

(1) Προσδιορίστηκαν οι **διαστάσεις οι οποίες διαφοροποιούν την εφαρμογή της RFID τεχνολογίας**. Πιο συγκεκριμένα βάσει της υπάρχουσας βιβλιογραφίας διαμορφώθηκε μια τυπολογία και κατηγοριοποίηση των εφαρμογών της τεχνολογίας RFID. Οι μελέτες περίπτωσης ανέδειξαν ότι μια εφαρμογή της τεχνολογίας RFID μπορεί να διαφέρει από μια άλλη βάσει των παρακάτω διαστάσεων:

(α) <u>την έκταση (scope)</u> στην οποία υλοποιείται, δηλαδή εάν είναι μεμονωμένη εφαρμογή (standalone application) και ικανοποιεί μια βασική επιχειρηματική λειτουργία ή περιλαμβάνει και υποστηρίζει μια πληθώρα εφαρμογών (family application).

(β) το <u>σκοπό της εφαρμογής (purpose)</u>, δηλαδή αν βασικός στόχος της είναι να αυτοματοποιήσει υπάρχουσες καθημερινές επιχειρηματικές διαδικασίες (transactional application) ή να έχει στρατηγικό στόχο (strategic application) και

(γ) το <u>επίπεδο της συνεργασίας με άλλους φορείς (span)</u> που απαιτείται για την υλοποίηση της εφαρμογής, δηλαδή το αν η εφαρμογή προϋποθέτει τη συνεργασία και άλλων εταίρων της εφοδιαστικής αλυσίδας (supply chain application) ή απλά αναπτύσσεται εσωτερικά της εταιρείας χωρίς την απαραίτητη συνεργασία άλλων οργανισμών (internal application).

(2) Το δεύτερο βασικό αποτέλεσμα από τις μελέτες περίπτωσης ήταν η **αναγνώριση από τα στελέχη των οργανισμών εμπράγματων δικαιωμάτων** στις υπό αξιολόγηση τεχνολογικές εφαρμογές. Συγκεκριμένα τα στελέχη και των τριών οργανισμών αναγνώρισαν την αξία του

εμπράγματος δικαιώματος να επενδύσουν αρχικά σε μια πιλοτική εφαρμογή με την προοπτική ότι αυτή η αρχική επένδυση θα προσδώσει άλλες μελλοντικές εφαρμογές (growth option). Ακόμη, τα επιχειρηματικά στελέχη αναγνώρισαν τη δυνατότητα να εφαρμόσουν την τεχνολογία σε στάδια και να επενδύσουν σε μελλοντικές εφαρμογές στην RFID τεχνολογία μόνο εάν η αρχική επένδυση αποβεί καρποφόρα (stage option). Ακόμη στο δεύτερο και τρίτο οργανισμό αναδείχτηκε η σημασία του δικαιώματος που μπορούν να κερδίσουν τα στελέχη του οργανισμού εάν προχωρήσουν και κλιμακώσουν την επένδυση στην τεχνολογία σε επιπλέον καταστήματα/αποθήκες/εργοστάσια και προϊόντα (scale option). Τέλος, στη δεύτερη μελέτη περίπτωσης επιχειρηματικά στελέχη εξέφρασαν το γεγονός ότι επιθυμούν να καθυστερήσουν την επένδυση στην τεχνολογία για τρία χρόνια, όταν δηλαδή η τεχνολογία θα είναι πιο ώριμη και το κόστος της θα έχει μειωθεί. Η συγκεκριμένη αναφορά αναφέρεται στο δικαίωμα αναβολής της επένδυσης (option to defer). Τέλος, η παρουσία των άνω εμπράγματων δικαιωμάτων αποκαλύφθηκε και μέσω του υπολογισμού της καθαράς παρούσας αξίας και της αντίστοιχης ανάλυσης ευαισθησίας.

Επίσης, οι δύο πρώτες εταιρείες οι οποίες εξετάστηκαν αποκάλυψαν ποιοτικά στοιχεία σχετικά με τους παράγοντες οι οποίοι πιθανώς να επηρεάζουν τη δημιουργία και την αναγνώριση των εμπράγματων δικαιωμάτων. Αυτοί οι παράγοντες αναφέρονται σε οργανωσιακές ικανότητες ή τεχνολογικά χαρακτηριστικά. Το αν αυτά τελικά επιδρούν σημαντικά στην αναγνώριση των εμπράγματων δικαιωμάτων εξετάζεται στην επόμενη φάση με τη διεξαγωγή ποσοτικής εμπειρικής έρευνας (Κεφάλαιο 5).

Οι μελέτες περίπτωσης αποκάλυψαν επίσης ότι η αξία των εμπράγματων δικαιωμάτων ενδυναμώνεται σε συγκεκριμένες κατηγορίες και τύπους RFID εφαρμογών. Για παράδειγμα, τα αποτελέσματα των μελετών περίπτωσης αποδεικνύουν ότι το δικαίωμα των στελεχών να καθυστερήσουν και να αναβάλουν την επένδυση (delay option) παρουσιάστηκε πιο έντονα στη δεύτερη μελέτη περίπτωσης η οποία σχετιζόταν με την αξιολόγηση μιας μεγάλης κλίμακας εφαρμογής με στρατηγικό στόχο και το χαρακτηριστικό ότι αφορά σε μια εφαρμογή η οποία υλοποιείται κατά μήκος μιας εφοδιαστικής αλυσίδας και όχι μόνο εσωτερικά σε έναν οργανισμό. Η συγκεκριμένη εφαρμογή λόγω των χαρακτηριστικών αυτών εμφάνισε, σύμφωνα με τα επιχειρηματικά στελέχη, μεγάλο βαθμό αβεβαιότητας ο οποίος σύμφωνα με τη θεωρία αυξάνει την αξία και τη σημαντικότητα των εμπράγματων δικαιωμάτων, όπως για παράδειγμα την αξία του να αναβάλει κάποιος μια επένδυση. Αυτή η παραδοχή εξετάζεται εμπειρικά βάσει στατιστικής ανάλυσης στην επιβεβαιωτική φάση της έρευνας (Κεφάλαιο 6).

Ως αποτέλεσμα των μελετών περίπτωσης είναι τα ερωτήματα που είχαν τεθεί αρχικά να αναθεωρηθούν και να γίνουν πιο συγκεκριμένα. Τα ανανεωμένα ερωτήματα αφορούσαν συγκεκριμένους τύπους εμπράγματων δικαιωμάτων και συγκεκριμένους τύπους εφαρμογών που εξετάζονται στη δεύτερη και επιβεβαιωτική φάση της συγκεκριμένης διατριβής.

(β) Επιβεβαιωτική φάση: Μια πιλοτική και δύο κύριες μελέτες πεδίου (field studies)

Στόχος της επιβεβαιωτικής φάσης της έρευνας είναι αναπτύσσοντας ένα ερευνητικό πλαίσιο να μελετήσει εμπειρικά και ποσοτικά την επίδραση των εμπράγματων δικαιωμάτων στη συμπεριφορά των επιχειρηματικών στελεχών όταν αξιολογούν μια τεχνολογική εφαρμογή. Οι βασικές υποθέσεις αφορούν στο ότι συγκεκριμένοι τύποι εμπράγματων δικαιωμάτων επηρεάζουν τη συμπεριφορά επιχειρηματικών στελεχών και συγκεκριμένα την αξία που προσδίσουν σε ένα τεχνολογικό έργο όταν το αξιολογούν και τελικά στην υιοθέτηση αυτού του έργου από τον οργανισμό τους. Παράλληλα, πραγματοποιείται η υπόθεση ότι αυτή η σχέση ενδυναμώνεται σε συγκεκριμένους τύπους τεχνολογικών έργων. Οπότε και μελετάται η επίδραση του παράγοντα "τύπος τεχνολογικού έργου" (IT project type) ως μια ρυθμιστική παράμετρος (moderator) που επηρεάζει τη σχέση εμπράγματων δικαιωμάτων και της αντιλαμβανόμενης επιχειρηματικής αξίας ενός έργου (value of returns). Τέλος, στο ερευνητικό πλαίσιο εντάσσονται και συγκεκριμένες παράμετροι που προτάσσονται από τη βιβλιογραφία ότι επηρεάζουν τη δημιουργία των εμπράγματων δικαιωμάτων. Το παραπάνω ερευνητικό πλαίσιο χωρίζεται σε δύο μέρη (μοντέλα) και εξετάζεται με δύο βασικές εμπειρικές μελέτες και μια πιλοτική.

<u>Πιλοτική Έρευνα (ενότητα 3.4.3 κεφαλαίου 3)</u>

Η πιλοτική έρευνα η οποία αναφέρεται στο Κεφάλαιο 3 της διατριβής, πραγματοποιήθηκε στην Ελλάδα. Σε αυτήν την έρευνα συμμετείχαν 98 εταιρείες. Στόχος της πιλοτικής έρευνας ήταν να ελέγξει το ερωτηματολόγιο για τη συλλογή των δεδομένων, να γίνουν κάποιες πρώτες στατιστικές αναλύσεις και να πραγματοποιηθούν οι αναγκαίες βελτιώσεις και προσαρμογές του ερωτηματολογίου και των ερωτήσεων που αυτό περιλαμβάνει. Η έρευνα διανεμήθηκε ηλεκτρονικά και σε εκτυπώσιμη μορφή σε εταιρείες που συμμετείχαν σε ένα συνέδριο που διεξήχθηκε στην Αθήνα, σχετικά με τις νέες τεχνολογίες, όπως η RFID τεχνολογία, για τη βελτίωση της λειτουργίας των αποθηκών. Απώτερος στόχος ήταν να εξεταστεί το ενδιαφέρον των εταιρειών αυτών για τη συγκεκριμένη τεχνολογία και να εξεταστεί σε πρώτη φάση αν οι εταιρείες αυτές αναγνωρίζουν τα εμπράγματα δικαιώματα κατά τη διάρκεια της αξιολόγησης. Ως αποτέλεσμα της πιλοτικής έρευνας ήταν η επαναδημιουργία του κεντρικού ερωτηματολογίου και εργαλείου για τη συλλογή δεδομένων η οποία περιελάμβανε μεταξύ άλλων: τον επαναπροσδιορισμό των ερωτήσεων, την αποσαφήνιση ορολογιών οι οποίες δεν ήταν πρωτίστως σαφείς, την προσθήκη ερωτήσεων, την προσαρμογή του τρόπου μέτρησης των μεταβλητών και την επανασυγγραφή των ερωτήσεων, όπου χρειαζόταν, έτσι ώστε να είναι πιο σαφείς και ακριβείς.

Εμπειρική Έρευνα 1 (Κεφάλαιο 5)

Η πρώτη εμπειρική έρευνα είχε **στόχο** να διερευνήσει την επίδραση που έχει το δικαίωμα επέκτασης μιας αρχικής τεχνολογικής εφαρμογής σε μελλοντικές εφαρμογές (growth option) στη γενικότερη αξιολόγηση αυτής της εφαρμογής από τις επιχειρήσεις. Επίσης, βασικός στόχος ήταν να μελετήσει ποιοι είναι αυτοί οι παράγοντες οι οποίοι πυροδοτούν τη δημιουργία και αναγνώριση αυτού του δικαιώματος. Οι συγκεκριμένοι παράγοντες που εξετάστηκαν προέρχονται από τη βιβλιογραφία που σχετίζεται με την υιοθέτηση καινοτόμων εφαρμογών από επιχειρήσεις (IT innovation firm adoption) καθώς και από τη βιβλιογραφία και τη θεωρία των εμπράγματων δικαιωμάτων.

Για το συγκεκριμένο ερευνητικό στόχο πραγματοποιήθηκε μια **ποσοτική εμπειρική έρευνα**, όπου 109 στελέχη επιχειρήσεων 14 διαφορετικών χωρών αξιολόγησαν RFID έργα τα οποία είτε είχαν ήδη υλοποιήσει είτε σκέπτονταν να αξιολογήσουν. Τα στελέχη ερωτήθηκαν για την αξία που βλέπουν σε ένα έργο RFID και ερωτήθηκαν για χαρακτηριστικά της εταιρείας τους (π.χ. ικανότητες καινοτομίας) αλλά και τεχνολογικά χαρακτηριστικά σε σχέση πάντα με τον οργανισμό τους (π.χ. πόσο στρατηγικό είναι το αντίκτυπο της τεχνολογικής εφαρμογής), έτσι ώστε να μελετηθούν οι κατάλληλες συσχετίσεις μεταξύ των μεταβλητών. Περίπου το 80.7% των ερωτηθέντων ήταν εξοικειωμένο με την τεχνολογία RFID.

Για την **ανάλυση των αποτελεσμάτων** χρησιμοποιήθηκαν **δομικά μοντέλα εξισώσεων (structural equation modeling) και επιβεβαιωτική ανάλυση παραγόντων (confirmatory factor analysis)** έτσι ώστε να αξιολογηθεί το μοντέλο μέτρησης και να εκτιμηθούν οι αλληλεπιδράσεις και συσχετίσεις των παραμέτρων που μας ενδιαφέρουν. Τα δομικά μοντέλα εξισώσεων θεωρήθηκαν τα πιο κατάλληλα για την ανάλυση της συγκεκριμένης έρευνας μιας και συνδυάζουν τη διερεύνηση λανθανουσών μεταβλητών με πολλαπλούς δείκτες, την επίλυση ταυτόχρονα πολλαπλών εξισώσεων και ανάλυση σχέσεων-"διαδρομών" (path analysis) (Joseph F. Hair et al. 2009; R. Ho 2006). Παράλληλα χρησιμοποιήθηκαν η λογιστική παλινδρόμηση (logistic regression) και στατιστικοί έλεγχοι για τη σημαντικότητα του growth option ως μεσολαβητική μεταβλητή με τον έλεγχο Sobel (mediation analysis-Sobel test).

Εμπειρική Έρευνα 2 (Κεφάλαιο 6)

Στόχος της δεύτερης εμπειρικής έρευνας ήταν να μελετηθεί η επίδραση τριών κατηγοριών εμπράγματων δικαιωμάτων (1) το δικαίωμα επέκτασης μιας εφαρμογής σε μελλοντικές (growth option), (2) το δικαίωμα αναβολής μιας επένδυσης (option to defer) και (3) το δικαίωμα της κλιμακωτής επένδυσης σε μια εφαρμογή (stage option) στη συμπεριφορά των εταιρειών και τις επενδυτικές τους αποφάσεις όταν αξιολογούν αυτή την εφαρμογή. Βασικός στόχος επίσης ήταν να διερευνηθεί το αν η επίδραση και η αξία αυτών των δικαιωμάτων διαφοροποιείται ανάλογα με τον τύπο μιας εφαρμογής που αξιολογείται. Για αυτό το σκοπό αξιοποιήθηκε η τυπολογία η οποία αναπτύχθηκε ως αποτέλεσμα των μελετών περίπτωσης. Η συγκεκριμένη έρευνα αναπτύσσεται στο Κεφάλαιο 6.

Για το στόχο της συγκεκριμένης έρευνας πραγματοποιήθηκε διεθνής **ποσοτική εμπειρική έρευνα** με τη χρήση δομημένων ερωτηματολογίων και με βάση το ίδιο με την προηγούμενη μελέτη δείγμα των 109 εταιρειών από διαφορετικές ευρωπαϊκές χώρες οι οποίες έχουν δραστηριοποιηθεί στην RFID τεχνολογία. Δόθηκε στα διοικητικά στελέχη μια λίστα από εφαρμογές RFID. Στη συνέχεια, τους ζητήθηκε να επιλέξουν μια από αυτές τις εφαρμογές την οποία είτε είχαν ήδη εφαρμόσει είτε σκέπτονταν να εφαρμόσουν και να την αξιολογήσουν σε σχέση με τη συνολική αξία που προσδίδουν σε αυτήν και σε σχέση με τα εμπράγματα δικαιώματα που προσφέρει αυτή η εφαρμογή. Παράλληλα, τους ζητήθηκε να κατηγοριοποιήσουν αυτήν την εφαρμογή βάσει της τυπολογίας που τους δόθηκε.

Η **ανάλυση** πραγματοποιήθηκε με τη χρήση στατιστικών μετρήσεων: για την ανάλυση των σχέσεων μεταξύ των μεταβλητών χρησιμοποιήθηκε η μέθοδος πολλαπλής παλινδρόμησης (multiple regressions), ενώ για τη σύγκριση διαφορετικών ομάδων (groups) του δείγματος χρησιμοποιήθηκε η ανάλυση κατά ομάδες (multi-group analysis) και ανάλυση διακύμανσης (two way ANOVA).

Τα κύρια αποτελέσματα της επιβεβαιωτικής φάσης η οποία αποτελείται από τις δύο παραπάνω κύριες εμπειρικές μελέτες της διατριβής συνοψίζονται στα παρακάτω:

- Το αν τα διοικητικά στελέχη αναγνωρίζουν ή όχι εμπράγματα δικαιώματα σε ένα έργο πληροφοριακής τεχνολογίας που αξιολογούν επηρεάζει την αξία που πιστεύουν ότι έχει αυτό το έργο. Πιο συγκεκριμένα, τα αποτελέσματα υποστηρίζουν ότι όσο αυξάνεται η αναγνώριση του δικαιώματος επέκτασης ενός έργου σε μελλοντικά (growth option) και του δικαιώματος κλιμακωτής επένδυσης (stage option) τόσο αυξάνεται και η αξία που αποδίδουν τα στελέχη σε αυτό το έργο. Αντιθέτως, τα δεδομένα αποκαλύπτουν οτι όσο αυξάνεται η αντίληψη από τους επιχειρηματίες οτι έχουν τη δυνατότητα να αναβάλουν την επένδυση σε ένα έργο (option to defer), τόσο μειώνεται η αξία που θεωρούν οτι έχει αυτό το έργο. Υποθέτουμε οτι το τελευταίο συμβαίνει διότι η αναβολή μιας επένδυσης σε ένα έργο μπορεί να αποβεί αρνητική για μια εταιρεία επειδή ενδεχομένως επωφελούνται οι ανταγωνίστριες εταιρείες που ήδη έχουν επενδύσει σε αυτό (Lankton & Luft 2008; Jan 2011). Επίσης, αν μια εταιρεία αναβάλει μια επένδυση σε ένα έργο πιθανότατα να προκύψουν και διαφυγόντα κέρδη εξαιτίας αυτής της αναβολής (Angelou & Economides 2008a). Επομένως, σύμφωνα με τα πιο πάνω η αναβολή μιας επένδυσης μπορεί να είναι ασύμφορη για μια επιχείρηση.

- Η αξία των εμπράγματων δικαιωμάτων είναι σημαντική σε συγκεκριμένους τύπους έργων και όχι σε όλους τους τύπους. Σημαντική είναι η αξία των εμπράγματων δικαιωμάτων σε έργα τα οποία χαρακτηρίζονται ως έργα και εφαρμογές μεγάλης κλίμακας (large scale projects) που έχουν στρατηγικό στόχο (strategic projects), υποστηρίζουν μια οικογένεια εφαρμογών (family applications) και εφαρμόζονται κατά μήκος μιας εφοδιαστικής αλυσίδας (supply chain projects). Αυτό εξηγείται γιατί τα συγκεκριμένα έργα είναι αυτά που έχουν και το μεγαλύτερο βαθμό αβεβαιότητας (uncertainty) και μη αναστρεψιμότητας του κεφαλαίου που έχει ήδη επενδυθεί (irreversibility). Ως αποτέλεσμα, αυτού του είδους τα έργα δημιουργούν και τη μεγαλύτερη ανάγκη για να ληφθεί υπόψη η διοικητική ευελιξία που προσφέρουν μέσω της άσκησης των εμπράγματων δικαιωμάτων με απώτερο στόχο τη μείωση του κινδύνου και της αβεβαιότητας που κρύβουν.
- Τεχνολογικά χαρακτηριστικά που σχετίζονται με το αντίκτυπο μιας τεχνολογικής εφαρμογής σε έναν οργανισμό (δηλαδή όταν το αντίκτυπο είναι στρατηγικό με βιώσιμο ανταγωνιστικό πλεονέκτημα το οποίο επιφέρει ραγδαίες αλλαγές) καθώς και οργανωσιακά χαρακτηριστικά (ικανότητες καινοτομίας, απόκτησης γνώσης από την εφαρμογή μας τεχνολογίας και αξιοποίησης των παραπάνω σε μελλοντικά πεδία) μπορούν να πυροδοτήσουν τη δημιουργία και την αναγνώριση του δικαιώματος επέκτασης μιας επένδυσης σε μελλοντικές εφαρμογές (growth option). Μέσω αυτών των χαρακτηριστικών μπορούμε να προβλέψουμε αν είναι δυνατό να αναγνωριστούν αυτά τα δικαιώματα από διοικητικά στελέχη όταν αξιολογούν ένα έργο πληροφορικής.
- Το δικαίωμα επέκτασης μιας επένδυσης σε μελλοντικές εφαρμογές παίζει το ρόλο της παραμέτρου-μεσολαβητή (mediator) και υποστηρίζει την κατανόηση του πώς συγκεκριμένοι τεχνολογικοί και οργανωσιακοί παράγοντες επηρεάζουν τις επενδυτικές αποφάσεις των διοικητικών στελεχών σχετικά με την αξιολόγηση μιας τεχνολογικής εφαρμογής.

Συνεισφορά διδακτορικής διατριβής

Βάσει μιας κριτικής βιβλιογραφικής ανασκόπησης τριών ερευνητικών πεδίων και μιας ποιοτικής και ποσοτικής φάσης, η συγκεκριμένη διδακτορική διατριβή αναπτύσσει και ελέγχει εμπειρικά ένα υβριδικό ερευνητικό πλαίσιο (framework) αναφοράς και αντίστοιχα μοντέλα με στόχο να μελετηθεί η προβλεπτική ικανότητα των εμπράγματων δικαιωμάτων πάνω στην αξιολόγηση και υιοθέτηση καινοτόμων έργων πληροφορικής. Για τη δημιουργία αυτού του υβριδικού πλαισίου αναφοράς χρησιμοποιήθηκαν μεταβλητές από επιστημονικά πεδία δύο βασικών κλάδων: τον κλάδο των χρηματοοικονομικών, όπου υιοθετήθηκε η θεωρία των Εμπράγματων Δικαιωμάτων (Real Options Theory), και τον κλάδο της διοίκησης των πληροφοριακών συστημάτων, όπου αξιοποιήθηκαν θεωρίες υιοθέτησης καινοτόμων τεχνολογικών εφαρμογών (IT innovation adoption theories) και θεωρίες σχετικά με την κατηγοριοποίησή τους (IS classification). Τα αποτελέσματα της διατριβής αυτής υποστηρίζουν τις περισσότερες από τις υποθέσεις που αναπτύχθηκαν και ως αποτέλεσμα προσφέρουν σημαντική συνεισφορά στην επιστημονική κοινότητα και συγκεκριμένα στο σχετικά νέο ερευνητικό πεδίο που μελετά το πώς τα εμπράγματα δικαιώματα επηρεάζουν τη συμπεριφορά διοικητικών στελεχών όταν αξιολογούν την επένδυση σε καινοτόμες τεχνολογίες (Behavioral implications of Real Options for IT investments). Πιο συγκεκριμένα η διατριβή αυτή συμβάλλει στη βιβλιογραφία με τους εξής τρόπους:

- **Επεκτείνει και υποστηρίζει τις ολιγάριθμες εμπειρικές έρευνες που έχουν πραγματοποιηθεί για τη μελέτη της επίδρασης των εμπράγματων δικαιωμάτων στην επενδυτική συμπεριφορά** των διοικητικών στελεχών. Τα αποτελέσματα της διατριβής ως προς την επίδραση των εμπράγματων δικαιωμάτων άλλοτε συμφωνούν και άλλοτε αντιτίθενται με τα αποτελέσματα προηγούμενων μελετών και γι αυτό το λόγο δημιουργούν και την ανάγκη για περαιτέρω έρευνα η οποία καλύπτεται από την παρακάτω δεύτερη συνεισφορά της διατριβής.
- Η συγκεκριμένη διατριβή αποτελεί, σύμφωνα με τη δική μας γνώση, την ***πρώτη εμπειρική ποσοτική μελέτη*** **η οποία εξετάζει το αν το μέγεθος της επίδρασης των εμπράγματων δικαιωμάτων μεταβάλλεται ανάλογα με τον τύπο μιας τεχνολογικής εφαρμογής που αξιολογείται.** Η συγκεκριμένη μελέτη καλύπτει το σχετικό ερευνητικό κενό που έχει υπογραμμιστεί από τη βιλιογραφία (Tiwana et al. 2006; L. C. Wu & C. S. Ong 2008), υποστηρίζοντας ότι η αξία των εμπράγματων δικαιωμάτων είναι μεγαλύτερη για συγκεκριμένους τύπους τεχνολογικών εφαρμογών (π.χ. μεγάλης κλίμακας έργα με στρατηγικό χαρακτήρα που υποστηρίζουν ένα πλήθος εφαρμογών) και όχι για όλους τους τύπους. Με αυτόν τον

τρόπο υποστηρίζει την ανάγκη για τη μελέτη των εμπράγματων δικαιωμάτων σε συγκεκριμένες περιπτώσεις (δηλ. συγκεκριμένες εφαρμογές) και όχι σε ένα ομοιογενές σύνολο από τεχνολογικές επενδύσεις (Lankton & Luft 2008).

- Επίσης, η συγκεκριμένη διδακτορική διατριβή συνεισφέρει στον κλάδο της αξιοποίησης των εμπράγματων δικαιωμάτων για την αξιολόγηση έργων πληροφορικής μέσω του ότι **μελετά και αναγνωρίζει τους τεχνολογικούς και οργανωσιακούς παράγοντες που επιδρούν θετικά στην αναγνώριση και τη δημιουργία των εμπράγματων δικαιωμάτων σε ένα τεχνολογικό έργο.** Παρόλο που η μέχρι τώρα βιβλιογραφία (Fichman 2004; McGrath & MacMillan 2000; Scarso 1996; Y. J. Kim & Sanders 2002) προτείνει και εξετάζει αυτούς τους παράγοντες με θεωρητικά ή μαθηματικά μοντέλα, πάρα πολύ λίγες εμπειρικές μελέτες έχουν πραγματοποιηθεί για να μετρήσουν και να ελέγξουν αυτούς τους παράγοντες και την επίδρασή τους στη συμπεριφορά των διοικητικών στελεχών. Οι τεχνολογικοί αυτοί παράγοντες σχετίζονται με το βαθμό επίδρασης που έχει ένα τεχνολογικό έργο σε έναν οργανισμό δηλ. το πόσο στρατηγικό, βιώσιμο και ριζικό είναι το αντίκτυπο. Οι οργανωσιακοί παράγοντες σχετίζονται με το βαθμό των ικανοτήτων των στελεχών ενός οργανισμού να είναι καινοτόμα, να μαθαίνουν από μια εφαρμογή και να χρησιμοποιούν αυτή τη γνώση σε άλλες παραπλήσιες εφαρμογές. Κάτω από το ίδιο πλαίσιο, η συγκεκριμένη μελέτη έχει συνεισφορά και στο ερευνητικό πεδίο που σχετίζεται με την υιοθέτηση καινοτόμων τεχνολογικών εφαρμογών από τις επιχειρήσεις (IT innovation adoption), επιβεβαιώνοντας εμπειρικά το μεσολαβητικό ρόλο που έχει το δικαίωμα επέκτασης μιας εφαρμογής (growth option) στην επίδραση των παραγόντων που προαναφέρθηκαν. Δηλαδή, η διατριβή υποστηρίζει ότι οι παραπάνω παράγοντες επηρεάζουν την αξιολόγηση και τελικά υιοθέτηση μιας τεχνολογικής εφαρμογής μέσω του δικαιώματος που εμπεριέχει αυτή η εφαρμογή να προσφέρει άλλες μελλοντικές εφαρμογές. Η συγκεκριμένη συνεισφορά αναφέρεται στο σχετικό ερευνητικό κενό που έχει υπογραμμιστεί από προηγούμενες έρευνες (Goswami et al. 2008) σύμφωνα με το οποίο: *"νέες μελέτες καλούνται να εξηγήσουν το μηχανισμό κάτω από τον οποίο συγκεκριμένοι παράγοντες επηρεάζουν την υιοθέτηση μιας τεχνολογίας από τις επιχειρήσεις"*.
- Ακόμη η διατριβή αυτή **εξετάζει εμπειρικά την αξία των εμπράγματων δικαιωμάτων και τα μοντέλα που έχουν αναπτυχθεί στην περίπτωση της RFID τεχνολογίας.** Συγκεκριμένα επεκτείνει τις πολύ λίγες συμπεριφορικές μελέτες (Goswami et al. 2008; Goswami et al. 2010) που έχουν διεξαχθεί στο χώρο της υιοθέτησης αυτής της τεχνολογίας κάτω από το πρίσμα της θεωρίας των

εμπράγματων δικαιωμάτων, μελετώντας διαφορετικούς από τις προηγούμενες έρευνες παράγοντες. Μέσω αυτής της μελέτης υποστηρίζεται ότι τα εμπράγματα δικαιώματα επηρεάζουν τις αποφάσεις και τη συμπεριφορά των διοικητικών στελεχών όταν αξιολογούν ένα έργο RFID. Παράλληλα τα αποτελέσματα υποστηρίζουν ότι η σχέση των εμπράγματων δικαιωμάτων και της αξιολόγησης ενός RFID έργου επηρεάζεται από τον τύπο ενός RFID έργου. Μέχρι στιγμής, οι προηγούμενες έρευνες μελετούσαν την RFID τεχνολογία ως μια ενιαία τεχνολογία και ως ένα ομοιογενές σύνολο χωρίς διαφοροποιήσεις. Η συγκεκριμένη διατριβή προτείνει μια ταξινόμηση των RFID έργων (όπως συζητήθηκε ως αποτέλεσμα των μελετών περίπτωσης) βάσει τριών παραμέτρων και αποδεικνύει εμπειρικά ότι η μέθοδος των εμπράγματων δικαιωμάτων έχει αξία και γίνεται αντιληπτή από τα διοικητικά στελέχη μόνο σε μερικούς τύπους RFID έργων. Όπως δείχνουν τα αποτελέσματα, τα RFID έργα τα οποία κρύβουν μια μεγαλύτερη αβεβαιότητα για το αποτέλεσμα έχουν και μεγαλύτερη αξία στο να αξιολογηθούν με τη θεωρία των εμπράγματων δικαιωμάτων. Τέτοια RFID έργα είναι αυτά που για να αναπτυχθούν χρειάζονται τη συνεργασία εταίρων στην εφοδιαστική αλυσίδα, έχουν στρατηγικό χαρακτήρα και αποτελούν υποδομές υποστήριξης πολλών εφαρμογών. Τέλος, η διατριβή αναπτύσσει ένα παραμετρικό και δυναμικό μοντέλο αξιολόγησης επενδύσεων σε RFID εφαρμογές το οποίο αν και στηρίζεται στη μέθοδο της Καθαράς Παρούσας Αξίας μπορεί να αποτελέσει έναν προθάλαμο για την εφαρμογή και αξιοποίηση των εμπράγματων δικαιωμάτων με τη χρήση ποσοτικών μαθηματικών μοντέλων.

- Τέλος, η συγκεκριμένη διατριβή αποτελεί σύμφωνα με τη γνώση μας την πρώτη **βιβλιογραφική επισκόπηση στο κομμάτι της χρήσης των εμπράγματων δικαιωμάτων για την αξιολόγηση τεχνολογικών εφαρμογών** η οποία κατηγοριοποιεί και αναλύει και τα δύο βασικά πεδία που έχουν χρησιμοποιηθεί για την ανάλυση, δηλαδή τη συμπεριφορική αλλά και την μαθηματική μοντελοποίηση. Η συγκεκριμένη διατριβή και για τα δύο πεδία δημιουργεί ένα πλαίσιο αναφοράς με μεταβλητές που επηρεάζουν την αξία των εμπράγματων δικαιωμάτων, υπογραμμίζει τα ερευνητικά κενά και προτείνει μελλοντικές ερευνητικές κατευθύνσεις που μπορούν να αποτελέσουν έναυσμα για περαιτέρω έρευνα στην αξία της μεθόδου των εμπράγματων δικαιωμάτων για την αξιολόγηση τεχνολογικών επενδύσεων.

Η συγκεκριμένη διατριβή έχει και πρακτική συνεισφορά η οποία συνοψίζεται στα παρακάτω σημεία:

- Τα διοικητικά στελέχη συμβουλεύονται να εντάξουν στην επιχειρηματική τους στρατηγική που σχετίζεται με τη διαδικασία αξιολόγησης τεχνολογικών εφαρμογών και τις επενδυτικές τους αποφάσεις τα εμπράγματα δικαιώματα. Πρέπει να γνωρίζουν ότι **η τελική τους απόφαση και η αξία που προσδίδουν σε ένα τεχνολογικό έργο μπορεί να επηρεαστεί από την ύπαρξη εμπράγματων δικαιωμάτων.** Πρέπει να γνωρίζουν ότι οι κλασικές και συνήθεις μέθοδοι προεξόφλησης των ταμειακών ροών δεν είναι οι κατάλληλες για την αποτίμηση τεχνολογικών εφαρμογών που εμπεριέχουν υψηλό βαθμό κινδύνου, μη αναστρεψιμότητα του κεφαλαίου που έχει αρχικά επενδυθεί και διοικητική ευελιξία στη λήψη αποφάσεων που σχετίζεται με την υιοθέτηση αυτών των εφαρμογών. Για την αξιολόγηση επενδύσεων αυτού του τύπου η θεωρία των Εμπράγματων Δικαιωμάτων αποτελεί την πιο κατάλληλη προσέγγιση (Dixit & Pindyck 1994).
- Τα διοικητικά στελέχη μπορούν να χρησιμοποιήσουν τις παραμέτρους που υπογραμμίζονται από τη συγκεκριμένη διδακτορική διατριβή ως παράγοντες που προάγουν τη δημιουργία των εμπράγματων δικαιωμάτων και να τις εισάγουν σε ένα **εργαλείο λήψης αποφάσεων** το οποίο σε συνεργασία με άλλες μεθόδους όπως η αναλυτική μέθοδος ιεράρχησης (analytical hierarchy process) μπορεί να τους βοηθήσει να λαμβάνουν αποφάσεις σχετικά με την επιχειρηματική αξία μιας επένδυσης.
- Η συγκεκριμένη διατριβή προτείνει μια **μήτρα με τύπους RFID εφαρμογών** ανάλογα με το στόχο μιας εφαρμογής (π.χ. στρατηγικό ή συναλλαγής), με την έκτασή της (αν αναπτύσσεται εσωτερικά ή σε συνεργασία με άλλες επιχειρήσεις) και με το επίπεδο υποστήριξης άλλων εφαρμογών (αν είναι μια υποδομή που υποστηρίζει πλήθος εφαρμογών ή μια μεμονωμένη εφαρμογή). Η συγκεκριμένη τυπολογία μπορεί να χρησιμοποιηθεί από τα στελέχη των επιχειρήσεων ως ένα πρακτικό **εργαλείο απόφασης και στρατηγικού σχεδιασμού** και να τους υποστηρίξει στο να χαρτογραφήσουν το χαρτοφυλάκιο RFID εφαρμογών που θέλουν να αναπτύξουν στη δική τους εταιρεία και παράλληλα να το συγκρίνουν με το χαρτοφυλάκιο άλλων εταιρειών.
- Ακόμη, υπογραμμίζεται ότι **η μέθοδος των εμπράγματων δικαιωμάτων δεν πρέπει να χρησιμοποιείται από τα στελέχη ως πανάκεια**. Η χρήση της μεθόδου των εμπράγματων δικαιωμάτων έχει αξία και νόημα σε μερικούς μόνο τύπους εφαρμογών. Γι αυτό το σκοπό, η συγκεκριμένη μελέτη δίνει οδηγίες σχετικά με το

πότε είναι καλύτερο να αξιοποιείται η μέθοδος των εμπράγματων δικαιωμάτων για την αξιολόγηση τεχνολογικών εφαρμογών και το πότε η μέθοδος αυτή είναι δύσκολο να έχει αξία και μπορεί να αποκατασταθεί απο την κλασική μέθοδο της καθαράς παρούσας αξίας.

- Τα αποτελέσματα παρουσίασαν ότι μπορούμε να προβλέψουμε τις επενδυτικές αποφάσεις και την αξία που δίνουν οι επιχειρηματίες σε ένα τεχνολογικό έργο που αξιολογούν μέσω των εμπράγματων δικαιωμάτων. Ως αποτέλεσμα, η πρακτική συνεισφορά αυτής της διατριβής έγκειται και στο ότι εταιρείες που αναπτύσουν εφαρμογές που βασίζονται σε νέες τεχνολογίες μπορούν να αξιοποιήσουν τη θεωρία των εμπράγματων δικαιωμάτων κατά τη διάρκεια **σχεδιασμού των εφαρμογών** (π.χ. να σχεδιάζουν εφαρμογές που υποστηρίζουν η μια την άλλη και μπορούν να δημιουργήσουν μελλοντικές προεκτάσεις) και να πείσουν παράλληλα εταιρείες- τελικούς χρήστες για την υιοθέτηση αυτών των εφαρμογών.

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1 INTRODUCTION

1.1 Introduction to the field and Research Motivation

Several innovative technologies (e.g. Web services, Extensible Markup language (XML), web-based Electronic Data Interchange) emerge in order to support and facilitate organisations' supply chain business processes by offering a lot of opportunities such as: real-time information, improved communication and data sharing, enhanced decision making, improved demand forecasting, operational benefits, reduced costs (Pramatari et al. 2009; Williamson et al. 2004; Prajogo & Olhager 2011; F. Wu et al. 2006; Tseng et al. 2011).

One of the emerging technologies for the enhancement of the supply chain is Radio Frequency Identification (RFID) technology. This technology provides real time information for unique product instance and context information supporting services such as "back room visibility and store replenishment, collaborative shelf management and collaborative in-store promotion management and evaluations" (Pramatari 2007). Its basic trait, which involves the automated and wireless unique identification of a tagged item, is essential in other environments than supply chain management such as: anti-theft systems, asset tracking, airline baggage handling, electronic tolling, and facilities management (e.g. libraries), where a non-line of sight system is required to extract information about object movement.

Due to the high cost of emerging technologies such as RFID and the budgeting constraints of organisations it is very important for managers to understand whether such IT investments are financially justifiable (Lee & Lee, 2011*). "Investments which are inadequately justified or whose costs, risks, and benefits are poorly managed, can hinder and even restrict an organisation's performance*(Gunasekaran 2001)". Several investment evaluation approaches have been followed for the justification of RFID and other innovative technologies. These include: strategic (J. Kim et al. 2008) analytical (Sharif & Irani 2006; Chou et al. 2006) or integrated approaches (Apostolopoulos & Pramatari 1997). One of the most common approaches is the economic method and the discounted cash flow approach (Ustundag et al. 2010; I. Lee & B.-C. Lee 2010; Bottani & Rizzi 2008). However, the current financial justification methods are inadequate to deal with IT investment issues (Gunasekaran 2001). Owing to the dynamic factors inherent in IT investments such as RFID, investment evaluation cannot be a single one-off evaluation procedure (Gunasekaran 2001). Traditional evaluation approaches ignore management's flexibility regarding investment decisions as they assume that once a project is approved all the cash flows will automatically take place (MacMillan et al. 2006).

Technologies such as RFID have got a lot of new attributes which make the above approaches not applicable. For example, RFID technology has got a cost which (based on the scale of the investment) depends on the number and the type of the utilised RFID readers and tags. The number and type of RFID equipment result in a variety of candidate applications and configurations. According to previous studies (Pramatari et al. 2009; Goswami et al. 2008) RFID is a highly risky technology (e.g. technical uncertainties over possible configurations, concerns regarding loss of privacy, organisational challenges) with irreversible cost (e.g. high cost of tags, high cost of infrastructure) and high level of flexibility (e.g. multiple alternative implementations based on the level of tagging, the placement and the number of readers). The majority of the previous studies on IT and RFID in particular investment evaluation do not take into consideration managerial flexibility of such investments as they mainly focus on static and not dynamic evaluation implying that the cost of candidate investments is fully reversible (Dixit & Pindyck 1994). However, previous scholars (Curtin et al. 2007) have underlined that flexibility and the different kind of options that an RFID investment can yield should be studied. When uncertainty and irreversibility are high omitting the value of managerial flexibility can lead to substantial understatement of the investment value (Fichman 2004).

The stage of gathering information and evaluating investments is followed by the adoption stage where a decision is made for making use of the technology innovation (Thong 1999). Previous studies, based on traditional IT adoption research paradigms (Rogers 1995; Tornatzky & Fleischer 1990) such as the framework of the "Diffusion of Innovation Theory" (DOI) or the "TOE framework" (i.e. Technology, Organisational, Environment), have investigated several innovation attributes and organisational or environmental factors which inhibit or promote firm adoption of IT (C. Zhang & J. Dhaliwal 2009; Chwelos et al. 2001; Oliveira & Martins 2011; Grandon & Pearson 2004; Kuan & Patrick Y.K. Chau 2001; Pan & Jang 2008; Tsai et al. 2012; Ke et al. 2009). Although pertinent literature offers significant contributions to understand firm adoption (Frambach & Schillewaert 2002), it ignores managerial flexibility and real options as determinants of technology innovation adoption. Pertinent literature underlines that *little is known about how managers' understanding of factors influences the decision process leading to IT and in particular RFID adoption* (Goswami et al. 2008). Scholars (Curtin et al. 2007) question the traditional IT adoption research paradigms and ask whether new adoption paradigms make sense for these emerging technologies such as RFID.

As a result of the recognised drawbacks of the traditional evaluation approaches Real Options has been proposed as a new paradigm for the investment evaluation and firm adoption of innovative technologies with high uncertainty and irreversibility. This approach has been derived from the field of Economics & Finance. It takes into consideration the flexibility of such investments as a way to confront several risks and uncertainties. Flexibility can be defined as the “Ability to respond or conform to a changing or new situation in a variety of ways” (Kumar, 1999), whereas “Uncertainty is an investment’s risk or volatility in cash flows that results from the inability to predict behaviours related to economy, market, technology or organisation” (Lankton and Luft, 2008:217). Based on Real Options approach, investment risk can be diminished through flexibility that occurs during investment decisions. Under flexibility, managers can revise their investment decisions in response to market developments (e.g. changes in the cost of the evaluated technology and other market conditions (e.g. new regulations) (Smit & Lenos Trigeorgis 2006; Y. J. Kim & Sanders 2002). Flexibility can be signified through the exploitation of several options. Common types of options include the option to expand a project, or else 'growth option', in order to capture additional cash flows from such growth, the option to develop a project in stages, referred to as 'stage option', and the option to delay a project with the aim to wait until more information is acquired, referred to as 'deferral option' (Lenos Trigeorgis 1993; Turban & Volonino 2010). If such options are available but are not considered during the investment assessment, then the investment will be undervalued (Lenos Trigeorgis 1993; Dos Santos 1991).

Real Options theory and analysis has been applied to the IS literature from 1990. Several scholars have applied Real Options to the investment evaluation of several technologies (Smit & Lenos Trigeorgis 2007; Sanyal & Sett 2011) such as platform and infrastructure technologies (Fichman 2004), telecommunication networks (Angelou & Economides 2008a), software development platforms (Taudes et al. 2000), enterprise applications such as ERP (Wu et al. 2008). However, the majority of the works which apply Real Options for IT evaluation follow the normative approach, where an option pricing model is applied to measure the real option value of an IT project (e.g. Dos Santos 1991; Benaroch & Kauffman 1999; Taudes 1998; Tiwana et al. 2007; Bardhan et al. 2004). A very limited number of studies have followed the behavioral approach, where the effect of Real Options on managers' perceptions is examined (Tiwana et al. 2006; Tiwana et al. 2007; Lankton & Luft 2008; Fichman 2004; McGrath 1997; Goswami et al. 2010). However, scholars have underlined the research necessity to investigate "*how the use of Real Options in capital budgeting affects managerial behavior and decisions*" (Denison 2009; Tiwana et al. 2006) not only in IT but for projects investments in general.

The few studies with the above aim have concluded that the effect of Real Options has a significant impact on managerial decision making for IT investments. However, these studies show a lot of discrepancies. For example while, some of the studies (Hult et al. 2010) show that the option to delay investments has a significant positive impact on the intention to adopt an IT investment, other studies (Tiwana et al. 2007) show that this impact is insignificant or even negative (Goswami et al. 2008). The different results revealed in previous studies create the motivation to study whether specific moderating factors are responsible for these inconsistencies. In addition, the great majority of studies applying Real Options in the IT field treat IT projects as a homogeneous group rather than looking at individual features or types of IT projects. However, *different types of IT projects might carry different option value* (L. C. Wu & C. S. Ong 2008; Tiwana et al. 2006; X. Li & Johnson 2002). For example, prior research (Q. Dai et al. 2007; Fichman 2004; Taudes et al. 2000) suggests that platform IT investments (e.g. ERP, wireless networking, infrastructure investments) are very good candidates for growth opportunities. Li & Johnson (2002) have shown in their normative study that “shared IT projects” (i.e. open standard technologies, e.g. wireless access), in contrast to “proprietary” ones, indicate a higher level of competition, thus the value of the option to wait is diminished. Wu and Ong (2008) in their study underline that small-scale applications (e.g. daily accounting and office automation systems) offer few options in contrast to other larger-scale investments. Although the pertinent literature has acknowledged the importance of extending research on the above issues, to our knowledge, no attempt has been made to empirically compare different types of IT projects[1] and examine whether the value of real options varies. In addition, limited effort has been devoted to identifying the features or the attributes of IT projects related to the creation of an option.

In addition, studies on IT Real Options, apart from examining the recognition of real options as a factor which influences the value and adoption of an IT project, propose variables which stimulate the creation and recognition of these options. These variables are tangible (e.g. cash flows of the IT application, volatility of the anticipated returns) or intangible (e.g. competition pressure, synergies among the assessed IT applications, organisational capabilities to implement the technology). However, the majority of these studies either develop conceptual models with propositions (Fichman 2004; Scarso 1996; Y. J. Kim &

[1] An example of IT classification and IT project types is offered in Chapter 4, Section 4.6.

Sanders 2002; McGrath & MacMillan 2000) or test the impact of these variables utilising quantitative mathematical modeling (Angelou & Economides 2009a; X. Li & Johnson 2002). Studies (Lankton & Luft 2008; Goswami et al. 2008; Goswami et al. 2010; Saya et al. 2010) which empirically investigate the significance of these variables on real option recognition based on managers' perceptions are very few.

1.2 Research Objective and Questions

Given the above research insufficiencies the present doctoral study has the aim to **study the behavorial implications of Real Options and their impact on managerial decision making regarding IT investments**. RFID technology is chosen as the context of this study to examine Real Options. This choice has been based on the fact that RFID is a highly uncertain and irreversible investment with high levels of flexibility. According to the literature these attributes of the technology makes real options approach applicable to the case of RFID. In addition, previous scholars have underlined the need for RFID to be studied under the Real Options perspective. Section 3.5 offers an analytical discussion on the justification of this technology as the main context of the present doctoral thesis.

In order to cover this research aim, this thesis has the aim to investigate the following *research objectives*:

- Empirically test the proposed by the literature factors which determine the recognition of a real option within an IT project,
- Extend very few previous works and refine understanding on the investigation of the impact of Real Options on the perceived value of an assessed IT project and its adoption,
- Conduct the first quantitative study (to the best of our knowledge) which empirically investigates the IT project type as a factor which can moderate this impact.

The above research objectives can be translated into the following *research questions*:

- **Research Question 1:** What are the determinants which influence the real option recognition embedded in an information technology project?

Although literature on Real Options utilisation for IT investment evaluation and adoption has acknowledged the importance of identifying the sources and the determinants which trigger the recognition of real options within IT projects, pertinent empirical studies are rare. The majority of previous studies either develop theoretical propositions (Fichman 2004; Scarso 1996; McGrath & MacMillan 2000; Y. J. Kim & Sanders 2002) or test the significance of these determinants within option pricing modeling. For example, Fichman (2004) identifies a set of organisational and technological factors that determine the option value in IT platform investments, while Kim and Sanders (2002) provide a qualitative decision support tool of strategic actions based on real options analysis. However, studies which empirically investigate whether these proposed determinants influence managerial perceptions and recognition of real options and ultimately decision making are scarce. Research Question 1 has the aim to fulfill this gap. This question needs to be answered because the factors which can significantly influence the recognition of real options can work as predictors of real options and ultimately IT project value. In addition, identification of the most important factors which influence real option recognition can facilitate managerial decision making regarding the utilisation of real options. Managers can understand the circumstances under which Real Options become evident. In addition, these tested qualitative factors can be parameterised and incorporated into the quantitative valuation (Su et al. 2009).

In addition this research question has the aim to cover a research need identified in the field of IT innovation adoption by firms. In this field, previous research (C. Zhang & J. Dhaliwal 2009; Chwelos et al. 2001; Oliveira & Martins 2011; Grandon & Pearson 2004; Kuan & Patrick Y.K. Chau 2001; Pan & Jang 2008; Tsai et al. 2012; Ke et al. 2009) offers a significant understanding on the factors which contribute to IT adoption by firms. However, scholars' call underlines that still little is known about <u>how</u> managers' understanding of these factors influence decision making. At the same time, literature highlights the necessity to find a new IT adoption research paradigm. In this thesis we would like to empirically test scholars' propositions regarding whether the impact of specific IT innovation adoption factors can be explained by the recognition of real options. By investigating this issue pertinent literature can understand better and clarify the firm adoption decision making process.

- **Research Question 2:** What is the impact of real options on the perceived value of returns of an information technology project and ultimately its actual adoption?

After being able for managers to recognise Real Options based on specific determinants, the impact of these options on the investment evaluation of an IT project can be tested. The research question 2 comes to fulfill identified research need to conduct behavorial studies to empirically examine *how option thinking is adopted by decision makers in evaluating IT project investments* (Tiwana et al. 2006). This need has been underlined by scholars (Su et al. 2009; Hult et al. 2010) for other types of project investments apart from information technology projects. This question is important to be answered as it will extend very few previous works on the behavorial implications of IT Real Options. The normative real options evaluation (i.e. the exploitation of quantitative option pricing modeling) prevails in the field whereas the intuitive real options valuation (i.e. behavorial implications of Real Options based on perceptions) is very limited. A second reason which justifies the significance of the specific research question is the following: *Understanding qualitative, intuitive judgement is crucial as firms need to identify the settings in which intuitive judgement is likely to perform well and can therefore substitute for the more costly alternatives of full-scale quantitative real options analysis* (Lankton & Luft 2008).

- **Research Question 3:** Is this impact strengthened or mitigated across different types of IT projects?

Although previous studies have been conducted and showed the significant impact of real options on managerial decision making for IT investments, the majority of the works treat IT project investments as a homogeneous group. However, according to the literature (Wu & Ong 2008; Tiwana et al. 2006; Li & Johnson 2002) Real Option value varies across the different types of IT projects. This issue can explain the several discrepancies that previous results show regarding the impact of real options. For example, the option to delay investments has been identified to have positive impact but in other studies the impact has been found to be negative or insignificant. These discrepancies can be related to the existence of moderating factors such as the type of the information technology project. However, to our knowledge there is no empirical quantitative study which tests how real option value changes among the different types of IT projects. The third research question of this thesis has the aim to cover this gap.

The investigation of the specific research question is vital as it fulfills scholars' (Lankton & Luft 2008) call to *investigate behavorial IT real options in specific settings* rather than in general. It is important for researchers and practitioners to understand *where real options are most warranted on theoretical grounds* (Fichman 2004). Based on the literature (L. C. Wu & C. S. Ong 2008) for some projects where there is low level of uncertainty or they do not take long to be implemented (e.g. small scale applications) real options add little value, thus NPV approach can be utilised directly. In addition, Fichman (2004) proposes that options might carry lower value in one-off application projects than in infrastructural projects. However, empirical behavorial studies which test these propositions in the IT context appear to be none. Empirically investigating these propositions can help managers to realise where real options approach is suitable to be exploited. Otherwise, they can be directed to misleading decisions. Managers need to understand when an evaluation approach suits the justification process, as a lack of understanding can cause managers to waste time and energy on an approach that yields no better results than simple rules of thumb (A. Gunasekaran et al. 2006).

1.3 **Research Approach**

To meet the thesis research objective and answer the respective research questions two research phases are followed. One is exploratory with the conduction of three case studies and the second is confirmatory with the execution of a web-survey.

1.3.1 **Exploratory Phase-Case Studies**

In order to address the questions: What is the impact of real options and whether this impact is moderated among the different types of IT projects, specific questions were investigated as prerequisites through the case studies. In particular, the aim of the case studies was to explore RFID investments evaluation process and identify the different types of Real Options that occur during this process. These types of options would then be explored in the confirmatory phase of the present thesis. In addition, through the case studies the aim to explore whether and how RFID deployment differs across the different implementations was going to be covered.

Each case study was derived from different fields. The first case study was about a Retailing company in the telecommunications industry which merchandises several products (mobiles, electronic devices etc.) and consists of 150 stores in Greece. The company is one of the biggest telecommunications providers in the Greek market. The second case concerned a Retail Distribution center which is one of the biggest supermarket chains in Greece. Finally, the third case concerned a distribution center and manufacturer company in the beverage sector in Greece which is part of an international company. Common issue in the above cases was the necessity to assess the value of RFID applications in their companies. A within case analysis and a cross-case discussion resulted in interesting findings that were utilised to form specific hypotheses for the empirical studies and refine the thesis initial research questions. For example, based on the three case studies it was found that RFID deployment varies based on several dimensions. Thus, different types of IT projects were revealed. These types were utilised as moderator factors for the quantitative confirmatory study analysed in Chapter 6.

For the data collection for each one case study several techniques (e.g. structured interviews, archival records, direct observations, focus groups, survey data, and workshops) were utilised. For the analysis of the case studies, the strategy of using both *quantitative and qualitative data* and drawing a *cross-case conclusions* were the main techniques that were exploited (Yin 2009). A thorough analysis of these data collection and analysis tools for each one case study will take part in Chapter 4.

1.3.2 Confirmatory Phase-Empirical Research

Based on the cross-case findings of the previous exploratory phase and the refined research questions which were more specific (i.e. specific types of real options and RFID investment project types), the second part of the doctoral thesis (i.e. the confirmatory phase) follows. The specific part addresses the previous discussed research questions in their refined version. One pilot study and two main studies are conducted. The pilot study (discussed in Chapter 3) helps to refine the items, word and format of the questionnaire. **The first study** (Chapter 5) has the aim to examine whether real options (and more specifically growth options) are recognised by managers for an IT assessment and whether the recognition of real options can influence the perceived value of an IT project and its overall adoption. In addition, aim of this study is to investigate what are the determinants which can trigger the generation and recognition of real options. **The second study** (Chapter 6) investigates the impact of three types of real options (growth option, stage option and deferral option) on the perceived value of returns. The main aim of this study is to examine whether this impact is strengthened or mitigated by IT project type.

To test the hypotheses in the model a survey under a generated web-instrument is conducted. The specific data collection technique is utilised as the main aim was to gather data about managerial behavior towards evaluation and adoption of innovative information technology projects. Based on written responses to specific questions and statements participants of the survey were asked to assess IT projects. In addition, the study had the aim to examine the relationship among specific variables. A survey based on the literature is a snap shot of views at a particular point of time regarding relationships that exist (Galliers 1992). Thus, the survey was one of the most appropriate techniques to use for this reason.

The context to test the above hypothesis was RFID technology. For this reason, the "RFID in Europe" network was utilised to distribute the specific survey. RFID in Europe AISBL is a non-for-profit organization established in 2012 with more than 300 members. It is an extension of an EU FP7 Thematic Network called RACE network RFID initiated in 2009. Aim of this network is to increase awareness for the technology and communicate RFID best practices. The participants of the survey have either been members of this network or had been contacted by members of that network. The respondents are expected to be the key personnel in their company involved in the respective RFID project they assess.

Representatives from 121 firms participated in the survey coming from 14 different European countries: Greece, Germany, Czech Republic, United Kingdom, France, Sweden, Ireland, Italy, Austria, Slovakia, Denmark, Belgium, Netherlands and Norway. A web-based questionnaire was used and distributed via e-mail to several recipients from 14 country representatives. From the 121 overall responses, 12 answers were discarded due to partial replies, resulting in 109 overall usable questionnaires.

Several statistical analysis techniques were utilised, such as Descriptive Statistics to understand the attributes of the data and the sample, Multiple regressions to examine the predictive ability of specific factors on dependent variables with the utilisation of SPSS and Smart pls software packages, Binary Logistic Regression (logit model) with SPSS to test the impact of a specific variable (perceived value of returns) on a binary one (actual adoption of an IT project), Confirmatory Factor analysis (CFA) and Structural Equation Modeling (SEM) to determine the reliability and validity of measurements as well as to examine the relationships among latent constructs (use of Smart pls version 2.0) and additional statistical tests to test differences between specific groups (e.g. Two way ANOVA , Multi Group analysis and t-tests) or Sobel tests to examine mediation. A detailed discussion on the data analysis tools is discussed in Chapter 4-Research Methodology.

1.4 **Contribution to the Literature**

Based on a critical review of three main research streams and a qualitative and quantitative approach, this thesis develops and tests empirically a theoretical framework to examine the predicting power of Real Options on the investment evaluation and adoption of information technology projects. The results of the present thesis provide support for the presented theoretical arguments and thus provide important contributions to the new stream of research (Tiwana et al. 2006; Tiwana et al. 2007; Lankton & Luft 2008; Goswami et al. 2008; Goswami et al. 2010; Fichman 2004) which investigates the behavorial implications of Real Options for the investment evaluation and adoption of innovative information technologies. More specifically:

- The present thesis extends very few previous studies on the **impact of Real Options on the assessment of information technology projects.** It studies the impact of the recognition of three real option types (i.e. growth, stage and the option to delay investments) on the perceived value of returns of information technology projects. This addresses the call for research by several scholars (Tiwana et al. 2006; Lankton & Luft 2008; Denison 2009) who have stated that there has been little research which examines *how the use of real options in capital budgeting affects managerial* *behavior and decisions*. The important issue, as it is underlined by the literature, is the fact that the studies on the intuitive judgement of Real Options are rare not only for IT but also for capital budgeting in general regardless of the type of the assessed project (technological or not). Results of the thesis support previous findings (Hult et al. 2010; Tiwana et al. 2006; Goswami et al. 2008) that growth option has a positive and significant effect on the perceived value of an assessed IT project. In addition, results of the thesis support that the option to delay IT investments is negatively perceived by managers. This finding contradicts previous studies (Tiwana et al. 2007; Hult et al. 2010) which have shown that the option to delay has a significantly positive or a non significant impact on managers' decisions. This thesis further shows that the stage option has a positive and significant impact on managerial perceptions regarding the value of an assessed IT project. The latter result comes to challenge previous findings (Goswami et al. 2010; Hult et al. 2010; Tiwana et al. 2007) which have not found a significant relationship.

- The above discrepancies with some of the previous studies' findings and the differences of results among the previous studies generated the necessity for this thesis to investigate the reasons for which these inconsistencies occur, thus investigate whether there are any moderating factors which modify the impact of real options. This thesis, to our knowledge, is the *first quantitative study* which investigates **whether the perceived impact of Real Options differs across the different types of Information Technology projects**. This aim addresses the recent call by scholars (Tiwana et al. 2006; L. C. Wu & C. S. Ong 2008) to study whether real option value varies across the different IT project types. Results indicate that the value of Real Options is perceived more significant in specific types of IT projects such as synergetic IT projects, strategic applications or technology projects which require the collaboration of supply chain partners. Findings show that the impact of Real Options diminishes in projects which operate as standalone applications, concern transactional processes and operate internally within an organisation rather than in a supply chain context. Hence, this thesis, in line with future research directions proposed by the literature (Lankton & Luft 2008), supports the need to study the impact of Real Options in IT capital budgeting rather in specific settings than as a homogeneous group of technology investments.
- In addition, the present study contributes to the IT Real Options field by empirically investigating the **antecedents of real option and in particular growth option recognition**. Although related research (Fichman 2004; McGrath & MacMillan 2000; Scarso 1996; Y. J. Kim & Sanders 2002) proposes the factors which influence the

recognition and utilization of technology options, very few studies have been conducted to measure and test empirically these factors. This study's findings support theory and show that growth options can be a source of the technology strategy characteristics (i.e. the level of strategic, sustainable and radical impact of a technology for an organisation) and organisational learning and innovative capabilities. The higher these factors the higher the possibility that managers will be able to recognise growth options embedded in an IT project. As a result, this thesis contributes to the literature by identifying after empirical testing the sources that influence the generation and recognition of growth options in IT projects.

- This thesis also contributes to the IT innovation adoption research stream in combination with the IT Real Options field with the following way. It helps better explain **how** specific organisational or technological IT innovation adoption determinants which are proposed by pertinent literature (Ramamurthy et al. 2008; Thong 1999; Rogers 1995; S. Kim & Garrison 2010; Kuan & Patrick Y.K. Chau 2001) promote or inhibit managerial perceptions for the value of an IT project. This study tests the propositions of several scholars (Fichman 2004; Scarso 1996; McGrath & MacMillan 2000) and offers empirical evidence to support that the **recognition of growth options mediates the effects** of particular IT innovation determinants (e.g. radicalness, divisibility of the IT investment) on the perceived value of an IT project and ultimately its adoption. This study extends previous work on IT Real Options (Goswami et al. 2008; Saya et al. 2010) which investigates the mediating role of real options in the relationship between other factors (e.g. institutional influences) and the IT project value or intention to adopt IT.
- The particular thesis extends very few previous studies (Goswami et al. 2008; Goswami et al. 2010) on the **behavorial implications of real options on the investment evaluation of RFID technology**. This study addresses the research call of the pertinent literature on RFID (Curtin et al. 2007) to investigate this technology by considering the managerial flexibility and the different kind of options that it can yield. This thesis showed that real options affect managerial decision making for RFID technology evaluation. A second contribution in the area of RFID technology investment evaluation and adoption is the following. Based on three real-world case studies regarding RFID implementation, this thesis proposes a classification/typology of RFID deployment based on specific dimensions (i.e. scope, purpose and span of RFID project). It also offers empirical evidence that this RFID classification moderates the impact of real options on the managerial evaluation of an RFID project. Based on the conducted quantitative study, findings show that: Strategic, platform and supply

chain RFID applications entail more significant real option value in contrast to transactional, standalone and internal RFID implementations.

- Finally, this thesis offers an analytical and critical **review on the field of the utilisation of Real Options for IT investment evaluation and adoption**. A synthesis, a critical analysis and a classification of the two main research streams (i.e. normative and intuitive) of this field to our knowledge is still lacking. This thesis has the aim to fulfill this gap and proposes future research directions for new researchers.

1.5 **Thesis Structure**

Chapter 2 presents a critical review on three main research streams: Investment evaluation and adoption of IT, Real Options analysis for the Information Technology assessment and RFID Technology. For each one of the three streams, specific research gaps are identified. Due to the aim of the specific doctoral thesis, this literature review is mainly focused on the second stream of research (Real Options for IT investment evaluation) where a detailed analysis is undertaken, while a classification framework of the pertinent previous studies is proposed. The last section of the chapter includes a synopsis of the identified research gaps for each one of the three research streams.

Chapter 3 portrays the followed Research Methodology. This chapter consists of the research objective and the initial research questions of the doctoral thesis (which are going to be refined after Chapter 4). It also contains the analysis of the followed research approach and epistemological considerations. In addition it offers a discussion of the Research Design which is followed in order answer the research questions. The Research Design is comprised of the exploratory phase of the thesis which is analysed in the next chapter and the confirmatory phase of the thesis which is going to be analysed in Chapters 5&6. A chronological reference to the overall Ph.D. research studies, which are conducted in this thesis are also included in the chapter. Chapter 3 ends with a discussion of the justification of RFID as the main context of this study.

Chapter 4 is devoted to the analysis of the three conducted case studies. The first section of this chapter refers to the case study research design including the multiple cases design, the case selection, data collection protocol and the data analysis. The next three sections consist of a within case analysis of the three case organisations respectively. We next address the cross-case findings. The last section of this Chapter includes the refined research questions based on the identified cross-case findings. The initial research questions as they were specified in the chapter of the methodology are modified and become more specific in order for us to be able to form and develop exact hypotheses in the next chapters.

Chapter 5 provides the analysis of the first part of the confirmatory phase of the doctoral thesis (Study I). This study examines the first part of the research framework depicted in Chapter 3. It specifically examines the impact of growth options on the value of returns and it investigates the factors which determine growth option recognition by managers. The chapter describes the development of the respective hypotheses based on theoretical foundations and arguments derived from literature on IT Real Options and IT innovation investment evaluation and adoption theories. Next, the followed research method which is followed to test the specific hypotheses are described. The research method refers to the data collection process, the studied context and the analysis of the exploited measures. The next section of this chapter incorporates the analysis of the results of study I including a) descriptive statistics, b) the evaluation of the measurement model and c) the testing of the hypotheses which includes the evaluation of the structural model. The last section includes a summary of findings of the study.

Chapter 6 describes study II of the confirmatory phase of the doctoral thesis. This study examines the second part of the research framework depicted in Chapter 3. It investigates the impact of three real option types on the perceived value of returns of assessed IT projects. It also examines whether or not the type of an IT project moderates the impact of these three types of real options. Chapter 6 starts with the hypotheses development based on theoretical propositions and previous studies on IT Real Options and IT classification. Next, the research method which is followed to test the formulated hypotheses is analysed. In addition, the results of this study are described in the next section including the descriptive statistics and the testing of hypotheses based on regression modeling. Next, further statistical analysis is undertaken to elaborate the results including Multi-Group analysis and ANOVA. The chapter ends with a summary of the main findings of this study.

The thesis ends with the **Chapter 7** where the results presented in the previous chapters are discussed. The main findings of the doctoral thesis and their relation with the initially proposed research objectives are presented. This Chapter provides information on how the findings have met the objectives of the specific research. Whether the thesis' findings supported or contradicted previous findings or theory is also discussed in the chapter. The next section includes the theoretical and practical contribution of the thesis. The last section refers to the limitations of the study and the propositions for future research.

At the end of the present thesis, there is also a list of appendices. **Appendix 1** is comprised of the questionnaire which was distributed to the participants of the pilot study in Greece. It also includes some indicative descriptive results which gave a picture of the main variables (i.e. real options) included in the pilot study. **Appendix 2** incorporates the main data collection instrument of the two full scale empirical studies as they are analysed in Chapters 5&6. The main differences between Appendix 1 and 2 indicate the refinement of the questionnaire from the pilot study to the full scale studies. The second part of Appendix 2 also incorporates a detailed list with the measures and the pertinent literature utilised for the data collection instrument in this study. The respective measurement scales proposed by the literature can serve as the basis for relevant future studies.

Appendices 3-5 refer to the data collection instruments and the data analysis of the three case studies which are examined in the exploratory phase of the present doctoral thesis (Chapter 4). In particular, **Appendix 3** refers to the first case study (i.e. the retailing company in the telecommunications industry). The appendix includes the questionnaire which was distributed to the employees of the specific company to gather the required data for the current (As-Is) business processes and the RFID enabled (To-Be) business processes. It also presents the cost and benefit calculations and estimations based on which the cost-benefit analysis of the RFID investment is carried out. **Appendix 4** refers to the second case study investigated in the present thesis which refers to the Supermarket Company in Greece. It is comprised of the questionnaire distributed to the end-users of the proposed RFID enabled system in order to gather data regarding the evaluation of this system. The second part of appendix 4 consists of the cost-benefit analysis of the two examined RFID enabled services: (a) promotion management service and (b) dynamic pricing service. **Appendix 5** refers to the third case study (i.e. the retailing beverage company). The first part of the appendix includes the questionnaire distributed to the employees to gather data for the NPV analysis of the RFID investment. The second part of the appendix consists of the Net Present Value analysis and the respective assumptions for the NPV calculations.

CHAPTER 1: INTRODUCTION

- Introduction to the field and Research Motivation
- Research Objective and Questions
- Research Approach
- Research Contribution
- Thesis Structure

CHAPTER 2: RESEARCH BACKGROUND ON THREE STREAMS

- IT investment evaluation and adoption
- Real Options and IT
- RFID Technology

CHAPTER 3: RESEARCH METHODOLOGY

- Research Objective & Questions
- Research Approach
- Research Design
- Ph.D. Research Studies
- Context justification

CHAPTER 4: RFID EVALUATION IN THREE CASE STUDIES

- Case study research design
- Case study analysis for three organisations
- Cross-case findings
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CHAPTER 5: FACTORS AFFECTING REAL OPTION RECOGNITION

- Hypotheses development
- Research Method
- Results
- Summary of findings

CHAPTER 6: THE MODERATING EFFECT OF THE IT PROJECT TYPE ON REAL OPTION VALUE

- Hypotheses development
- Research Method
- Results
- Summary of findings

CHAPTER 7:DISCUSSION OF FINDINGS & CONCLUSIONS

- Key findings and Discussion
- Theoretical Contribution
- Practical Contribution
- Limitations and Future Research

Figure 1.1 Thesis Structure

2 RESEARCH BACKGROUND ON THREE MAIN STREAMS: IT INVESTMENT EVALUATION & ADOPTION, REAL OPTIONS METHODOLOGY AND RFID TECHNOLOGY

2.1 Introduction

The aim of the specific chapter is to make a critical review on the previous studies in the three main research streams related to the thesis and to identify the research gaps which stimulated the motivation of this research. The first section (Section 2.2) includes a review on previous studies on "IT Investment evaluation and adoption". Section 2.3 analyses research on "Real Options for IT investment evaluation and adoption", while next section (2.4) reviews studies on the "Evaluation and adoption of RFID Technology in the supply chain". Due to the focus of this research, Section 2.3 will be analysed more thoroughly. The chapter ends with a synopsis of the research gaps identified in the previous sections (Section 2.5).

2.2 IT investment evaluation and adoption

2.2.1 IT investment evaluation studies

A variety of different innovative information technology applications have lately introduced to the organisations. However, many of these applications are very costly for companies to implement. Due to constraints regarding the budget of a company, it is very important for managers to clearly understand whether such IT investments are financially justifiable (Lee & Lee, 2011). *"….Quality with which investment decisions are made on IT projects can have a dramatic effect on an organisation….Poor investments, those that are inadequately justified or whose costs, risks, and benefits are poorly managed, can hinder and even restrict an organisation's performance……Careful and correct IT investment (or project selection) decisions are an economic and competitive necessity……*(Gunasekaran 2001)".

Due to the significance of IT justification and the companies' financial constraints, several studies have been conducted to assess the business value of IT. Based on the literature which reviews IT investment evaluation studies (Gunasekaran et al. 2006; Irani & Love 2002) there are different types of technology appraisal approaches.

(a) Economic approach

One of the most well-known and mostly utilised approaches is the economic approach which takes into consideration the financial aspects of an IT investment (Irani & Love 2002). The Net Present Value (NPV) is an example of one of the most popular economic appraisal methods. The specific approach estimates the overall value of a project based on its estimated cash flows (inflows and outflows) based on a cost benefit analysis. NPV takes into consideration the 'time value of money' and inflation. The expected cash flows (savings minus cost) of an investment are calculated for the future and discounted back to their present value. Based on whether the overall net present value of an IT investment is negative or positive, a decision for the investment is made. The NPV formula is depicted below.

$$NPV = -C_0 + \sum_{t=1}^{n} \frac{S_t - C_t}{(1+r)^t}$$

Where:

- C_0 *: The cost of the initial investment the year 0*
- r *: The risk-adjusted discount rate*
- S_t *: The savings derived from the investment the year t*
- C_t *: The cost derived from the investment the year t*
- n *: life of an investment in years*

Another example is the payback period (PP) which refers to the calculated period of time which is needed for an IT investment to 'repay' its initial cost of investment.

$$Payback\ period\ (number\ of\ years) = \frac{Initial\ cost\ of\ the\ investment}{Annual\ net\ cash\ inflow}$$

There are a lot of studies which assess IT investment through the economic approach. For example, Bottani & Rizzi (2008) examined the economical suitability of RFID technology in the supply chain for fast moving consumer goods. The technology was considered to be applied within a supply chain and for specific business processes (e.g. receiving, put away and shipping processes). The authors considered different RFID implementation scenarios based on specific attributes (e.g. type of product tagging). Based on a cost-benefit analysis of the applied technology, the authors concluded which is the most beneficial implementation. The authors are based for their analysis on specific financial variables such as: the cost of hardware, cost of RFID equipment, estimated labor savings. Another work (Brand et al. 2004) conducts a cost benefit analysis for the deployment of an intelligent transportation system program to improve commercial vehicle operations. Several variables are taken into consideration and estimated in monetary basis such as: truck transit time savings, capital and operating cost of the system.

The main benefit of the specific approach is that results which are based on financial measurements are easily comparable to respective results for other candidate IT investments. In addition, they are considered to be objective (Anandarajan & Wen 1999) as they focus on the monetary representation of the project outcome. Furthermore, due to the budget constraints, managers are keen on estimating the value of an IT investment based on monetary value. Such an estimation would clarify whether or not an IT investment can have an impact on the financial survival of a firm.

However economic approaches have a lot of **limitations**. One of the most important ones is that these approaches ignore intangible measurements which can account for a vital outcome of an appraised technology investment. Examples of these intangible variables could be the enhanced learning experience that an organisation could achieve by investing in an IT project or the more timely decisions from a new system that a manager can gain (K. C. Laudon & J. P. Laudon 2006, p.539). Under the same perspective, approaches such as discounted cash flow method have been criticised as approaches which cannot be applied to strategic investments (Eric K Clemons 1991) as they are based mainly on monetary analysis and they ignore the strategic impact that a technology investment has got. For this reason, financial models can give an application bias because transaction and clerical systems always produce more measurable tangible benefits than management information systems or other decision support systems (K. C. Laudon & J. P. Laudon 2006, p.538). Thus, there is the possibility of underestimating the value of such systems if the decision maker is based only on monetary estimates.

Another important issue is that financial models do not express the risks and uncertainty of their own cost and benefit estimates (K. C. Laudon & J. P. Laudon 2006, p.538). Although cost tends to be up-front and tangible, benefits may vary due to high levels of uncertainty such as technical adjustments, organisational resistance to change, technical problems. Uncertainty could be tackled with flexible managerial actions, such as postponing an investment in order to see how it is going to be implemented by other competitors. This kind of flexibility however, is ignored by the economic approaches. The economic approaches are based on a one-shot evaluation, without considering how specific variables (e.g. regulation, price of the technology, outcome of a pilot implementation) would give the opportunity to a decision maker to change his decisions.

(b) Strategic approach

Another approach is the strategic investment evaluation approach which considers quantitative and qualitative variables regarding the long term impact of an IT investment (Irani & Love 2002). Strategic approaches take into consideration several aspects of the IT investment such as the level of the competitive advantage that this investment would offer to an organisation, the impact of the investment on the business strategy of the company and on its research and development activities and aims. Other considerations for the strategic approach is whether the appraised IT investment improves the organisation's growth, success and its leadership in the market (Irani, 2002).

One of the most well researched frameworks which is utilised for the justification of information technology projects based on strategic considerations is the 'Strategic Alignment Model' (SAM) (Figure 2.2) which is introduced by Venkatraman et al. (1993). The authors discuss the linkages of four domains: business strategy, IT strategy, organisational infrastructure and processes and information systems infrastructure and processes. Business strategy includes decisions regarding the business scope and product offerings, IT strategy includes dimensions of IT scope such as system reliability, integration. Organisation infrastructure and processes refer to administrative business processes and the workflow, whereas IT infrastructure and processes are concerned with the IT processes, IT skills. The basic idea is that decisions in one domain will have an impact on the others. For example, a company can justify an IT investment and a change in the current information system infrastructure and processes only if this investment is aligned with the current business strategy of a firm. Under the same perspective, a new information system will require new IT skills and infrastructure which will next require a possible business process reengineering. Based on this framework decision makers can appraise an IT project based on specific strategic criteria assigned to this model. One work which deploys SAM is that of Presley (2006) who develops a model for the justification of two alternative ERP investment projects in a specific company based on the strategic alignment model. The authors quantify managerial intuitive judgment on the ERP utilisation. The authors examine what is the impact of the two ERP systems on organisational processes regarding their compatibility. Specific organisational processes are examined (i.e. materials management, production planning and control and order processing). The authors examine also how the ERP system will affect company's strategy and more specifically the differentiation of the firm, its cost and its flexibility. Specific weights are assigned to each criterion, pair-wise comparisons are made in order for the authors to reach to a conclusion.

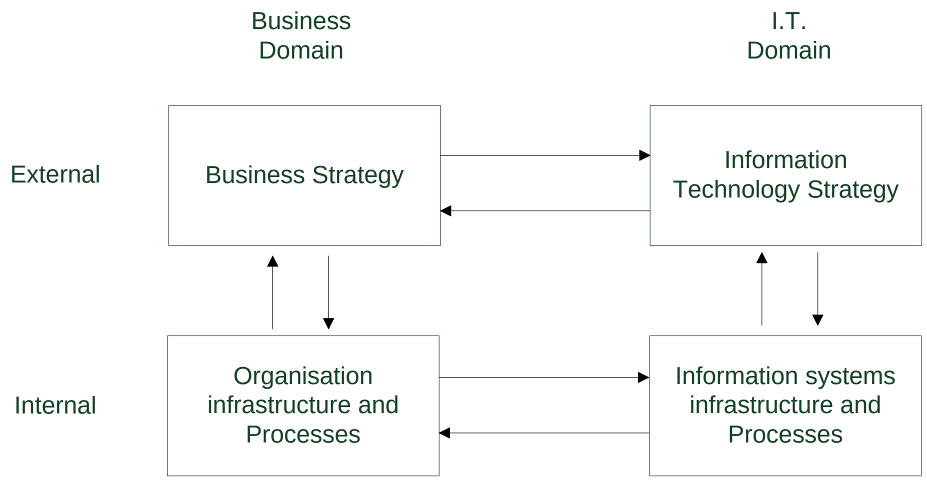


Figure 2.1 The Strategic Alignment Model (Henderson and Venkatraman, 1993)

Another study which measures the level of strategic IT alignment in a business process level is that of Tallon's & Pinsonneault's (2011). The authors based on a survey evaluate many aspects of business strategy processes including: whether activities in the organisation can support innovation, increase the pace of development and R&D, create customer loyalty and build market share. In a second part of the survey, the authors ask respondent companies to indicate the level of the IT use (high/low) in the above business strategy processes. The authors match the first with the second part in order to identify the level of IT-business alignment. Based on a seven-point Likert scale, the authors measure subjectively the above variables based on the level of companies' agreement/disagreement with specific statements. Another work which utilises a strategic approach to evaluate IT investment is that of Palvia's (1997). The author develops a model to assess the global and strategic impact of information technology. The author measures specific aspects of the information technology within companies such as: the level of the impact of IT on offering new products and services compared to competitors, the level of improvement of strategic planning in the company due to the introduction of the technology, the level of integration among the company's partners as a result of the IT implementation. In the author's paper, these aspects are measured by subjective indicators (i.e. questions) and the companies report their level of agreement/disagreement with the respective statements based on a 5-point Likert scale.

The most important attribute which is assigned to this approach is the fact that it takes into consideration the alignment between the evaluated technology investment with the business strategy of a firm which is neglected by other IT investment evaluation approaches. However, strategic approaches have got important **limitations**. In particular, the above techniques ignore the risk and time related to an IT investment (Irani & Love, 2002).

Regarding the risk, an investment may include high level of uncertainty which has to be taken into consideration when managers appraise an information technology project. To reduce risk, decision makers should be aware of the opportunity to change their decisions after a period of time based on new coming information regarding the investment (e.g. the value of the technology diminishes, the technology becomes a commodity, the regulation rules change etc.). In addition, high risky IT projects may have a greater possibility to offer high amounts of value of returns. Another disadvantage of the strategic approaches is that they do not take into consideration economic factors during the investment evaluation (Irani & Love, 2002). However, economic factors are vital for a firm and ignoring the economic impact of a technology investment can create ambiguous decision results. Another limitation is that they are based mainly on subjective measurements. An objective measurement would offer an easier and more robust way of comparison among candidate technology investments.

(c) Analytical approach

Another method of IT justification is: the analytical approach. In this approach models such as scoring models, computer-based techniques and programming techniques are utilised to consider qualitative and quantitative assessment factors (Gunasekaran et al. 2006; Irani & Love 2002).

An example of an analytical approach is the multi-attribute decision analysis method to evaluate information technology investments. Multi-attribute decision analysis takes into consideration several variables which are qualitative, quantitative, tangible or intangible. Specific 'utilities' are assigned to each one of these criteria. These utilities are the particular importance that is given to each of these criteria. One of the common utilised techniques is the Analytical Hierarchy Process (AHP), where particular evaluation criteria are identified in order to assess an investment such as IT. Specific weights are given for these criteria and pair-wise comparisons are made in order for the company to choose the best IT investment from the alternative ones.

An example of a study which utilised the AHP process to assess IT investments is that of Hallikainen et al. (2002). The authors evaluated a web content management system for a multinational company and they compared four different packages which were offered in the market from different companies. The authors defined the evaluation criteria based on IS project utilities named as returns derived from the programmes and risks. Several parameters were taken into consideration such as: ease of learning, ease of use, adaptation requirements, administration cost, administrative efficiency, technical complexity, number of links to current systems. The 'critical success factors' were assigned to specific weights and the importance of these factors was defined. The authors in order to conclude on these weights, interviewed the key company representative of the case-project. This person was responsible for making the investment approval. The representative based on a questionnaire that the authors developed evaluated the weights of the evaluator parameters and conducted pair-wise comparisons of the investment alternatives. The authors conducted sensitivity analysis in order to see how sensitive the priorities of the alternatives are to the changes of the input data (i.e. the importance of the criteria). After the analysis the authors concluded on the best alternative.

One of the most famous approaches which utilises multi attribute decision making with analytical tools is ***'Fuzzy Cognitive Mapping'*** which is an application of Artificial Intelligence technique which graphically represents state variables within a dynamical system through links that signify cause and effect relationships (Sharif & Zahir Irani 2006). These links are augmented with fuzzy or multivalent weights that are quantified via numbers or words (Sharif & Zahir Irani 2006). The main principle that forms the 'fuzzy logic' is that instead of having 'yes' or 'no' to some user-specified question, variables can be 'yes' or 'no' to some degree (Z Irani 2002).

Figure 2.3 depicts an example of an evaluation of an IT investment based on strategic (A), tactical (B), operational (C) and Financial (D) considerations. The mapping shows how the concepts are linked and affected by each other based on specific measurements: 'very much', 'not as much' etc. These measurements are assigned to particular weights. For instance the '+always' depicts that one variable would have a positive effect to another variable which equals to +1, the 'never' would have a zero effect, the 'very much' denotes that the effect would be equal to '0.750'. For example, reading in the figure the arrows from D to A means that justifying a project purely on a financial term has little effect (denoted by the 'not as much') on strategic considerations (DA-). For example, the cost of an IT investment would not have an effect on the competitive advantage that this IT would offer to a company. On the contrary, justifying a project based on the impact of IT on its operations has always a positive effect on the financial considerations because operational activities can be appraised financially as 'day-to-day operations' and can be quantified (DC+). For example, the impact of IT on the company's business operations would have a substantial impact on the labor cost which is encapsulated though financial terms. All these equations are entered into a simulation model with the aim to model these interdependencies. The simulation model runs the results are derived.

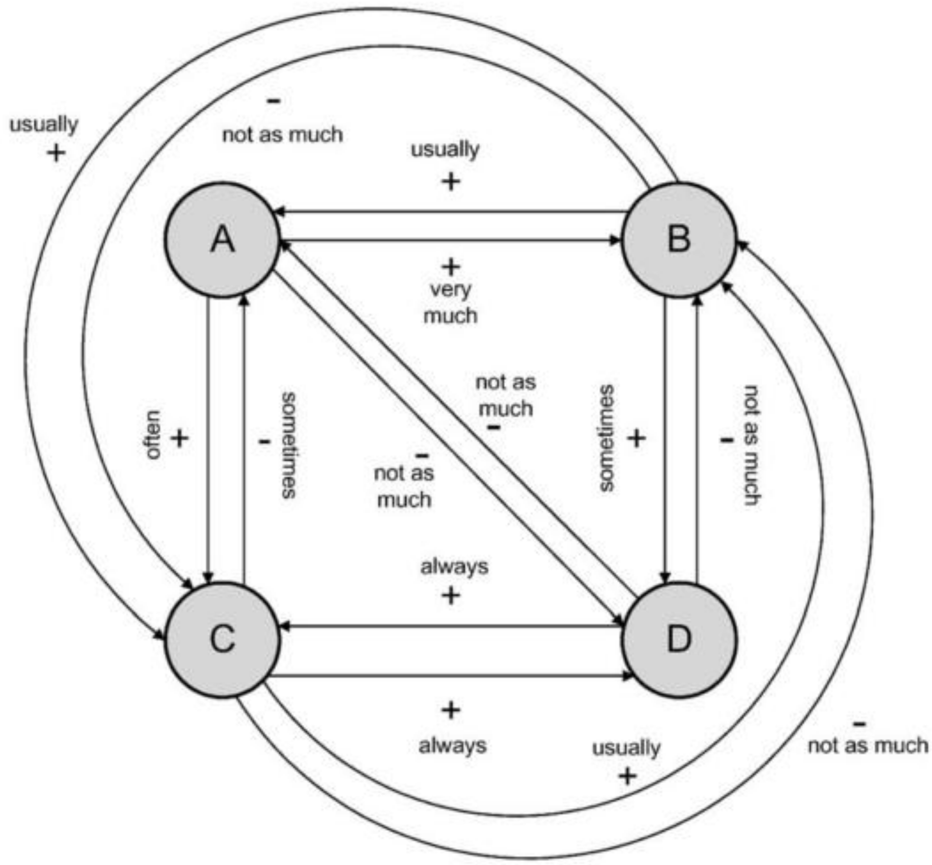


Figure 2.2 Conceptual Fuzzy Cognitive Mapping for IT investment appraisal (Zahir Irani 2002)

One study (Sharif & Irani 2006) of this approach, developed and utilised a computer-based Fuzzy Cognitive Mapping process to evaluate a Manufacturing Resource Planning (MRP) system based on the weighting of several criteria such as strategic, tactical, operational, project benefits, risks, cost, and value characteristics. The interrelationships among these criteria are modeled trough fuzzy mapping. Another study (Chung & Skibniewski 2007) made a justification of an ERP system based on fuzzy cognitive mapping. The authors assigned weights to specific evaluation criteria such as: software cost, strategic impact of ERP, improved data management, real time and accurate information. They next indicated how these criteria are interrelated.

The main benefit of the analytical approach is the fact that it takes into consideration several qualitative or quantitative variables into one common model in order to evaluate an IT investment. However, the **limitation** is the fact that the whole assessment is based on subjective measurement and weights which makes difficult the comparison among the several appraised technology investments. Another limitation is the fact that the specific approaches are quite challenging to be deployed as they require the need to explore complicated relationships among variables and in order to be put into force they require complicated software programming facilities.

(d) Hybrid approach

Due to the several limitations of each one of the above evaluation approaches, studies on IT assessment have utilised hybrid approaches with the aim to combine the above techniques. These studies utilise **integrated approaches** which combine subjectivity with structure and they use techniques which integrate financial, quantitative and qualitative variables through tools such as: Multi-attribute decision making, weighting factors (Irani & Love 2002). For example, Apostolopoulos & Pramatari (1997) in their study present and analyse a justification process for the installation of a telecommunications and data network for the Hellenic Aviation Industry. In their work they have utilised an integrated approach with financial variables (e.g. development cost, operational-maintenance cost) and technical evaluation criteria (e.g. reliability, security, ease of use, response time). Another study (T.-Y. Chou et al. 2006) combines the multi-criteria decision modeling with fuzzy approaches to evaluate an IT investment. What is important is the fact that the authors underline that only a software worksheet such as Excel is required for the calculations. The authors assign to several criteria specific weights, based on expert team's evaluations. Another work (Small & I. J. Chen 1997) based on survey concluded on that firms which use hybrid justification approaches which include both economic and strategic justification techniques were found to attain higher levels of success from these advanced manufacturing technology projects than the ones which have utilised only one method.

The table below summarises the limitations discussed above for each one of the IT investment evaluation approaches and it includes an introductory explanation on how real options methodology deals with these limitations. A detailed analysis of the Real Options approach will follow in one of the following sections (2.3) of this chapter.

Table 2.1 Real Options Vs other IT investment evaluation approaches

Approach	Limitations	How real option approach tackles these limitations
Economic approach	The approach does not take into consideration uncertainty of the IT investments.	It takes into account the risks and the uncertainty embedded in IT investments by measuring 'volatility' of the investments.
	Lacks considering managerial flexibility	The approach takes into consideration flexibility through the exploitation of options (e.g. option to postpone an IT investment in order to minimise loss). A manager has the choice to exercise or not a real option. This kind of flexibility can diminish the existing uncertainty.
	Focuses on tangible, monetary variables ignoring intangible	Although Real Options approach is an extension of the NPV approach it can incorporate strategic

	measurements such as the strategic aspect of an IT investment.	considerations such as the growth opportunities of the assessed IT project.
	Treats investments as short-term and now-or-never decisions (Kogut & Nalin Kulatilaka 1994).	Does not consider IT investment as a one-shot but as a dynamic evaluation process. This process takes into consideration new information derived from the organisation itself or its environment (e.g. prices of the technology in the future, outcome of a pilot implementation, growth opportunities of an IT infrastructure)
Strategic approach	Does not take into consideration risk (Z Irani & P. E. D. Love 2002)	Takes into consideration uncertainty and risk through estimating the 'volatility' of the returns of an IT investment. Tackles uncertainty through the flexibility that has a manager to exploit or not different types of real options.
	Does not take into consideration 'time' (Z Irani & P. E. D. Love 2002). However, time has an important impact on managerial decisions for an IT investment due to the changing environment of the organisation related to the IT.	Real Options approach takes account of time in the investment evaluation process as the level of exercising a real option.
	Not accounting for economic factors (Z Irani & P. E. D. Love 2002)	Takes into consideration economic factors (value of returns, cost of the investment, volatility of the expected value of returns)
	They are based on subjective measurements which may make difficult the objective comparison among candidate IT investments.	It is based on objective measurements (i.e. value of returns, volatility of the value of returns, risk, and time).
Analytical approach	Too complex to be conducted (programming basis, multi-attribute analysis)	Less complex due to the fact that it is based on a specific logic and its parameters are basically economic.
	They are based mainly on subjective measurements.	Based on objective measurements (i.e. value of returns, volatility of the value of returns, risk, time)

Research Gap on IT investment evaluation studies

As it is summarised in the above table, although the discussed IT justification approaches are significant for the decision making they have some important limitations which form several literature gaps and room for future research. In particular, several economic methods such as the Discounted Cash Flow (DCF) model have been criticized as inappropriate for evaluating investments with uncertain future cash flows and irreversible sunk costs, because they do not take into consideration the inherent flexibility of such investments. The current financial justification methods are inadequate to deal with IT investment issues (Gunasekaran 2001). Owing to the dynamic factors inherent in innovative IT investments, their evaluation cannot be a single one-off evaluation procedure (Gunasekaran 2001). Traditional evaluation approaches ignore management’s flexibility regarding investment decisions as they assume that once a project is approved all the cash flows will automatically take place (MacMillan et al. 2006). However, studies in the pertinent field have underlined the necessity of taking into consideration managerial flexibility during justification of IS projects. For example, studies have shown that managers when evaluating high-risk projects need to take into consideration managerial flexibility during assessment in order to determine to what extent the assessed IT project can be delayed or not in order to resolve current uncertainties or wait for the technology to be more mature (Joshi & Pant 2008).

Regarding the strategic approaches, there is a lack of considering the risk and time related to an IT investment (Irani & Love, 2002). In order to minimise the risk inherent in IT investments, decision makers should take into consideration the opportunity to alter their decisions based on new coming information (e.g. refined regulation, evolution and level of maturity of the technology). A decision maker for example can postpone its strategic decision to invest in an IT project at a later point of time in order to take advantage of a technology's cost decrease. Another important issue is that strategic IT approaches do not take into consideration economic factors for the investment evaluation (Irani & Love, 2002) although they are vital for the viability of a firm. Finally, analytical approaches are based on complex and subjective measurements which make IT justification more difficult to be accomplished.

Finally, an important research gap which is derived from the above literature is the fact that the majority of the current investment evaluation studies consider IT project as a homogeneous group, although each type of IT investments has individual characteristics. *"The 'quest' for one best method is proving fruitless….A major improvement of IS evaluation lies in matching the methods to characteristics of the IS investment…The project characteristics affect the way in which an investment decision is made and indicate which of the alternative appraisal techniques might be more suitable for a particular project (Farbey 1999)".* As a result, the suitability of the above IT investment evaluation approaches depends on the attributes of the assessed IT project. Although some theoretical works and propositions have been made on this "matching problem", still pertinent empirical studies lack researchers' attention creating a fruitful room for future research.

Table 2.2 Research Gap on IT investment evaluation studies

Quotations	Research Gap
The current financial justification methods are inadequate to deal with IT investment issues (Gunasekaran 2001) *"When uncertainty and irreversibility are high, omitting the value of managerial flexibility can lead to substantial understatement of the value of investments in new IT* (Fichman 2004; Dixit & Pindyck 1994). *Owing to the dynamic factors inherent in IT investments, evaluation must be regarded as a continuous process which needs to be constantly reviewed. It cannot be tenable to justify a policy proclaiming a single one-off evaluation procedure (Gunasekaran 2001).*	Conduct empirical studies for the investment evaluation of Information Technologies by: -Embedding the variable of managerial flexibility and -Considering the evaluation process as a constantly reviewed process and not a single-one off evaluation procedure.
The 'quest' for one best method is proving fruitless….A major improvement of IS evaluation lies in matching the methods to characteristics of the IS investment….The project characteristics affect the way in which an investment decision is made and indicate which of the alternative appraisal techniques might be more suitable for a particular project" (Farbey 1999)	Rare consideration and empirical research have been made for **matching** an investment evaluation method with a particular IT investment. Consider the individual characteristics of each type of Information Technology and match them with IT evaluation approaches.

2.2.2 IT adoption studies

"The stage of gathering information and evaluating information about technology innovations is followed by the adoption stage where a decision is made about making use of the technology innovation (Thong 1999)". In order for firms to justify a technology adoption, it is important to understand the factors that lead to such a decision.

There is a wide field in the literature which focuses on the examination of determinants which affect a firm's decision to adopt an innovative information technology application. Previous studies have mainly utilised two theoretical backgrounds. The first is the Diffusion of Innovation Theory (DOI) introduced by Rogers (1995) who is focused on the attributes of innovation (i.e. relative advantage, compatibility, complexity, trialability and observability) as the driving forces of its adoption. The second background theory is Tornatzky's and Fleischer's (Tornatzky & Fleischer 1990) "TOE framework", according to which: there are three main elements which entail variables that influence firm IT innovation decision and adoption: the technological, the organisational and the environmental context. Previous empirical research on IT innovation has examined factors which are derived from these three areas. In particular, determinants from the first area which refer to the assessed technology have been examined such as: the perceived direct or indirect benefits derived from the technology implementation (Kuan & Chau 2001), interoperability and interconnectivity of the technology itself (Chau & Tam 1997), technology competence (Zhu & Kraemer 2005), relative advantage, complexity and compatibility of the assessed innovation (Rogers 1995; Thong 1999; Ramamurthy et al. 2008). As far as the second context is concerned, several organisational parameters have been empirically tested for their impact on IT adoption such as: organisational size (G. Lee & Xia 2006; Zhu & Kraemer 2005; Thong 1999; Pan & Jang 2008), technological knowledge (Kuan & Chau 2001; Kim & Garrison 2010), organisational financial resources and commitment (Chwelos et al. 2001; Zhu & Kraemer 2005) IT deployment capability (C. Zhang & J. Dhaliwal 2009), top management/organisational support (Grandon & Pearson 2004). Regarding the third context, factors from a firm's environment are examined for their impact on IT adoption, such as: external pressure from competition and partners (Iacovou et al. 1995; Frambach & Schillewaert 2002), dependency on trading partners (Chwelos et al. 2001; Chang et al. 2008), network externalities (Frambach & Schillewaert 2002), regulations (Zhu & Kraemer 2005; Pan & Jang 2008), institutional pressures (D. Henderson et al. 2012).

<u>Research Gap on IT adoption studies</u>

Although previous studies on IT adoption offer a significant understanding on the adoption decision process, they rarely address the impact of managerial flexibility (i.e. real options) on managerial decisions. Based on the literature, this flexibility includes value which if not considered may underestimate investments. Literature refers to the fact that there is room for future research regarding the "*understanding of 'how' organisational, environmental or technological factors influence decision process for IT innovation* (Goswami et al. 2008)". In this case, managerial flexibility with the form of options could be a variable which can be investigated for its mediating role between the examined from the literature IT innovation determinants and the IT adoption. *"Future research can be directed towards designing empirical studies to gain a better understanding on the role of Real Options in organisational adoption of IT innovation* (Goswami et al. 2008; Goswami et al. 2010)".

Table 2.3 Research Gap on IT firm adoption studies

Quotations	Research Gap
"Little is known of how managers' understanding of factors external to the organization, the technology and the organizational context influences the decision process leading to IT adoption (Goswami et al. 2008)	Investigate the role of managerial flexibility as an additional factor or a mediating factor which influences IT adoption
"Future research can be directed towards designing empirical studies to gain a better understanding on the role of Real Options in organisational adoption of IT innovation (Goswami et al. 2008; Goswami et al. 2010)"	Examine the impact of Real Options on organisational adoption of IT innovation

2.3 **Real Options evaluation for Information Technology projects**

Managerial flexibility (which is identified in the two previous literature streams as a necessity in IT justification and adoption studies) has been taken into consideration and analysed through Real Options Methodology. As a result of the recognized drawbacks of the traditional evaluation methodologies (e.g. NPV approach), Real Options (RO) analysis has been suggested as a promising alternative justification approach which takes into consideration the flexibility of such investments as a way to confront several risks and uncertainties. "A project embeds Real Options when it offers management the opportunity to take some future action in response to events occurring within the firm and its business environment" (Benaroch & Kauffman 1999). These opportunities and actions are signified by the Real Option types. Common types of options include the option to expand a project (so as to capture additional cash flows from such growth), the option to terminate the project that is doing poorly (in order to save cost) and the option to delay a project (with the aim to wait until more information is acquired) (Turban & Volonino 2010). According to the pertinent literature, these opportunities create an "option value" for a project such as an IT investment, thus it is important to be taken into consideration during justification. In contrast to the traditional evaluation methodologies, which focus on a now-or-never decision, Real Options analysis promotes a dynamic evaluation approach for the IT investment justification that properly reflects the value of managerial flexibility in project execution (Fichman 2004).

Prior research in the Information Systems (IS) field (Dos Santos 1991; Benaroch & Kauffman 1999; Taudes 1998; Tiwana et al. 2007) has applied Real Options analysis to IT justification while recognizing its importance. Although there have been previous efforts (Angelou & Economides 2005; Tallon et al. 2002; Alleman et al. 2008) to review this research area, there has been no attempt to synthesize and compare the conclusions and the gaps of the two main differentiated research streams (i.e. normative and intuitive studies). The normative studies employ formal option pricing formulas to justify IT investments, whereas intuitive studies are based on managers' perceptions regarding the Real Options value of investments. These two main streams indicate two different IT justification approaches through the use of the Real Options analysis. They include different perspectives, goals and processes, while introducing diverse gaps and opportunities for further research.

Thus, the aim of this section is to elicit the current state of research in the Real Options IT justification field by synthesizing these two research approaches in order to highlight the main findings and open research issues. In addition, this study classifies and analyses the literature based on the option types, in order to highlight under-researched areas regarding the option types and examine their applicability in the IT field.

The review of 64 articles published between 1990 and 2012 in top academic journals reveals that the majority of research focuses on the normative Real Option value of the examined IT projects, whereas the intuitive stream of research is under-explored and significant qualitative parameters are rather neglected. Furthermore, while the IS literature calls for research on IT "artifacts" rather than IT in general (Orlikowski & Iacono 2001), up-to-now the great majority of studies applying Real Options in the IT field treats IT projects as a homogeneous group rather than looking at individual features or types of IT projects. Further findings and open research issues are discussed in the following sections.

2.3.1 General concepts on IT Real Options

2.3.1.1 *From traditional evaluation approaches to the Real Options approach*

New information technologies emerge as candidate investments for several companies. Since some of these technologies do not occur as necessities for organizations, they become subject to investment evaluation processes in order to be justified. As a result of the recognized limitations of the traditional evaluation methodologies (e.g. NPV approach), Real Options analysis has been suggested as an alternative approach which takes into consideration the flexibility of such investments as a way to confront several risks and uncertainties. Flexibility can be defined as the "Ability to respond or conform to a changing or new situation in a variety of ways" (R. Kumar 1999), whereas "Uncertainty is an investment's risk or volatility in cash flows that results from the inability to predict behaviours related to economy, market, technology or organisation" (Lankton & Luft 2008:217). Through Real Options, decision makers can reduce risk by changing their investment decisions as new information in terms of prices, costs and other market conditions becomes available (Y. J. Kim & Sanders 2002).

This flexibility can be signified through several options that occur for an investment decision. The Real Options approach tends to incorporate the value of these kind of options because it assumes that investment projects can be stopped, put on hold, redirected or postponed (MacMillan et al. 2006). For example, should the results of a first-stage investment occur to be unfavorable, a manager can abandon or reduce the scope of the following second-stage projects (Dos Santos 1991). On the contrary, traditional evaluation approaches, such as NPV, neglect the value of these options and do not take into consideration management's flexibility regarding investment decisions as they assume that once a project is approved all the cash flows will automatically take place (MacMillan et al. 2006). Traditional approaches treat investments as now-or-never type decisions. If such options are available but are not considered during the investment assessment, then the investment will be undervalued (Dos Santos 1991).

Another limitation of utilizing traditional approaches for the justification of initial investments in IT is the fact that they do not take into consideration the benefits that can be created in the form of future investment opportunities (Dos Santos 1991). For example, the NPV approach takes into consideration the short-term monetary payoffs of an initial investment, ignoring the value of possible long-term payoffs or second-stage investments that this initial investment can result in (Kogut & Nalin Kulatilaka 1994). On the contrary, Real Options valuation is based on the logic that "the cash flows of many investments consist of the income from the assets in the current use plus a growth option to expand in new markets in the future (Dos Santos 1991)".

2.3.1.2 *Different views of Real Options*

To address the above limitations of the traditional evaluation approaches, Myers (1977) introduced the term "Real Options" and proposed its utilization for the valuation of non-financial/real investments. Real Options analysis comes from the Finance field and it extends Option Pricing modeling into the real world. In the field of Finance, options refer to financial assets. An investor pays a certain premium (i.e. option price) to acquire an option. This option gives the right but not the obligation for the investor to buy a certain amount of stock at a given price (i.e. choice of exercising the option in the exercise price) after a given time period (i.e. the time to expiration). At the time of expiration, if the actual stock price is higher than the exercise price the investor will exercise the option by buying the amount of the stock at the exercise price and possibly earn a profit, otherwise it will abandon the option and only lose the premium (Su et al. 2009). Real Options are those in which the underlying asset is a real and not a financial asset (Amram & Nalin Kulatilaka 1999). Real Option gives the right but not the obligation to take a specific decision (e.g. invest, defer or alter) regarding the underlying real asset investment.

Real Options have been introduced as a dynamic decision making process and have been regarded and defined in the literature in multiple ways. It can be considered as a strategic tool to evaluate and justify business project investments (Dos Santos 1991; Trigeorgis 1996; Benaroch & Kauffman 2000; Kim & Sanders 2002). For example, RO-based financial models or qualitative models can be deployed to evaluate an IT project. Alternatively, the asset/ investment itself can comprise options (McGrath et al. 2004). For example, one initial investment has growth options to create future investments. In addition, in the literature it is shown that Real Options is the response (management action) or the future choices to the risk of an investment (Angelou & Economides 2009; Trigeorgis 1993). For instance, if one technology creates knowledge barriers (risk) to an organization, then the manager can have the option to stage the investment rather than implementing it in a full-scale way. Finally, in some cases (McGrath et al. 2004; Kogut & Nalin Kulatilaka 1994; R. L. Kumar 2002) Real Options are studied as a strategy/ way of thinking. For example, companies can implement a sequential-incremental investment strategy for their IT investment portfolio. According to the theory, the higher the uncertainty level of an investment, the higher the option value.

2.3.1.3 *Research on the application of Real Options to IT justification*

A number of researchers (Dos Santos 1991; Benaroch & Kauffman 1999; Taudes 1998; Tiwana et al. 2007) have applied Real Options theory for Information Technology justification. Table 2.3 includes representative journals which have published more than one article from 1990-2012 on the IT Real Options. The majority of the papers have been published in the Journal of Management Information Systems (JMIS).

Table 2.4 Journals which published more than 1 article on IT Real Options

Journal of Management Information Systems (JMIS)	12
MIS Quarterly (MISQ)	3
IEEE Transactions on engineering management	3
Decision sciences Journal (DSJ)	2
Information and Management (I&M)	2
Decision support systems (DSS)	2
California Management Review (CMR)	2
Information Systems Research (ISR)	2

Telematics and Informatics	2
Telecommunications Policy	2
Research Technology Management (RTM)	2
Management Science (MS)	2
The journal of Systems and Software (JSS)	2
International Journal of Project management (IJPM)	2

Figure 2.2 depicts the number of articles published (in journals) on the subject of IT Real Options, which has increased during the last period 2006-2012, demonstrating a growing interest on this subject.

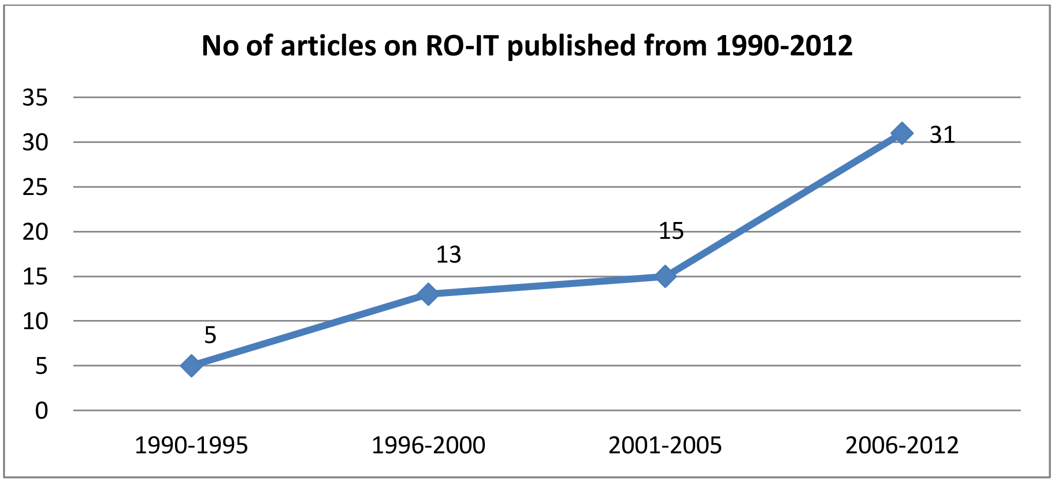


Figure 2.3 The number of published articles on IT Real Options (from 1990-2012)

As it is shown on Figure 2.3, the majority of the articles are empirical *[i.e. research based on observations* (Alavi & Carlson 1992)] as they apply Real Options approach to IT applications and conclude on specific results based on case studies, experiments, surveys and field studies. In this class, the development of mathematical models and their application to specific case studies prevails. Finally, the conceptual articles [i.e. research based on *ideas, frameworks and speculation rather than on systematic observation* (Alavi & Carlson 1992)] discuss mainly ideas and frameworks regarding the utilization of Real Options approach to IT investment decisions.

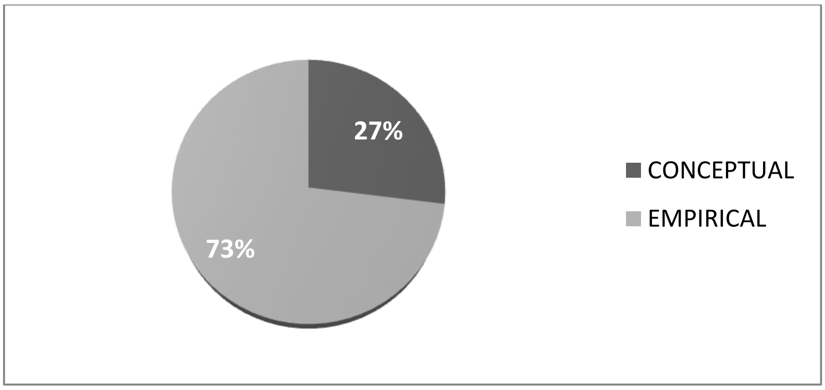


Figure 2.4 Conceptual and Empirical articles on IT Real Options published in journals from 1990-2012

The table below shows representative authors who have published research on Real Options and Information Technology.

Table 2.5 Representative authors having published on IT Real Options

Author	No of papers	Journals	University
Benaroch	8	MISQ, JMIS, ISR	Whitman School of Management, Syracuse University, USA
Angelou &Economides	5	JORS, Communic.Policy, Telematics & Informatics	University of Macedonia, Greece
Kauffman	6	MISQ, CAIS, ISR,ITM,JMIS	W. P. Carey School of Business, Arizona State University (ASU), USA
Keil	4	DS, CMR, Account.mgt and IT	Georgia State University, USA
Clemons	3	CACM, JMIS	The Wharton School of the University of Pennsylvania, USA
Fichman	3	ISR, CMR, DS	Boston College , Carroll School of Management, USA
Tiwana	3	DS, CMR	University of Georgia, Terry College of Business, USA
McGrath	2	AMR, RTM	Columbia University, USA
Taudes	2	MISQ, JMIS	Vienna University of Economics and Business, Austria
Dos Santos	1	JMIS	University of Louisville,USA
Trigeorgis	1	QREF	University of Cyprus, Cyprus

Due to the growing interest of the IT Real Options and the acknowledged significance of this approach, there have been insightful review studies (Angelou & Economides 2005; Tallon et al. 2002; Alleman et al. 2008) on this area. However, these studies do not consider at the same time the two different main research streams (i.e. the intuitive and the normative). Their main focus is on the normative stream of research and the application of option pricing formulas to specific IT applications. This section of the thesis has the aim to classify and discuss these two different research streams and underline open issues for further research.

2.3.2 IT Real Options Taxonomy

2.3.2.1 *IT Real Options Taxonomy by Option Type*

Prior research (Trigeorgis 1993; Benaroch 2001) has classified the types of Real Options into two major categories: i) Growth and ii) Operating. Research on IS has incorporated both of the above categories of options in IT investment decisions.

Growth options: Several studies in the IS literature examine this type of option. In these studies, an early IT investment is seen as a prerequisite or a link in a chain of interrelated projects opening up future growth opportunities (Trigeorgis, 1993:204). The cost of the initial investment is viewed as the premium that a company is willing to pay to buy the option to invest in other related investments in the future. Dos Santos (1991) presented how an Option pricing model (Margrabe 1978) can be used to justify an initial investment in an integrated services digital network (ISDN) technology which can lead to future second-stage investments. Taudes (1998; Taudes et al. 2000) through RO models justified the introduction of a software platform because it could open the door to other follow-on projects, such as e-commerce and electronic data interchange (EDI). Panayi & Trigeorgis (1998) assessed a Telecommunications IT infrastructure in Cyprus and concluded that options valuation can justify such strategic investments even if NPV suggests otherwise (Panayi & Trigeorgis 1998:675). The pertinent literature has suggested that a growth IT option can be a result of several factors such as: high synergetic effects among the IT projects in a company, high level of modularity of the technology investments or a result of learning processes (Scarso 1996).

One of the main conclusions of the above studies is the fact that taking into consideration the growth option of an IT investment can reveal an additional value driver of this investment. Otherwise the IT justification can underestimate the value of an appraised IT project.

Operating options: This type of option has been also studied by several researchers in the IT field. “Operating options” give management the opportunity to adapt traits (timing, scale) of an investment to unforeseen conditions (Benaroch 2001:429). Several studies (Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Campbell 2002) have assessed the value of the option to defer an IT investment, which is one example of an operating option. The question behind this kind of option is rather “when to invest?” than “whether or not to invest” (Taudes et al. 2000). The above authors (Benaroch & Kauffman 2000) using option pricing formulas estimated the optimal period of years to defer the investment in an ATM banking network infrastructure. Other types of operating options such as abandon or change the scale (expand or contract) of an IT investment have been examined in other research papers (R. L. Kumar 2002; L. Wu et al. 2008; Benaroch 2002; Benaroch 2001).

Other researchers (Whang 1992; Eric K Clemons & Weber 1990) have evaluated IT projects by taking into consideration other kinds of operating options such as the option of a company to “outsource” the development of the evaluated project or “lease” the resources for this development. In this way, the company can transfer the associated risk or avoid committing internal resources (Yeo & Qiu 2003). Another type of option which has been considered in the IS field (Herath & Herath 2008) is the “learning option”. Investing in a project can be used to create an opportunity for a company to learn. For example, a firm can initiate a pilot IT project and based on the outcome of this first stage it can learn about the environmental variables (e.g. customer demand, investment cost) and react respectively (e.g. abandon or continue the investment in this project).

The above studies have shown that exercising operating options, thus assessing IT projects rather as a process of continuous monitoring of the business and technical environment than as a now-or-never decision can offer benefits and save costs for a company (Scarso 1996; L. Wu et al. 2008). For example, studies (Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Angelou & Economides 2009; Clemons & Gu 2003; Campbell 2002) have shown that “waiting before investing” or dividing an investment into several stages, could yield additional benefits by providing time for rectifying some of the uncertainties about the project.

It is important to underline the fact that the above options can overlap with each other. For example, an IT investment which can be divided into several stages (stage option) can offer the opportunity of the “learning-by-doing” (Benaroch 2001) from each stage of the investment and consequently result to a learning option.

The table below includes the discussed types of options, their definitions and some examples of the IT applications where Real Options are exploited by the pertinent IS literature.

Table 2.6 IT Real Options and pertinent literature

Real Option types	Definition in the IS sector	Example of IT Real Options/applications used in the studies	Pertinent literature in IS
Growth	An initial investment opens the door for potential follow-on IT investments (Taudes et al. 2000; L. Trigeorgis 1996).	An initial investment in a software platform can offer future follow-on investments (e.g. EDI-based invoicing, web-based e-commerce systems; IT platforms e.g. Infrastructure platforms, e.g. wireless networking , enterprise application platforms e.g. ERP, (Taudes et al. 2000; Fichman 2004), telecommunications IT infrastructure (Panayi & Trigeorgis 1998)	(Alleman et al. 2008; Angelou & Economides 2005; Angelou & Economides 2008a; Angelou & Economides 2008b; Angelou & Economides 2009; Bardhan et al. 2004; Benaroch et al. 2006; Clemons 1991; Dai et al. 2007; Dos Santos 1991; Fichman 2004; Fichman et al. 2005; Keil & Flatto 1999; Kim & Sanders 2002; Kulatilaka & Venkatraman 2001; Kumar 1996; Lankton & Luft 2008; Panayi & Lenos Trigeorgis 1998; Pendharkar 2010; Taudes et al. 2000; Taudes 1998; Tiwana et al. 2006; Tiwana et al. 2007; Wu et al. 2008; Wu et al. 2008; Yeo & Qiu 2003)
Abandon	Dispose of an unprofitable project and redeploy remaining project resources (Brach 2003; Fichman et al. 2005)	Due to regulatory issues, a firm decides to abandon the investment in an Internet sales channel.	(Angelou & Economides 2005; Benaroch 2001; Benaroch 2002; Fichman et al. 2005; Keil & Flatto 1999; Kim & Sanders 2002; Kumar 2002; Pendharkar 2010; Scarso 1996; Schwartz & Zozaya-Gorostiza 2003; Tiwana et al. 2006; Tiwana et al. 2007; Wu & Ong 2008; Wu et al. 2008)
Stage	Break up an IT investment into incremental, conditional steps-stages (Brach 2003).	Instead of a full-scale investment in an IT security system, the investment is broken up into several projects that are undertaken after resolving uncertainty (Herath & Herath 2008)	(Angelou & Economides 2005; Balasubramanian et al. 2000; Y.-S. Chen et al. 2009; E.K. Clemons & B. Gu 2003; Fichman et al. 2005; Hemantha S. B. Herath & T. C. Herath 2008; Hilhorst et al. 2008; M Keil & Flatto 1999; R. L. Kumar 1996; Scarso 1996; Tiwana et al. 2006; Tiwana et al. 2007)
Switch	An asset developed for one purpose can be redeployed to serve another purpose (Fichman et al. 2005)	Reuse the resources of one Web-sales system for other purposes e.g. for Intranet	(Angelou & Economides 2005; Fichman et al. 2005; Keil & Flatto 1999; Kim & Sanders 2002; Scarso 1996; Tiwana et al. 2006; Tiwana et al. 2007; Wu & Ong 2008)
Deferral	Postpone an investment up to “t” time (e.g. years) and wait until further information reduces market uncertainty (Benaroch 2001; Brach 2003)	A company delays its investment in a POS debit services for an electronic banking network to resolve any uncertainties.	(Angelou & Economides 2005; Angelou & Economides 2008a; Angelou & Economides 2009b; Balasubramanian 2000; Benaroch 2002; Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Benaroch 2001; Benaroch, Lichtenstein, et al. 2006; Campbell 2002; Fichman et al. 2005; Harmantzis & Tanguturi 2007; Keil & Flatto 1999; Kim & Sanders 2002; Kumar 2002; Lankton & Luft 2008; Lee et al. 2009; McGrath 1997; Pendharkar 2010; Scarso 1996; Schwartz & Zozaya-Gorostiza 2003; Tiwana et al. 2007; Wu & Ong 2008; Li & Johnson 2002)

Scale	The allocated resources (e.g. budgets, personnel, HW,SW) in an IT investment can be contracted or expanded (Fichman 2004)	Due to high risk of the customer demand, a firm can contract one investment in a Web Sales channel and use it only to support e-ordering and e-payment.	(Angelou & Economides 2005; Benaroch 2001; Benaroch 2002; Fichman et al. 2005; Keil & Flatto 1999; Kim & Sanders 2002; Kumar 2002; Kumar 1999; Panayi & Trigeorgis 1998; Scarso 1996; Tiwana et al. 2006; Tiwana et al. 2007; Wu & Ong 2008; F. Wu et al. 2008)
Compound	IT investment involves two or more of the above options (Benaroch 2002)	An ERP system implementation is divided in stages (option to stage) and if the first stage is favorable, then the company decides to include additional modules in the next phase (growth option).	(Benaroch 2002; Panayi & Lenos Trigeorgis 1998; Angelou & Economides 2008a; Angelou & Economides 2005; Benaroch et al. 2007; F. Wu et al. 2008; Angelou & Economides 2008b; Özogul et al. 2009; Pendharkar 2010)
Learning	Investing in operating options can be used to create a window for education and learning. (Yeo & Qiu 2003)	A second-stage investment in an IT Security System is undertaken depending on what is learned in the first stage project/investment.	(Angelou & Economides 2005; Herath & Herath 2008; Kim et al. 2009; Scarso 1996; Wu & Ong 2008; Yeo & Qiu 2003)
Lease	"IT investment resources can be leased and if information arriving during the investment life signifies that the expected revenues are low, then the next lease payment can be avoided". (Benaroch 2002)	A company can lease the software for its accounting IT system from another company.	(Eric K Clemons 1991; Eric K Clemons & Weber 1990)
Outsource	IT investment can contracted to a third party/outsourcing company, in order to transfer the risk of the cost of an in-house deployment(Benaroch 2002)	Due to the in-house software inability, a company has the option to outsource the software construction, to a third party .	(Whang 1992)

Discussion

The majority of the studies focus on the above mentioned option types in order to find the optimal investment decision for one IT project with the aim to magnify the profitability of a firm. However, to our knowledge there has been no attempt by previous research to incorporate the types of options into the IT investment management for other purposes, such as for environmental ones. For instance, a switch option can give the opportunity for a company to reuse the resources utilized for one information system to cover the resource requirements of another system similar to the old one. This opportunity can save resources and have a positive impact on the environment. Future research can study and focus on this aspect.

Under the same perspective, there is limited research (R. L. Kumar 2002; T. Chen et al. 2009; Benaroch, Lichtenstein, et al. 2006; Benaroch 2001; Benaroch 2002; Benaroch et al. 2007) on utilizing growth and operating options for risk management and alleviation. Benaroch et al. (2006) argue that the types of options can be considered as ways to mitigate specific risks of an IT investment. Rather than considering the kind of options that one investment encompasses, future studies can consider what options one investment should entail in order for a company to deal with the embedded risks. Further research can conclude on a formal validated framework which supports the mapping of the risk mitigations to specific types of options, in order to minimize the subjectivity of this process (Benaroch, Lichtenstein, et al. 2006).

In addition, there are a lot of opportunities for further research on other Real Option types (other than growth and operating options) which are neglected by the majority of the literature dealing with IT justification. Examples of these types of options are the “learning options”, “lease options” or the “outsource options”. Future research can extend previous work (Herath & Herath 2008; Clemons & Weber 1990a; Whang 1992) by modeling and evaluating these kinds of options for the case of IT investments.

Another point to note is that prior studies have focused on one category or type of Real Options that an IT project encompasses, whereas in the real environment typical IT investments (Angelou & Economides 2005) incorporate multiple interactive options (Özogul et al. 2009). Future research can extend previous work (Hemantha S B Herath & Park 2002; L. Wu et al. 2008; F. Wu et al. 2008) on justifying IT investments through the evaluation and the modeling of multiple, compound options. Interesting results can be shown when examining possible interactions among the different options.

The great majority of studies applying Real Options in the IT field treat IT projects as a homogeneous group rather than looking at individual features or types of IT projects. However, different types of IT projects might carry differential option value (Tiwana et al. 2006; L. C. Wu & C. S. Ong 2008; X. Li & Johnson 2002). For example, prior research (Fichman 2004; Taudes et al. 2000; Q. Dai et al. 2007) suggests that platform IT investments (e.g. ERP, wireless networking, infrastructure investments) are very good candidates for growth opportunities. Li & Johnson (2002) have shown in their normative study that “shared IT projects” (i.e. open standard technologies, e.g. Wireless Access Protocol), in contrast to "proprietary" ones, indicate a higher level of competition, thus the value of the Real Option to wait is diminished. Wu & Ong (2008) in their conceptual study underline the fact that small-scale applications (e.g. daily accounting and office automation systems) offer few options in contrast to other larger-scale investments. However, there have been very few attempts to compare different types of IT projects to examine their differentiated type of option and the respective value they generate. In addition, limited research specifies the features or the attributes of the types of IT projects which produce the creation of an option.

Moreover, based on the previous studies (Lankton & Luft 2008; Y. J. Kim & Sanders 2002; Scarso 1996), different types of IT options encompass a different source of value and are affected by different factors. For example, the value of the option to grow an investment can be a result of the synergetic effects that exist between an old IT project and a new investment (Scarso 1996). On the contrary, the option to switch from one IT investment into another is more valuable when there is high compatibility and interconnection among the examined IT equipment. Lankton & Luft (2008) have shown that the increase of competition in an industry increases the perceived value of the option to grow an investment in an IT project, whereas, decreases the value of the option to delay this investment, because the competitors will benefit from this delay. Although previous studies have suggested this issue, there is room for future research. Further research can also examine the impact of several underexplored factors on each option type in IT projects and conclude on insightful results. Empirical studies can be used to conclude on the most significant factors that result in the generation of a specific opportunity-option for the investor, in order to support managers in IT investment decisions.

2.3.2.2 *IT Real Options Taxonomy by Evaluation Approach*

Literature on IT Real Options can be further classified in two main classes based on the evaluation approach: (a) normative and (b) intuitive studies (Lankton & Luft 2008). The first class includes all the studies that utilize option pricing models (OPM) for the evaluation of an IT project, whereas, the intuitive studies evaluate IT projects based on managers' perceived Real Option value. These two approaches indicate two different areas inside the IT Real Options field that merit a separate thorough analysis. The two approaches signify the utilization of different evaluation methodologies and have diverse critical issues to deal with and distinct findings. In addition, through this classification, the different factors that are taken into account in each stream of research are separately identified. The two approaches encompass different types of criteria and factors in order to justify one IT investment. In the case of the normative approaches, the employed factors which affect an options value are quantified, whereas in the case of the intuitive approaches the criteria are qualitative and based on intuition. However, there are a few studies which combine the two approaches. The two figures below include these categories and their subcategories. The detailed subcategories will be explained and analyzed in the following paragraphs respectively.

(Note: From the figures below the articles which are solely conceptual are excluded)

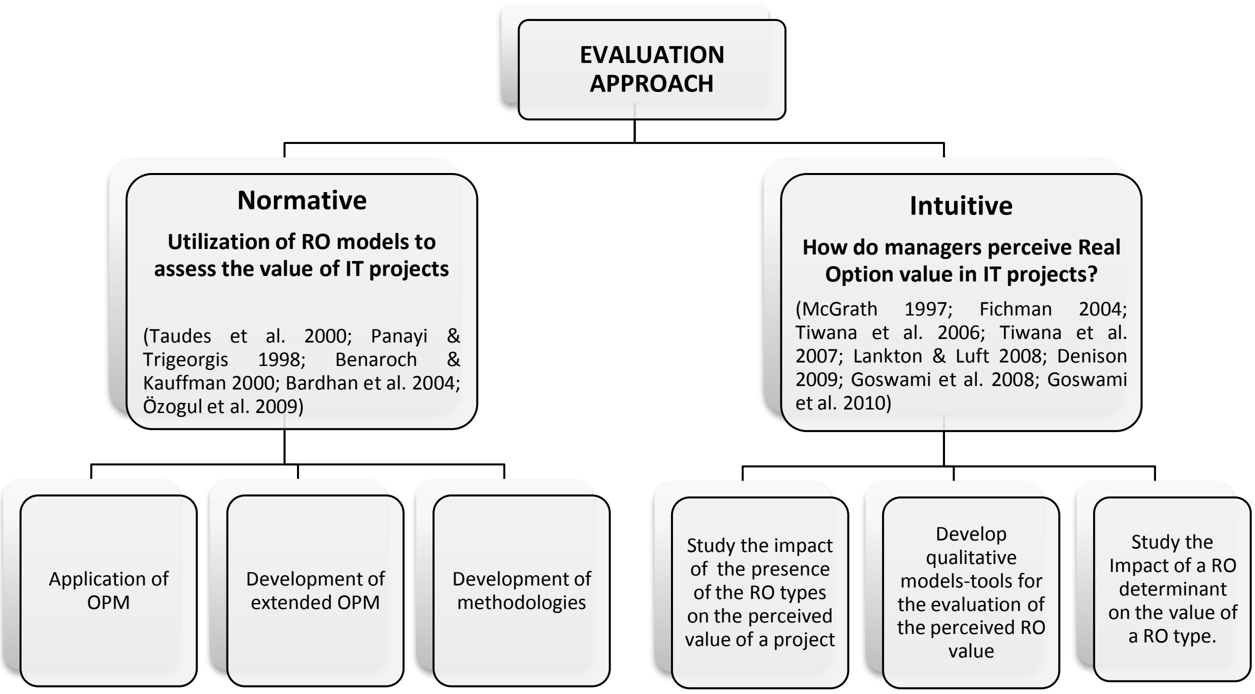
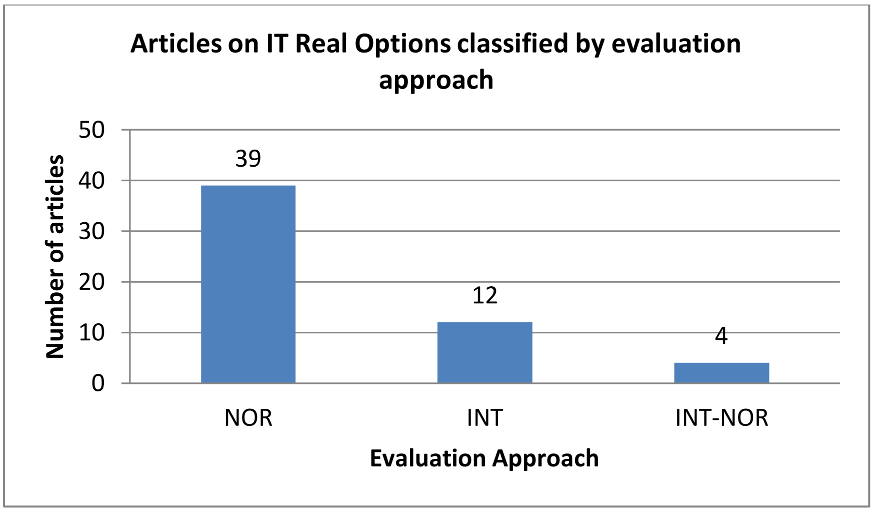


Figure 2.5 IT Real Options Taxonomy (based on the evaluation approach)



NOR: Normative studies (i.e. option pricing models), INT: Intuitive (i.e. Behavorial implications of Real Options), INT-NOR: Studies which follow both approaches (Note: The papers which are solely "Conceptual" have been excluded from this figure)

Figure 2.6 Empirical studies on IT Real Options

(A) Normative studies

The normative studies can be further classified into the three following subcategories based on their research aim.

Table 2.7 Normative studies on IT Real Options

Normative studies on Real Options for IT	References
Application of Option Pricing Models (OPM)	(Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Panayi & Trigeorgis 1998; Kumar 1996; Kumar 1999; Kumar 2002; Taudes et al. 2000; Wu et al. 2008; Dos Santos 1991; Taudes 1998; Yeo & Qiu 2003; Harmantzis & Tanguturi 2007; Li & Johnson 2002)
Development of extended Option Pricing Models (OPM)	(Schwartz & Zozaya-Gorostiza 2003; Pendharkar 2010; Campbell 2002; Clemons & Gu 2003; Dai et al. 2007; Herath & Herath 2008; Lee et al. 2009; Kim et al. 2009; Li 2009)
Development of methodologies	(Özogul et al. 2009; T. Chen et al. 2009; Benaroch 2001; Balasubramanian et al. 2000; Benaroch 2002; Bardhan et al. 2004; Benaroch, Shah, et al. 2006; Benaroch, Lichtenstein, et al. 2006; Scarso 1996; MacMillan et al. 2006; Benaroch et al. 2007; Angelou & Economides 2008b)

The first part of the normative studies apply standard option-pricing formulas such as the Black & Scholes (1973) formula; Margrabe's formula (1978), or various lattice approaches such as the binomial method (e.g. the log-transformed Trigeorgis binomial method) to IT case studies. The aim of these papers is to show the applicability of the RO approach to real IT investment evaluation problems. In addition, these studies examine and test the impact of the (embedded in the option pricing models) quantitative input variables on the final option value of an IT project. These factors include the estimated revenues and cost of the evaluated project, the volatility of the cash flows, the risk-free interest rate of return and the time interval of exercising the option.

The second stream of the normative studies extends existing options pricing models (OPM) in order to include factors that have not been previously considered (e.g. the level of competition, the volatility of the cost of the investment) into the evaluation process and measure their impact on the business value of an IT project. These studies show that apart from the real option value determinants which the option pricing models test other important quantitative parameters (such as the level of demand, competition or the level of synergies among the technologies in an organisation) can have an impact on the final measured option value. For example, option pricing modeling approaches prove that higher uncertainty (volatility of returns) leads to a higher option value for a firm to defer its investment in order to resolve this uncertainty. However, several additional factors may moderate this impact. For example, Pendharkar (2010) developed a RO model to take into consideration for the IT investment evaluation the cash flow interdependencies and correlations among multi-stage IT investments. In addition, Dai et al. (2007) had the aim to develop a model in order to examine and quantify the impact of demand volatility and competition on the value of an IT infrastructure. The table below illustrates the main factors which have been taken into consideration by normative option pricing models to quantify real option value in IT project investments.

Table 2.8 Quantitative Determinants of real option value investigated under the normative approach

RO Factors	Definition/Explanation	References
Expected present value of cash flows from an investment	Expected revenues coming from the investment	(Q. Dai et al. 2007; Dos Santos 1991; R. Kumar 1999)
Exercise price/investment cost	Expenditures associated with the investment	
Time to expire	Period of time from owning the IT investment to when the IT investment opportunity (e.g. the follow-on applications) runs out due to competition, regulation, demand changes	
Uncertainty/Volatility of the cash flows	Uncertainty of an investment that deals with organizational (ex. acceptance of the technology by a firm), market or competitive risks (Benaroch 2002)	
Risk-Free interest rate		

Cash flow interdependencies among the evaluated projects	Investment in second-stage investments may increase or decrease cash flows from the first stage investment	(Pendharkar 2010)
Variable option exercise prices - Time dependent issues	E.g. inflation, price decrease of the investment	
Level of demand	Market demand (High/low) for the IT-enabled products	(Q. Dai et al. 2007)
Competition	Duopoly	

Finally, the third group builds a RO-based methodology including proposed steps to be followed for the investment evaluation of IT projects. These methodologies have the aim to guide managers on how to structure, manage and design technology investments in order to take the most beneficial investment decision. Angelou & Economides (2008b) for example, propose a methodology for telecommunication investments in order to help managers choose the optimum implementation strategy among several alternatives. Balasubramanian (2000) build a decision-tree based methodology and, through the utilization of dynamic programming, guide managers on how to assess an infrastructure investment, in order to choose from a set of business alternatives.

The above studies suggest that options pricing models can be applied to IT justification and reveal a hidden value under specific conditions. Uncertainty about the outcome, flexibility to diminish this uncertainty and irreversibility are the main attributes of an IT investment which make the utilization of the RO approach applicable (Angelou & Economides 2008b). Prior research suggests that in high risk areas involving new and emerging technologies (e.g. wireless infrastructures, web-services) and IT infrastructure investments, RO can reveal investment possibilities and strategic opportunities that would not become noticeable otherwise (Nalin Kulatilaka & Venkatraman 2001; Benaroch & Kauffman 1999; Benaroch & Kauffman 2000). On the other hand, IT investments that cannot be deferred, such as those triggered by a high level of competition or by a required need of doing business, benefit less from the RO approach because waiting is generally not feasible (Lucas 1999).

Contrary to the studies above, which support the applicability of the RO approach to IT investment evaluation problems, there are researchers who conclude on the limitations of its applicability. Based on this part of the literature, RO could produce only approximate valuations, which in some case can even lead to erroneous results (Benaroch, Shah, et al. 2006). Researchers (Dos Santos 1991; Taudes et al. 2000) question the validity of the RO results as they suggest that good estimates of the input variables (e.g. the variance of the cash flows) may be difficult to obtain and they are based on intuitive interpretations and subjective judgment. However, *"The values of these input parameters to the model are catalysts for the final decision"* (Harmantzis & Tanguturi 2007). Furthermore, McGrath et al. (2004) argues that option pricing models cannot be applied to the IT investments because their core assumption (i.e. the price of the evaluated asset is known and tradable) does not hold. In addition, some researchers argue that the RO approach may be too complex to be applied to the IT investment evaluation (Tallon et al. 2002). This debate is thoroughly analyzed in the review article of Tallon et al. (2002).

Gaps and Future research direction for the normative studies

Incorporate into the normative option pricing models qualitative factors: The majority of these studies are based on quantitative factors (e.g. Cash flows, cost) while neglecting qualitative variables which can significantly influence the value of an IT project. However, IT projects are exposed to different sources of risks and uncertainties arising from the external environment of a firm (e.g. customer demand, partners' support) or from the organization and the technology itself. This kind of uncertainties can be measured by qualitative variables. There is limited research (Angelou & Economides 2009a; Hilhorst et al. 2008; X. Li 2009) on how to quantify qualitative factors and embed them in the RO modeling. Angelou & Economides (2009a) propose a methodology/ model for the evaluation of investment decisions in IT by modeling qualitative evaluation criteria, such as the level of uncertainty of the firm's capabilities, environmental and technology issues. The authors underline that the mere use of RO models can mislead managers in investment decision, as qualitative factors can significantly influence the overall value of an assessed IT project. Future research can incorporate qualitative factors into RO formulas as management utilities.

Lack of customised option pricing models. In addition, previous studies focus on the utilization of standard option pricing formulas. However, the level of uncertainty is diverse in different types of IT projects, thus one general RO model for a project evaluation is likely to provide ambiguous results (Pendharkar 2010). As a result, researchers are recommended to create advanced option valuation mathematical models which are customized and tailored to a particular IT investment (Pendharkar 2010) embedding in the existing RO models value determinants and individual IT project characteristics that are not currently considered.

Modeling of compound options. The normative evaluation of IT projects based on Real Options focuses on one type of option. For example, a Real Option model can help a manager decide when to invest in a project. However, the same evaluation model cannot support another decision, such as whether it is beneficial to abandon a project or not.

Nevertheless, an IT project can entail different types of options. Few models have been developed to examine simultaneously several different Real Option types (Hemantha S B Herath & Park 2002; L. Wu et al. 2008; F. Wu et al. 2008). Future research can develop sophisticated models (e.g. dynamic programming) which embed a number of options simultaneously in order to value different sources of flexibility. Further work can construct computer based models to facilitate the comparison of different alternative paths (comprised of several types of options) in order to find the optimal one.

Evaluation of the IT project synergies. Research on Real Options for justifying IT projects has mainly focused on valuation decisions for a stand-alone IT projects (Angelou and Economides, 2008a), neglecting that the value and the cost of some IT projects can overlap and have a critical effect on each other. The value, for example, of a future IT project can depend on the value of an initial project as they can share the same cost or create additional benefits when implemented together. Although the IS literature (Iniestra & Gutierrez 2009; J. W. Lee & S. H. Kim 2000; Santhanam & Kyparisis 1996; Verma & K. K. Sinha 2002; Liesio et al. 2008) has acknowledged the importance of taking into consideration synergies among IT projects, few studies (Pendharkar 2010; Bardhan et al. 2004; Benaroch, Shah, et al. 2006; Angelou & Economides 2008a) have considered them for the IT investment evaluation through the RO analysis. Future research on the normative IT evaluation can model these interdependencies and examine their impact on the value of an IT project.

(B) Intuitive studies

Except for the evaluation of IT projects using option pricing models, very few studies evaluate IT projects based on managers' perceptions through surveys, experiments and conjoint analysis. Apart from the IT field, the intuitive Real Options approach is underexplored in general, considering all the application fields. Denison's (2009) study underlines the fact that: *"Very few papers have examined the behavioral implications of Real Options despite that a number of RO researchers have called for such an examination"* (McGrath 1999; Kogut & Nalin Kulatilaka 1994; Bowman & Hurry 1993).

Researchers have underlined the necessity of conducting research on the intuitive managerial judgments of Real Options for a number of reasons (Denison 2009). Organizations need to examine the circumstances where the intuitive judgment can perform well and can complement the costly utilization of formal option pricing models (Lankton & Luft 2008). Intuitive judgment is important because it depicts managers' feeling, beliefs and preferences which can sometimes outweigh the results of a quantitative evaluation and have an essential contribution to investing and financing decisions (Pendharkar 2010). *"Surveys of chief information officers, senior IT executives and IT professionals in the 90s found qualitative, intuitive judgments of IT strategic value played a significant role in decision making*." (Lankton & Luft 2008). The studies under the IT Real Options intuitive approach, can be further categorized into the following three subcategories:

Table 2.9 Intuitive studies on IT Real Options

Intuitive studies on Real Options for IT	References
Study the impact of the presence of the RO types on the perceived value of an IT project/ Technological innovation	(Tiwana et al. 2006; Tiwana et al. 2007; Verdu et al. 2012)
Develop qualitative models-tools for the evaluation of the perceived RO value.	(Fichman 2004; McGrath & MacMillan 2000; McGrath 1997)
Study the Impact of a RO determinant on the value of a RO type.	(Goswami et al. 2008; Goswami et al. 2010; Saya et al. 2010; Lankton & Luft 2008)

The first stream of research studies the impact of the presence of the RO types on the perceived IT business value and the willingness to invest. Tiwana et al. (2006) found that managers recognize and value the presence of Real Options when assessing IT projects. It is concluded that the presence of the Real Option types increases managers' willingness to continue a troubled IT project and that managers ascribe more value to growth options than to operational (Tiwana et al. 2006). Another study (Tiwana et al. 2007) had the goal to examine if this relationship suffers from bias by testing whether or not the estimation of the NPV of a project influences the effect of the Real Options on the overall value of the project. The authors concluded that managers associate Real Options with perceived value only when a project's quantifiable benefits are low (when NPV<0) and fail to do so when they are high. In addition, in another study (Verdu et al. 2012) it is shown that real options have a positive impact on the capacity of an organisation to introduce technological innovation in environments with greater uncertainty.

The second group of research is based on developing qualitative Real options based tools for the assessment of IT projects. These tools encompass factors that can contribute to the Real Options value. Managers can assess the RO value of uncertain IT projects by scoring a series of statements which examine the level of the proposed variables. McGrath (1997) and McGrath & MacMillan (2000) describe a score methodology as a management tool for assessing qualitatively the option value of technology projects through a number of RO determinants. These factors measure several uncertainties coming from the exogenous environment of a firm (e.g. demand structure and competitive response), the organization itself (e.g. firm capabilities) or the assessed technology (e.g. the needed investment cost and the parallel technology cost that a project creates). Another study (Fichman 2004) develops a theoretical framework on the determinants of the Real Options value of IT platform investments. Based on the author, the Real Options value determinants include characteristics of the technology context (e.g. divisibility) or the organizational context (e.g. innovative capabilities). The proposed variables either increase or decrease real option value. These determinants refer to organisational or technological features from the IT innovation field which are proposed to have an impact on option value and ultimately on IT adoption. The model focuses on the value of growth option and factors which have an economic construal from a real options perspective. Apart from the evaluation of growth option value for IT platforms, Fichman's model is a tool for management and prediction of IT platform adoption and implementation. However, to our knowledge there has been yet any empirical work on these proposed factors.

Lankton & Luft (2008) launch the respective **third stream of intuitive research**, which empirically investigates the impact of specific variables on the real option value of an IT project. The authors, through an experiment and survey, examined how the level (high or low) of the technical uncertainty and the industry structure (monopoly or competition) influence the effect of the Real Options presence on the IT investment decision. They concluded that as uncertainty increases, individuals perceive deferral options as more valuable but growth options as less valuable. The deferral option judgments are consistent and the growth option ones are inconsistent with Real Options theory, which supports that as uncertainty gets higher, the value of an option increases too. They have also found that competition diminishes perceived deferral option value while enhancing growth option value, despite that the theory supports there would be no change to the Real Options value. However, this statement only holds under perfect competition. Under imperfect competition (e.g. oligopoly), RO values of delaying an investment diminish with higher degree of competition due to companies' fear of 'pre-emption' (i.e. the possibility that a competitor may gain an advantage by investing first in a project before the other companies) (Tsekrekos 2003). Thus, the authors underline that some discrepancies between the intuitive judgment and the Real Options theory may occur for specific types of options and settings.

Another study (Goswami et al. 2008) shows that specific institutional variables (i.e. institutional influences, institutional regulations and mindfulness) are significantly related to the recognition of several types of options (i.e. growth, learning, staging and deferral options). The study shows the impact of these options on the intention to adopt RFID technology. In addition, in a second study Goswami et al. (2010) find that the organisational strategy type moderates the relationship between the recognition of real options from RFID technology and organisational decision makers' intention to invest in RFID. Another work (Saya et al. 2010) shows the impact of technological attributes under the influence of institutional pressure on the recognition of real options. The authors show that real options have an impact on the intention to adopt cloud computing.

Scarso (1996) proposes that learning processes and tacit know-how can be resources of growth options, thus lead to a non-incentive to defer adoption. Another factor which according to the pertinent literature has a strong influence on the option value is the synergies, i.e. information technology projects which interact or produce a combined effect. Several studies (Scarso 1996; Kim & Sanders 2002) have proposed or examined through normative modeling that "interaction effects" or "interdependencies" among several information technology projects have an important effect on option value. In particular, Kim & Sanders (2002) develop a framework according to which an organisation can evaluate the option value of a portfolio of IT investments based on two factors: interaction effects and competition level. For example, when interactions effects among the IT applications and competition reactions are high, the framework recommends that it would be more valuable for an organisation to switch up (switch option) its resources from one IT application to another. On the contrary, when the interaction effects among the assessed IT applications and the competition reactions are low the authors propose that an organisation should defer an investment. There are several other studies (McGrath & MacMillan 2000; Lankton & Luft 2008; X. Li & Johnson 2002) which examine the impact of competition level on the option value. Li & Johnson (2002) have shown that when competition is low the value of the option to defer an investment is increased. In addition, other studies refer to other option value determinants such as: the technological feature of divisibility (Fichman 2004) (i.e. technology can be divided for sequential implementation). They support that these factors can positively influence the option value of an IT project.

The table below includes the real option determinants which are proposed and investigated in the studies of the second and the third research stream respectively within the intuitive approach.

Table 2.10 Qualitative Determinants of real option value investigated under the intuitive approach

RO Factors	Definition/Explanation	References
QUALITATIVE DETERMINANTS		
Technology strategy perspective		(Fichman 2004)
Radicalness	The extent of potential improvements in organizational products or processes enabled by the technology	
Strategic Importance of affected products/processes	The extent to which products or processes potentially improved by the innovation are central to the competitive position or value proposition of the firm	
Sustainability of advantage	The extent to which expected improvements to a firm's strategically important products or products resist rapid duplication by competitors	
Innovative capabilities	The extent to which an organization possesses resources (human, technical, organizational) conducive to effective deployment of the innovation	
Organisational learning perspective		
Knowledge barriers	The extent of the burden of organizational learning associated with adoption	
Learning-related endowments	The extent to which an organization possesses knowledge, skills, routines, incentives, and other resources conducive to effective organizational learning surrounding the innovation	
Contributions to exploitable absorptive capacity	The extent to which knowledge to be gained during deployment contributes to absorptive capacity in domains with long-lasting strategic relevance	
Technology Bandwagon		
Recognition of network externalities	The extent to which a technology increases in value to individual adopters with the size of the adoption network	
Prospects for network dominance-class	The extent to which the innovation's technology class is likely to achieve a dominant position relative to competing technology classes	
Prospects for network dominance-instance	The extent to which the technology instance being adopted is likely to achieve a dominant position relative to competing technology instances within the same class	
Technology Adaptation		
Interpretive flexibility	The extent to which a technology permits multiple interpretations on the part of adopters about how it should be implemented and used	
Divisibility	The extent to which a technology can be divided for sequential implementation in such a way that each incremental segment positions the firm for a positive payoff, even if no further implementation segments are pursued	
Drivers of revenues:		(McGrath 1997; McGrath & MacMillan 2000)
Cash Flows:		
Demand structure	The level of future demand for the offered technology	
Speed of Adoption	Level of the technology adoption (rapid/slow)	
Blocking potential	A business is prevented from accessing critical resources/sales channels or customers by other parties' actions	
Sustainability:		
Competitive response	Competitors' reaction to the entry of the assessed technology	
Ease of imitation	Imitation from competitors	
Standards	Control that a company has by selling upgrades, by creating network of influential customers.	
Drivers of cost:		
Commercialization cost:		
Investment cost to enter the market	Expenditures of a company which enters a market with this technology	
Investment to build infrastructure	Infrastructure expenditures	

Parallel technology cost	When tangible or intangible assets already in place make commercialization easier, a project has higher potential benefits	
Industry development cost	In new industries commercialization cost is higher	
Development cost:		
Firm capabilities/resources	Company's resources (e.g. experience)	
Spillover effects	Spillover effects between the old and the new business may lower development cost	
Damage-downside risk	The level of catastrophic risk the development effort might represent to a firm	
Interaction effects	A new IT investment may interact with current assets or investments. (e.g. synergies)	(Kim & Sanders 2002)
Competition reactions	A new IT investment may force competitors to think about counter investments to compete with the investment.	
Level of risk of the investment decisions	Level of uncertainties regarding the investment	(Wu & Ong 2008)
Level of profitability	Expected benefits-returns from the investment	
Competition level (in shared or proprietary investments)	Strong/Low competition	(X. Li & Johnson 2002)
Level of switching cost	Level of technology lock-in-The situation where management has little flexibility to switch to other technology solutions	
Growth Learning processes, tacit know-how, cumulativeness of technical improvements, modularity of technology investments, first-mover advantages, synergetic effects	Technological sources for the generation of a growth option	(Scarso 1996)
Exit Sunk costs, investment reversibility, specialization of tangible and intangible assets	Technological sources for the generation of an abandon option	
Wait Uncertainty reduction, acquisition of valuable information, price decrease, weak appropriability of technical advantages	Technological sources for the generation of a defer option	
Contract Economies of scale in the use of the new technology	Technological sources for the generation of a contract option	
Switch Standard compatibility, transferability of technical knowledge, inter-connectability of technical equipment	Technological sources for the generation of a switch option	
Technological uncertainty	Uncertainties about how well the technology will work	(Lankton & Luft 2008)
Industry structure	Monopoly/Competition	
Institutional influences	Normative and mimetic pressures on the organization based on the actions of the other members of the institution	(Goswami et al. 2008)
Mindfulness	Attending to RFID with reasoning grounded in one's own organizational facts and specifics	
Institutional regulations	Rules, sanctions and directives from other members of the institution guiding the actions of the organization.	
Business Strategy	Different types of organizational business strategy that a manager follows based on Miles and Snow (1978) typology: "Defenders", "Analyzers" and "Prospectors"	(Goswami et al. 2010)
Perceived Accessibility	The extent to which computing resources can be accessed from anywhere over any platform	(Saya et al.

Perceived scalability	The extent to which provisioned computing resources can dynamically adjust to variable loads such as changes in the number of users, required storage capacity, and processing power	2010)
Perceived cost effectiveness	The extent to which the benefit derived from a computing resource is worth the cost invested (Wells	
Perceived lack of security	A system's ability to prevent unauthorized access or modification to information in storage, processing, or transit	
Institutional influences	Organizations face pressures to adjust their behaviors to conform to shared notions, violations of which may affect their political power, institutional legitimacy, and ability to secure resources and customers	

The following table offers a synopsis of some of the common variables that influence real option value which have been proposed by the literature (either in intuitive studies or incorporated into option pricing normative models).

Table 2.11 Determinants of Technology Real Option value (categorised per factor)

Factor	Meaning /Authors
Divisibility	Capability of the technology to be incrementally implemented in stages. Ability or interest of the organisation to divide the technology implementation.
Divisibility	(Fichman 2004)
Capability of staging the investment	(Angelou & Economides 2008a; Angelou & Economides 2009a)
Modularity /Interpretive flexibility	The technology is composed of different components which can be separated and recombined/The technology can be implemented under multiple interpretations
Interpretive flexibility	(Fichman 2004)
Modularity of technology investment	(Scarso 1996)
Business flexibility-modularity	(Angelou & Economides 2008a; Angelou & Economides 2009a)
Synergies	A portfolio of information technology projects which interact or produce a combined effect (e.g. the one project is prerequisite for the other or the one project supports the other)
Synergetic effect	(Scarso 1996)
Interaction effect	(Y. J. Kim & Sanders 2002)
Interdependencies	(Angelou & Economides 2008a)
Cash flow interdependencies	(Pendharkar 2010)
Interconnections	(Scarso 1996)
Competition	The level of competition in the industry
Competitive response	(McGrath 1997; McGrath & MacMillan 2000)
Competition	(Q. Dai et al. 2007)
Competition level	(X. Li & Johnson 2002)
Competitive factors	(Angelou & Economides 2008b; Angelou & Economides 2009a; Angelou & Economides 2009b)
Competition reactions	(Y. J. Kim & Sanders 2002)
Industry structure (monopoly/competition)	(Lankton & Luft 2008)
Learning capabilities	The capabilities of a firm to learn from the exploitation of the technology.
Learning-related endowments, absorptive capacity	(Fichman 2004)
Learning processes and tacit know-how	(Scarso 1996)
Preemptive learning and absorptive capacity	(X. Li 2009)

Gaps and Future research direction for the intuitive studies

Although there are few studies (not dealing with IT) (Yavas & Sirmans 2005; Miller & Shapira 2004; Busby & Pitts 1997; Howell & Jagle 1997) which examine how decision makers perceive the Real Options value of an assessed project, very little research refers to IT projects.

Study the impact of RO factors on the perceived business value of an IT project : The above studies identify and investigate the impact of several determinants on the recognition and exploitation of option value and the value of an assessed IT application. However, the majority of these studies treats these determinants as conceptual factors or tests them through quantitative normative modeling. Research on the empirical investigation of these IT option value antecedents, based on the examination of managers' perceptions and views is rare. Future research can investigate the significance of these factors on the recognition and value of real options. The aim of a future study would be to empirically test the existing Real Options models which are consisted of qualitative RO value determinants and add further RO determinants in the models or synthesize the existing ones. An interesting research question to conduct a study on would be the following: “What are the most significant RO factors that influence a managers’ decision to invest or not in an IT project?”. In addition, there is limited research on empirical research on the factors that affect a specific type of option (e.g. growth option). Further research could examine and analyse important differences among the different types of options and their respective determinants of value. Results can guide investors to focus on the most significant RO factors that contribute to the increase of the perceived business value in order to support their investment decisions.

Examine the perceived Real Options value of different types of IT projects :The majority of the empirical intuitive studies treat IT investments as a homogeneous group, while neglecting how the perceived RO value can vary among different types of IT projects. However, different types of projects might carry differential option value (Tiwana et al. 2006). Further empirical studies can be conducted to extend previous work (X. Li & Johnson 2002; L. C. Wu & C. S. Ong 2008) and answer questions such as the following: “Do different types of IT projects carry differential perceived option value?” or “How do the different types of IT projects influence the perceived value of an option?” For example, growth options can have a low perceived value in one-off application projects than in infrastructural ones (Tiwana et al. 2006). This study can also identify the factors (e.g. how strategic an IT project is) that can act as moderators in the above relationship.

The importance of identifying the impact of Real Options in different types of IT projects is supported by the literature on IT/IS justification. According to the literature (Z Irani & P. E. D. Love 2002) each investment project in IT/IS displays its own unique characteristics and offers a diverse range of risks, benefits and costs. Thus the development of a generic appraisal technique may be considered too rigid". Based on this view, Real Options methodology is not a panacea and may not be the appropriate technique for all the types of IT/IS projects.

The perceived RO value that is ascribed by different stakeholders: Furthermore, previous research does not take into consideration the differences that may occur in the RO value among different investors. Future research can study how and why the perceived RO value may be differentiated among various stakeholders (Tiwana et al. 2006). For example, some stakeholders may prefer an all at once funding in order to obtain maximum control of an investment (Angelou & Economides 2009a). Thus, an option to stage an investment would be assessed by these stakeholders to have a low value.

The perceived RO value among the different stages of an IT project: The majority of the empirical intuitive studies focus on the Real Options value of an IT project at a single point in time, rather than examining how the Real Options value can vary over a period of time (Tiwana et al. 2006; Tiwana et al. 2007). Nevertheless, IT can pass through a series of stages based on several factors such as its maturity level, the degree of the required business transformation and the type of benefits and goals that it underpins (Gibson & Nolan 1974; Venkatraman 1991; H. L. Lee 2007). An example of classification stages is that in Lee's (2007) study, according to which IT can be a part of the “substitution” stage, where it can replace an existing technology, the “scale” stage, where it can support multiple points in the supply chain, and the “structural” stage, in which technology can generate new business activities and processes. Future research can examine the differentiated RO value that is derived from IT project through these different stages.

Comparison between the normative and intuitive value of an IT project: Howell's & Jagle's (1997) study examines if managers’ intuition is compatible with the Real Options theory. Its aim was to examine any possible discrepancies between the perceived and the normative Real Options value (i.e. the one which is based on formulas) of an assessed project. However, this study has not been undertaken for IT projects. Further studies can apply this type of research to the IS field and conclude on and explain any possible discrepancies among the intuitive and the normative value of an IT project. Future research is recommended to identify when and why these discrepancies occur (Lankton & Luft 2008).

Real Options viewed as an IT strategy: Most of the pertinent studies treat options either as a tool to justify business project investments or as one asset/ investment that comprises opportunities (e.g. future investments or future responses to the risk of this investment). However, according to the literature on Real Options (Bowman & Hurry 1993; McGrath et al. 2004; Bowman & Moskowitz 2001) an option can be considered as a strategy of a firm. This aspect has been neglected by the pertinent empirical studies in the IT sector. In particular, future research can study the impact of a Real Options IT strategy on the IT performance. This study can compare two kinds of followed IT strategies: one which supports the one-shot (one stage) IT implementation and one which supports an incremental IT implementation divided in stages (with embedded options/ actions taken in each stage) and examine their influence on the IT performance.

(C) Hybrid approach

There is a third stream of research (Angelou & Economides 2009a; Angelou & Economides 2009b; Angelou & Economides 2008a; Hilhorst et al. 2008) which combines the normative and intuitive interpretation of the RO value. Its aim is to utilize a holistic approach for the justification of IT investments through the RO analysis by developing models or decision analysis frameworks (e.g. Real Options pricing models combined with analytical hierarchy process/multi-attribute analysis) which are consisted of many tangible and intangible parameters which contribute to the RO value. The researchers in this field highlight that previous studies have ignored the multi-dimensional nature of IT investment decisions (Hilhorst et al. 2008) and that they are influenced by a set of risks (e.g. firm, market, technology, competition risks) whose estimation may be not easy to be quantified by the existing Real Options pricing models (Angelou & Economides 2009b). Studies show that a combined Real Options analysis with quantitative and qualitative parameters can produce valuable information and enhance decision making. Some of the studies have shown that the addition of non-financial criteria in an evaluation model can lead to very different outcomes. For example, Angelou & Economides (2009b) have found that "the ranking of the decision alternatives may change when quantitative and qualitative factors are integrated in comparison to the purely quantitative analysis performed by the typical RO models". Thus, studies have shown that Real Options formal analysis may be different from the managerial perspective for specific investments.

In addition, these studies have concluded on a set of factors which can be treated qualitatively and be incorporated into one integrated evaluation model. For example, Angelou & Economides (2009b) have included in their evaluation model the qualitative competition factor “information spillovers” which can influence the option value of an IT investment strategy. In particular, this factor shows that a firm which enters first into a new market which is uncertain will reveal the true condition of the market’s demand. This information will be then distributed to following competitors who (by delaying their investment) will learn from this and will enter the market only if it is profitable. This factor is proposed that it will increase the value of the Real Option to delay an IT investment (“defer option”). Thus, the investment decision will be influenced likewise.

Another study (Li 2009) demonstrates that with the benefits of preemptive learning considered, higher uncertainty sometimes encourages earlier adoption of a new technology which can dominate risk reduction benefits from a delayed adoption. The author embeds in an option pricing model a company's absorptive capacity and relates it with options and technology adoption. In particular, Li (2009) has found that when an organisation encompasses learning and absorptive capacity capabilities, higher uncertainty for an IT investment can encourage earlier adoption of this technology, thus diminish the value of the option to wait. To test this impact, the author has embedded this intangible factor in a developed quantitative model.

The table below illustrates the determinants which affect real option value based on the studies which have exploited a hybrid approach.

Table 2.12 Quantitative and Qualitative determinants of RO value under the hybrid approach

RO Factors	Definition/Explanation	References
Capability-interest of staging the investment (CSI).	A firm can consider the investment as a whole entity	(Angelou & Economides 2009a)
Option cost of delay (OCD).	Expected revenue losses due to the delay of the investment	
No clarified growth options (NCO).	ICT growth investment opportunities can be hardly defined, from competition threat, environmental/regulatory changes, revenue losses	
Cost of business flexibility-modularity (CBF).	Creating a growth option usually involves making the ICT platform more generic and modular for obtaining higher flexibility, experiencing however higher cost	
Competition factors	First and second mover action	(Angelou & Economides 2008b; Angelou & Economides 2009b)
Network effects(demand)	A market where “tipping” effects are strong	
Cost of switching	If the cost of switching among suppliers is strong there is a stronger advantage to enter the market first (the value of the option to defer the investment is decreased)	
Information spillovers	A firm which enters first into a new market which is uncertain will reveal the true condition of the market’s demand. This information will be then distributed to the following competitors who (e.g. by delaying their investment) will learn from this and will enter the market only if it is profitable.	
Network effects (competitors)	A firm’s investment project has higher value if another company also invests	

Interdependencies	Among ICT projects inside a portfolio. Hard dependencies when a capability required for one project is also required for another project or when a project is prerequisite for another. Soft dependencies when a capability of one project supports or enhances capabilities required by other projects.	(Angelou & Economides 2008a)
Preemptive learning and absorptive capacity	Learning benefits from expedited adoption could dominate risk reduction benefits from a delayed adoption.	(Li 2009)

This stream of research has the purpose to employ the developed holistic models and methodologies to compare alternative scenarios of IT implementation strategies (Hilhorst et al. 2008; Angelou & Economides 2009a; Angelou & Economides 2009b) or value and prioritize a portfolio of IT projects (Angelou & Economides 2008a).

Table 2.13 Hybrid (normative and intuitive) approach on the IT Real Options

Hybrid (normative and intuitive) approaches on Real Options for IT	References
Development of models / methodologies which combine qualitative and quantitative RO factors for the evaluation of IT projects/IT implementation strategies	(Angelou & Economides 2009a; Angelou & Economides 2009b; Angelou & Economides 2008a; Hilhorst et al. 2008; Li 2009)

<u>Gaps and future research direction for the hybrid approach:</u>

There are very few attempts which combine Real Options analysis with multi-attribute techniques / models (e.g. AHP), in order to incorporate into the IT evaluation process different types of uncertainties and integrate quantitative with qualitative Real Options factors. Thus, there is a lot of room for further research. In addition, there are a lot of opportunities to conduct research on the ways/ methods to quantify Real Options qualitative factors and include them into a holistic RO evaluation framework. Further research can employ and develop more sophisticated techniques (e.g. dynamic programming) to facilitate such a holistic approach.

This section provided a comprehensive review of the current state of research and application of the Real Options approach to IT justification, by examining 64 pertinent articles published between 1990 and 2012 in top academic journals, as classified in the following table.

Table 2.14 Summary of references on the field of IT Real options per each classification category

Classification	Sub-classification	References
General concepts		(Eric K Clemons 1991; Kogut & Nalin Kulatilaka 1994; Nalin Kulatilaka & Venkatraman 2001; Tallon et al. 2002; Y. J. Kim & Sanders 2002; Fichman et al. 2005; Angelou & Economides 2005; Alleman et al. 2008)
Types of Real Options	Growth	(Alleman et al. 2008; Angelou & Economides 2005; Angelou & Economides 2008a; Angelou & Economides 2008b; Angelou & Economides 2009a; Bardhan et al. 2004; Benaroch, Shah, et al. 2006; Clemons 1991; Dai et al. 2007; Dos Santos 1991; Fichman 2004; Fichman et al. 2005; M Keil & Flatto 1999; Y. J. Kim & Sanders 2002; Kulatilaka & Venkatraman 2001; Kumar 1996; Lankton & Luft 2008; Panayi & Trigeorgis 1998; Pendharkar 2010; Taudes 1998; Taudes et al. 2000; Tiwana et al. 2006; Tiwana et al. 2007; Wu & Ong 2008; F. Wu et al. 2008; Yeo & Qiu 2003)
	Operating	(Alleman et al. 2008; Angelou & Economides 2005; Angelou & Economides 2008a; Angelou & Economides 2009a; Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Benaroch 2001; Benaroch 2002; Benaroch, Lichtenstein, et al. 2006; Campbell 2002; T. Chen et al. 2009; Fichman et al. 2005; Harmantzis & Tanguturi 2007; Hilhorst et al. 2008; M Keil & Flatto 1999; Kumar 2002; Lankton & Luft 2008; Lee et al. 2009; McGrath 1997; Pendharkar 2010; Scarso 1996; Schwartz & Zozaya-Gorostiza 2003; Tiwana et al. 2006; Tiwana et al. 2007; Wu & Ong 2008; L. Wu et al. 2008; F. Wu et al. 2008; Yeo & Qiu 2003)
Real Option evaluation approach	Normative evaluation & quantitative determinants	(Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Panayi & Trigeorgis 1998; Kumar 1996; Kumar 1999; Kumar 2002; Taudes et al. 2000; F. Wu et al. 2008; Dos Santos 1991; Taudes 1998; Yeo & Qiu 2003; Harmantzis & Tanguturi 2007; Li & Johnson 2002; Schwartz & Zozaya-Gorostiza 2003; Pendharkar 2010; Campbell 2002; Clemons & Gu 2003; Q. Dai et al. 2007; H. S. B. Herath & T. C. Herath 2008; Lee et al. 2009; Kim et al. 2009; Li 2009; Özogul et al. 2009; T. Chen et al. 2009; Benaroch 2001; Balasubramanian 2000; Benaroch 2002; Bardhan et al. 2004; Benaroch, Lichtenstein, et al. 2006; Benaroch, Shah, et al. 2006; Scarso 1996; MacMillan et al. 2006; Benaroch et al. 2007)
	Intuitive evaluation & qualitative determinants	(Tiwana et al. 2006; Tiwana et al. 2007; Fichman 2004; McGrath & MacMillan 2000; McGrath 1997; Lankton & Luft 2008; Goswami et al. 2010; Goswami et al. 2008; Saya et al. 2010)
	Hybrid approach	(Angelou & Economides 2009a; Angelou & Economides 2009b; Angelou & Economides 2008a; Angelou & Economides 2008b; Hilhorst et al. 2008)

As demonstrated by this review, there is a growing interest for the application of the Real Options approach to the justification of IT projects. However, the field is still new and has a lot of fruitful opportunities for future research. As it is revealed by the review, studies which utilise the normative approach and the exploitation of option pricing formulas prevail in this field. This conclusion stimulates the necessity to raise research in order to investigate unexplored issues derived from the second approach utilised in the IT Real Options field which refers to the behavorial implications of Real Options.

The following table summarises the research gaps identified in both research streams (normative and intuitive) for IT Real Options.

Table 2.15 Future research directions on IT Real Options studies

Quotations	Research Gap
Normative studies	
There is limited research on how to quantify qualitative factors and embed them in the RO modeling (Angelou & Economides 2009a; Hilhorst et al. 2008; Li 2009)	Need for more search on the development of formulas for the evaluation of compound IT options.
Researchers are recommended to create advanced option valuation mathematical models which are customized and tailored to a particular IT investment (Bowman & Moskowitz 2001; Pendharkar 2010)	Develop real options models which combine quantitative variables: (e.g. cost, benefit, volatility) with other qualitative variables/sources of uncertainties (ex. level of competition) in the models.
The level of uncertainty is diverse in different types of IT projects, thus one general RO model for a project evaluation is likely to provide ambiguous results (Pendharkar 2010)	Need for the development of new tailored-customized models based on the characteristics of specific IT projects.
Research on Real Options for justifying IT projects has mainly focused on valuation decisions for a stand-alone IT projects (Angelou & Economides 2008a)	Need to research on the evaluation of IT projects with synergies. Embed in the option pricing models the synergies of the IT projects as a parameter which influences their value.
Intuitive studies	
Little research on how the use of RO in capital budgeting affects the behavior and decisions of managers (Denison 2009)- *Empirical tests of Real Options are few* (Tiwana et al. 2007)	Empirically study the behavorial implications of Real Options-(How do managers value Real Options?)
"Little is known about the relative value that managers ascribe to the different types of options that may be embedded in IT projects" (Tiwana et al. 2006)	Empirically investigate the impact of the proposed by the literature determinants of real option value on managerial decision making for IT investment projects.
Different types of projects might carry differential option value (Tiwana et al. 2006; X. Li & Johnson 2002; L. C. Wu & C. S. Ong 2008)	Identify and empirically examine important moderating factors (e.g. types of IT projects, types of stakeholders, stages of IT projects) which can influence the impact of Real Options on the IT project value
Future research can study how and why the perceived RO value may be differentiated among various stakeholders (Tiwana et al. 2006)	✓ Identify and empirically examine the role of the IT project type as a moderator on the impact of Real Options on the IT project value
The majority of the empirical intuitive studies focus on the Real Options value of an IT project at a single point in time,	

rather than examining how the Real Options value can vary over a period of time (Tiwana et al. 2006; Tiwana et al. 2007) *Future research is recommended to identify when and why discrepancies between managers' intuition and Real Options theory occur. Differences between intuitive and normative real options values appear to be option and setting specific and thus need to be theorized with respect to specific options and settings* (Lankton & Luft 2008). *An option can be considered as a strategy of a firm on Real Options* (Bowman & Hurry 1993; McGrath et al. 2004; Bowman & Moskowitz 2001). *This aspect has been neglected by the majority of current research.*	✓ Identify and empirically examine the role of the type of a stakeholder as a moderator on the impact of Real Options on the IT project value ✓ Empirically study the impact of Real Options on the evaluation of different stages of the technology- Examine how does Real Option value varies over a period of time. Future research which conducts studies for the comparison of the two approaches (normative Vs intuitive judgement). Future research which examines the impact of different types of followed IT strategies (a RO- based IT strategy vs. a non RO- based IT Strategy) on firm performance.

2.4 RFID Technology in the supply chain

RFID Technology is the context where the hypotheses and the proposed research models explained in the following chapters are applied to. The following paragraphs discuss the main characteristics of RFID and previous studies on its evaluation and adoption. The main research gaps of these studies are also presented.

2.4.1 RFID technology in the supply chain

One of the main application areas of RFID Technology is supply chain management. “Supply chain management is the management of the interconnection of organizations which relate to each other between the different processes that produce value in the form of products and services to the ultimate consumer” (Slack et al. 2001). Information technology has been an enabler and facilitator of this interconnection. Several examples of information technologies have been evolved and contributed to the enhancement of supply chain management. The development of the traditional and the web-based Electronic Data Interchange (EDI) is an example of a technology which automated the existing information flows among supply chain partners and eliminated the respective labor cost (Williamson et al. 2004). Integration technologies such as extensible markup language (XML) and Web services are other examples of supply chain systems which have the aim to monitor real time events through portals (Eric W.T. Ngai et al. 2011) giving the opportunity to supply chain partners to access a company’s database (Williamson et al. 2004). IT supports the collaboration among the different partners (e.g. retailers, suppliers) within a supply chain

(Pramatari 2007), which is a prerequisite for the successful coordination of the several supply chain activities. Pertinent studies have underlined the benefits which occur as a result of the above IT supply chain technologies. In particular, improved information sharing, data flows among supply chain partners and improved communication among the business companies and their customers have been highlighted in the literature as the impact of IT on supply chain (Katerina Pramatari et al. 2009; Williamson et al. 2004). According to the literature, real-time supply chain information regarding important issues such as inventory levels, delivery status are enhanced (Prajogo & Olhager 2011) as a result of IT utilization. In addition, IT supports coordinated decision making, demand forecasting and enables higher efficiency in supply chain activities (Wu et al. 2006). Reduced inventory levels, costs and cycle times are other examples of operational benefits that might accrue as a result of information technology implementation in the supply chain (Tseng et al. 2011).

One of the emerging technologies which enable collaboration in the supply chain is the Radio Frequency Identification (RFID) Technology. The specific technology provides real time information for unique product instance and context information supporting services such as "back room visibility and store replenishment, collaborative shelf management and collaborative in-store promotion management and evaluations" (Pramatari 2007). Its basic trait, which involves the automated and wireless unique identification of a tagged item, is essential in many environments other than supply chain management e.g. anti-theft systems, asset tracking, airline baggage handling, electronic tolling, and facilities management (e.g. libraries), where a non-line of sight system is required to extract information about object movement. Retail supply chain is an area where RFID is mainly adopted. In this environment, RFID can serve a range of applications from upstream warehouse and distribution management to retail-outlet operations including shelf management, promotions management and innovative consumer services, as well as applications for the whole supply chain such as product traceability (K. C. Pramatari et al. 2005).

An RFID system is composed of three layers, as depicted in Figure 2.1: (i) a tag which is attached to or embedded in a physical object to be identified, (ii) a reader and its antennas which allow the tags to be interrogated and (iii) a software equipped with a middleware application that controls the RFID equipment, manages the data and interacts with other enterprise applications such as ERP, CRM or WMS (Asif & Mandviwalla 2005; Wamba et al. 2008). An RFID reader identifies any tagged item within its interrogating field. The reader extracts data (e.g. a unique identifier) from the identified tag and transmits it to a computer which filters and manages this data and all necessary information for providing specific business services. The difference among RFID and barcode technology is the fact that the readers can identify tagged items from a distance, automatically without requiring a line of sight. In addition, each item can be identified (separately from other items) having a unique identity. Furthermore, a high number of tagged items can be simultaneously identified, without the need of checking them one by one.

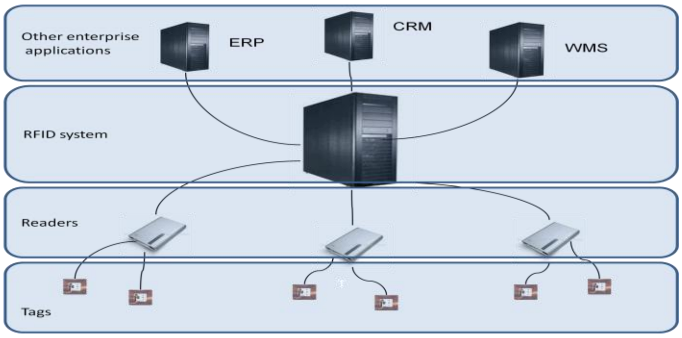


Figure 2.7 An RFID system and its components (based on (Chen et al. 2007))

2.4.2 Previous studies on RFID investment evaluation and adoption

Specifically for the RFID technology, there are a lot of studies which have the aim to assess its business impact. RFID justification studies have exploited the above discussed approaches. The majority of these studies have focused on back office operations such as inventory and warehouse activities. Studies based on several tools such as mathematical or simulation models (A. Karagiannaki et al. 2010; Kok et al. 2008; Doerr et al. 2006; E Fleisch & Tellkamp 2005; Rekik et al. 2008) appraise the impact of the technology on inventory management and more specifically on inventory replenishment, inventory inaccuracies, product misplacement errors and shrinkage. In addition, research based on financial, simulation or hybrid approaches (J. Kim et al. 2008; Bottani & Rizzi 2008; Wamba et al. 2008; A. Karagiannaki et al. 2007; Subirana et al. 2003) has evaluated the use of RFID for warehouse and logistics operations such as shipping, orders receiving and put away processes, concluding that RFID can lead to labor, material and transportation cost savings.

Specific RFID investment evaluation studies (Ustundag et al. 2010; Lee & Lee 2010; Bottani & Rizzi 2008) focus on the cost benefit analysis of RFID investments. For example, in Ustundag et al. (2010) a hybrid approach of simulation and fuzzy rule-based system is exploited in order to conduct an economic (cost-benefit) RFID investment analysis. The economic impact of RFID on supply chain activities (picking, shipping and inventory counting) is examined and the return on investment (ROI) is estimated. Another study (Lee & Lee 2010) develops an RFID investment evaluation model to estimate the cost savings of the RFID implementation to improve ordering, operating and just-in-time efficiency in the supply chain. In Bottani & Rizzi (2008) the authors estimate the economic impact of RFID on supply chain processes (e.g. products receiving, picking, put away process) based on the NPV approach and cost-benefit analysis. Doerr et al. (2006) develop a hybrid approach to assess not only quantitative but also qualitative benefits for an RFID application in the ordnance inventory. Through the Analytical Hierarchy Process method and simulation the authors conduct the NPV cost benefit assessment. Apart from the above studies which are focused on the business evaluation of RFID, little empirical research (L. S. Lee et al. 2008; S.-F. Tzeng et al. 2008) has anticipated the impact of RFID technology on customer facing activities such as customer service.

Although previous research on the investment evaluation of RFID technology is critical to justify RFID investments it has some limitations. "*It rarely does it take into consideration the flexibility and the different kind of options than an RFID investment can yield* (Curtin et al. 2007)". (Curtin et al. 2007)". Previous studies (Bottani & Rizzi 2008) have shown that the **cost** undertaken with the implementation of RFID is high in specific circumstances such as the implementation of the technology based on tagging per item. In addition, the RFID infrastructure cost is **irreversible**, thus making investment decisions more important to be certain. Moreover, innovative technologies such as RFID with new attributes and many issues to consider increase the levels of **uncertainty** and risk taking. "*Issues such as high cost of tags, technical uncertainties over possible configuration for tags and tag-readers, differences in available frequency bandwidths, social concerns regarding loss of privacy and security, etc. are some of the factors that result in uncertainty over the future destiny of the technology and its outcomes* (Goswami et al. 2008)" . In addition, RFID technology can offer to managers a high level of **flexibility** regarding its implementations due to its high level of modularity. For example, the technology can support several applications for a series of business processes with many alternative configurations based on several issues such as: the level of tagging, the placement and the number of the readers etc. Based on the literature, in the cases where we have irreversibility, uncertainty and managerial flexibility traditional discounted cash flow methods are not appropriate for the valuation of investment projects (Dixit & Pindyck 1994). Based on the literature, for the valuation of investment problems with these characteristics Real Options offers a better alternative. "*These sorts of options (e.g. pilot implementation) can change a project such as RFID that has a negative expected payoff based on conventional tools (e.g. NPV) to one with significant value* (Fichman et al. 2005)".

After RFID technology is evaluated, the next step is its adoption. Studies have been conducted to examine several factors which contribute specifically to the adoption of RFID technology. Previous studies have examined (a) technological factors such as the level of integration of RFID with other technologies, compatibility and complexity of the technology (Wang et al. 2010; Chang et al. 2008; Tsai et al. 2010), its explicitness and accumulation (C.-Y. Lin & Y.-H. Ho 2009), (b) organisational factors such as: organisational readiness and organisational needs (Kim & Garrison 2010; Tsai et al. 2012), RFID experience (Leimeister et al. 2009), firm size (Wang et al. 2010; Leimeister et al. 2009), top management support and employee fears (Thiesse et al. 2011), company-internal benefits derived from RFID (Leimeister et al. 2009; Kim & Garrison 2010; Thiesse et al. 2011) and (c) factors coming from the environment of the organisation such as: supply chain integration (Tsai et al. 2010), supply chain forces (Thiesse et al. 2011), competition, pressure from partners (Wang et al. 2010; Chang et al. 2008), government support (C.-Y. Lin & Y.-H. Ho 2009) and institutional factors (Goswami et al. 2008; Tsai et al. 2012).

Although the previous studies on RFID adoption have supported our understanding for the reasons under which companies adopt or do not adopt the technology they do not consider managerial flexibility embedded in RFID projects as a factor which can trigger adoption and affect managerial decision making. In addition, although previous works examine several variables as inhibitors or antecedents of RFID adoption, they do not explain 'how' these variables affect managerial decision making. *"A research gap exists regarding the subsequent adoption process of RFID technology…Future studies may identify additional factors which contribute to RFID adoption* (Thiesse et al. 2011; S.-I. Chang et al. 2008; C.-Y. Lin & Y.-H. Ho 2009). Under this perspective, other adoption factors and frameworks can be examined based on literature research calls: *Are traditional IT adoption research paradigms appropriate for RFID technology? What new adoption paradigms make sense?* (Curtin et al. 2007).

Table 2.16 Research Gap on RFID investment evaluation and adoption studies

Quotations	Research Gap
"*Previous literature on RFID evaluation rarely does it take into consideration the flexibility and the different* kind of options that an RFID investment can yield" (Curtin et al. 2007)" *Interesting opportunities for new research on RFID: Researchers could test the notion that infrastructure technologies may not be the primary drivers of business value themselves, but rather create real options for additional follow-on investments"…." What future options does establishing an RFID infrastructure create? How can the options be identified? (Curtin et al. 2007)".* *"A research gap exists regarding the subsequent adoption process of RFID technology…Future studies may identify additional factors which*	○ Study RFID investments evaluation through other evaluation approaches which take into consideration managerial flexibility (e.g. Real Options) ○ Consider in empirical studies RFID technology as an initial investment which can yield future applications.

contribute to RFID adoption (Thiesse et al. 2011; S.-I. Chang et al. 2008; C.-Y. Lin & Y.-H. Ho 2009) *Are traditional IT adoption research paradigms appropriate for RFID technology? What new adoption paradigms make sense? (Curtin et al. 2007)* *RFID is an appealing case for applying real options analysis* (Goswami et al. 2008)	o Conduct empirical research to examine the impact of Real Options on RFID adoption. o Examine the impact of several factors which trigger the creation of real options in RFID projects.

2.4.3 RFID Technology and Real Options

RFID technology is comprised of specific attributes that make investment unique among other technology investments. One of the main attributes of RFID derives from the fact that this technology can support not only "integrated" but also "non-integrated applications" which lead to several investment options. "Non-Integrated applications" refer to the use of RFID solely by an organization, as data is not shared between supply chain partners (Bottani & Rizzi 2008). One example of this application is the utilization of the RFID technology to improve access control. For instance, an employee's RFID tagged card is identified by a reading device which allows the access of the employee to a store. This application can be utilized solely by one company and it is common with other technology investments as they require the investment by one business entity internally. On the contrary, in "Integrated applications" data on products and pallets become available to all supply chain partners (Bottani & Rizzi 2008). These applications are based on a more complicated infrastructure require a tight and complex cooperation among different stakeholders. One example of an open-loop application is Collaborative Promotion management. In this case, a retailer and a supplier can collaborate based on RFID technology to offer enhanced promotion offerings to the consumers of a retailing store. In contrast to other technology systems, RFID technology investment decisions may be contingent on the collaboration among different organization partners which may stimulate issues of data sharing and ownership. In particular, several investment questions such as the following occur: Is the retailer or the supplier going to pay for the tagging of the products? Who is the owner of the RFID system? Is the value derived from an RFID system differentiated between different stakeholders? Who will receive the higher benefits? Why? These questions yield many different options for an investment.

Other aspects of RFID that differentiate it from other technology investments are based on the components of an RFID system, described above. Modification of these components can lead to a variety of different business alternatives and choices, creating flexibility for an investor (Dimakopoulou & Pramatari 2009). For instance, tagging is a new attribute which can take several forms. Cases or individual items can be tagged leading to a "Case" or an "item" level of tagging, respectively. This different level of tagging supports different types of applications. In addition, in contrast to other technology investments, this attribute creates a new type of cost for the investor which is parametric and dependent on the number of the products that are tagged. This cost can reach very high points as this number increases or when individual products are tagged ("item-level tagging). This type of cost in contrast to other types of investments is a follow-on cost during the whole life of an RFID investment. Except for the tags, an investor can be in front of many business alternatives based on the number, the type or the location of the second RFID component which is the reading devices. These alternatives result to the creation of a type of cost which is again parametric and contingent on the number of the reading devices. In addition, the third component of an RFID system which is the software can stimulate the generation of multiple business applications. Applications of this technology based on a common infrastructure can operate simultaneously (Violino 2005) and support a variety of business aims and processes.

Altering the form of the above RFID traits can lead to different business functions and applications. For instance, assume that a reader is located in an inventory room at a store to identify automatically the stock of the products. If a manager decides to place an additional reader at the check-out points of the store in order to identify the sold products, then another business function occurs. Through the automatic identification of the sold products and the necessary software adjustments, the inventory of the store can be updated and decreased automatically by the number of the purchased products. This is a result of adjusting the location of the readers and the software of the system. Thus, modifying the basic components of the RFID system can result to different implementation options and RFID enabled applications. "*Whenever an IT project has flexibility about which applications and functions to implement and when or how to implement them real options are present* (Fichman et al. 2005)".

In addition, the literature (Patil 2004) has also supported the applicability of Real Options to the case of RFID technology due to high uncertainties that the technology entails. *"Due to the huge amount of investment and high risk associated with RFID project, ROV is a more suitable method for justifying RFID projects "* (Wu et al. 2009). *"RFID technology satisfies many of the conditions that are required for applying the real options thinking* (Goswami et al. 2008) ". As a result of these uncertainties, exploiting different kind of options can alleviate the risks of an RFID investment.

Previous studies on the use of Real Options for the investment evaluation and adoption of RFID technology

Although the pertinent literature applies Real Options approach to IT investment evaluations (Benaroch & Kauffman 1999; Benaroch, Lichtenstein, et al. 2006; Benaroch et al. 2007; Panayi & Lenos Trigeorgis 1998; Nalin Kulatilaka et al. 1999), studies on the application of the Real Options approach to the case of RFID technology are rare.

One example is Wu et al. (2009), which demonstrates how the real options method can be utilized for strategic RFID investment decisions. The authors apply the binomial lattice method to a hypothetical numerical example. Another study (Lee & Lee 2011) exploits real option analysis to assess RFID adoption in the supply chain through a fuzzy real option model that the authors develop. The authors utilize numerical examples. In addition, another work (Patil 2004) shows why and how real options can be applicable to RFID technology. The specific study applies the Black-Scholes model to a hypothetical example for the RFID investment evaluation. While all the above studies show the applicability of the Real Options approach to the case of RFID, they do not utilize data from a real case investment problem.

Apart from the above studies, which assess RFID technology with option pricing models, there are very few other studies which examine managers' perceptions on an RFID project value through real options. In a series of papers by Goswami and coauthors, (Goswami et al. 2010; Goswami et al. 2008) managers' perceptions regarding the impact of options on the RFID technology evaluation are examined. However the latter studies focus on the impact of institutional pressures as determinants of real options recognition and on the moderating role of the business type strategy. There are many other variables based on the literature that have not been addressed by previous studies and can be examined in future research as factors which influence real options recognition and value for the evaluation of RFID technology. In addition, previous research treats RFID technology as an entity, without considering how real options value can be differentiated across the different types of RFID projects. Future empirical research can address this issue.

2.5 Synopsis of Research Gaps

The motivation of this thesis has been based upon the three reviewed research streams. Regarding the first stream on **IT Investment evaluation and adoption** we have identified the following main research gaps. The majority of previous studies ignore the impact of managerial flexibility on the evaluation of information technologies with high risk. However, not considering the value of managerial flexibility can underestimate the value of innovative IT investments (Fichman 2004; Dixit & Pindyck 1994). In addition, most of the studies consider evaluation process as a single-one off evaluation procedure. However, the dynamic attributes of IT investments call for a dynamic and continuous investment evaluation process. Finally, previous empirical research rarely considers the problem of matching an IT investment evaluation approach with a specific IT project, as the majority of the studies treat IT as an entity. However, according to the literature "*a substantial improvement of IS evaluation concerns matching methods to characteristics of the IS investment* (Farbey 1999)". As a result, the following research questions emerge:

- *What is the impact of managerial flexibility on IT investment evaluation?*
- *What are the factors which stimulate managerial flexibility inherent in IT investment evaluations?*
- *What are the characteristics of IT projects which can be compatible with specific IT investment evaluation approaches?*
- *What types of IT projects offer managerial flexibility to decision makers?*

In addition, previous studies have offered a substantial understanding on the factors which contribute to IT organisational adoption. However, it is revealed that little is known of "how" managers understanding of the investigated factors (e.g. organisational/ technological/environmental) influence decision process leading to IT adoption. Managerial flexibility and real options could possibly have an impact on IT adoption and may explain the impact of several parameters on IT adoption. Future research can be directed towards designing empirical studies to gain a better understanding on the role of Real Options in organisational adoption of IT innovations (Goswami et al. 2008; Goswami et al. 2010). However, pertinent empirical research is rare. Under this perspective future research questions could be the following:

- *What is the impact of managerial flexibility (i.e. real options) on IT adoption?*
- *What is the relationship among IT innovation adoption factors and real options?*

In addition, the review on the **IT Real Options field** demonstrates that most of the studies assess the normative Real Option value of IT projects based on option pricing formulas, while neglecting the perceived (intuitive) Real Option value of these projects and essential qualitative parameters. However, the multi-dimensional nature of the IT investment decisions which depend on a set of tangible and intangible parameters calls for a hybrid approach (Hilhorst et al. 2008). Thus, researchers are recommended to extend the underexplored intuitive research stream of the IT Real Options field and reconcile it with the normative, in order to enhance the quality of IT justification and cover the limitations of these two approaches if they were exploited separately.

Furthermore, while the IS literature calls for research on IT “artifacts” rather than IT in general (Orlikowski & Iacono 2001), up-to-now the great majority of research on Real Options in the IT field treats IT projects as a homogeneous group rather than looking at individual features or types of IT projects. However, the literature has underlined the significance of investigating Real Option value in different settings as different types of IT projects may carry diverse option types and respective value. This research area has not been empirically investigated. Future research should examine this issue in order to examine and explain any possible discrepancies of the perceived real option value among different types of IT projects.

In addition, while in the field of Real Options several option value determinants have been proposed that can trigger the recognition of Real Options and boost Real Options value, studies which empirically explore the impact of these determinants are rare. As a result, future research questions that can address the above research gaps are the following:

- *How do managers value Real Options embedded in information technology projects?*
- *Is managerial intuition regarding Real Options value different than Real Options theory? Why?*
- *Do different types of IT projects carry a different real option value? Why?*
- *What are the attributes of these IT projects?*
- *What are the factors which trigger the recognition and increase the value of a real option in IT investments?*

Regarding the third stream of research: **RFID technology-Investment evaluation and adoption** we concluded on the following gaps. Although previous studies have been conducted to assess and justify deployment of this technology, empirical studies which address managerial flexibility for the technology assessment are rare. Curtin et al. state that *“Previous literature on RFID evaluation rarely does it take into consideration the flexibility and the different kind of options that an RFID investment can yield” (Curtin et al. 2007)".* The majority of the studies evaluate RFID investments as a single one-off evaluation procedure rather than as a process of constantly reviewed decision making. Most of the studies utilise traditional justification approaches which are inadequate to take into account the dynamic factors and high risk of RFID investments. However, flexibility and options for an investment evaluation of a technology with high uncertainty such as RFID generates value. As a result, there is a need to justify these kinds of IT investments through dynamic processes and methodologies such as Real Options which take into consideration managerial flexibility during the evaluation. Based on this research gap future research can address the following questions:

- *How can managerial flexibility be applied to the RFID technology justification process?*
- *What is the impact of managerial flexibility and options on RFID investment evaluation?*
- *What are the types of options than an RFID investment can generate?*

The review of this field and more specifically on firm adoption of RFID technology reveals also that there is a research gap regarding the subsequent adoption process of RFID technology. Scholars' calls invite researchers to find new adoption paradigms and parameters for RFID adoption in order to gain a better understanding. Researchers are recommended by the pertinent literature to understand what the influence of Real Options on RFID adoption is. As a result of the above future research questions can be the following:

- *What is the impact of Real Options on RFID adoption?*
- *What are the factors which can trigger the generation of Real Options embedded in an assessed RFID application and ultimately influence its adoption?*

From the literature gaps identified in the previous sections for the three research streams the following table includes all the identified research gaps. In bold are the research gaps which are related to the specific aim of this research.

Table 2.17 Synopsis of Research Gaps

Quotations from each research stream	Research Gaps
1. IT Investment evaluation and adoption	
1a. IT Investment evaluation	
The current financial justification methods are inadequate to deal with IT investment issues (Gunasekaran 2001) *"When uncertainty and irreversibility are high, omitting the value of managerial flexibility can lead to substantial understatement of the value of investments in new IT* (Fichman 2004; Dixit & Pindyck 1994). *Owing to the dynamic factors inherent in IT investments, evaluation must be regarded as a continuous process which needs to be constantly reviewed. It cannot be tenable to justify a policy proclaiming a single one-off evaluation procedure (Gunasekaran 2001).* *The 'quest' for one best method is proving fruitless….A major improvement of IS evaluation lies in matching the methods to characteristics of the IS investment….The project characteristics affect the way in which an investment decision is made and indicate which of the alternative appraisal techniques might be more suitable for a particular project" (Farbey 1999)*	**Conduct empirical studies for the investment evaluation of Information Technologies by:** **-Embedding the variable of managerial flexibility and** **-Considering the evaluation process as a constantly reviewed process and not a single-one off evaluation procedure.** Rare consideration and empirical research have been made for **matching** an **investment evaluation method with a particular IT investment. Consider the individual characteristics of each type of Information Technology and match them**

	with IT evaluation approaches.
1b. IT adoption	
"Little is known of how managers' understanding of factors external to the organization, the technology and the organizational context influences the decision process leading to IT adoption (Goswami et al. 2008) *"Future research can be directed towards designing empirical studies to gain a better understanding on the role of Real Options in organisational adoption of IT innovation (Goswami et al. 2008; Goswami et al. 2010)"*	**Investigate the role of managerial flexibility as an additional factor or a mediating factor which influences IT adoption.** **Examine the impact of Real Options on organisational adoption of IT innovation.`**
2. Real Options for IT	
2a. IT Real Options- Normative studies	
There is limited research on how to quantify qualitative factors and embed them in the RO modeling (Angelou & Economides 2009a; Hilhorst et al. 2008; Li 2009) *Researchers are recommended to create advanced option valuation mathematical models which are customized and tailored to a particular IT investment ((Bowman & Moskowitz 2001; Pendharkar 2010)* *The level of uncertainty is diverse in different types of IT projects, thus one general RO model for a project evaluation is likely to provide ambiguous results (Pendharkar 2010)* *Research on Real Options for justifying IT projects has mainly focused on valuation decisions for a stand-alone IT projects (Angelou & Economides 2008a)*	-Need for more research on the development of formulas for the evaluation of compound IT options. -Develop real options models which combine quantitative variables: (e.g. cost, benefit, volatility) with other qualitative variables/sources of uncertainties (ex. level of competition) in the models. -Develop new tailored-customized models based on the characteristics of specific IT projects. -Embed in the option pricing models the synergies of the IT projects as a parameter which influences their value.
2b. IT Real options- Intuitive studies	
Little research on <u>how the use of RO in capital budgeting affects the behavior and decisions</u> of managers (Denison 2009)- *Empirical tests of Real Options are few* (Tiwana et al. 2007) *"Little is known about the relative <u>value that managers ascribe</u> to the <u>different types of options</u> that may be embedded in <u>IT projects</u>"* (Tiwana et al. 2006) *Different types of projects might carry differential option value* (Tiwana et al. 2006; X. Li & Johnson 2002; L. C. Wu & C. S. Ong 2008) *Future research can study how and why the perceived RO value may be differentiated among various stakeholders* (Tiwana et al. 2006) *The majority of the empirical intuitive studies focus on the Real Options value of an IT project at a single point in time, rather than examining how the Real Options value can vary over a period of time* (Tiwana et al. 2006; Tiwana et al. 2007) *Future research is recommended to <u>identify when and why discrepancies between managers' intuition and Real Options theory</u> occur. Differences between intuitive and normative real options values appear to be option and setting specific and thus need to be theorized with respect to <u>specific options and settings</u>* (Lankton & Luft 2008). *An option can be considered as a strategy of a firm on Real Options* (Bowman & Hurry 1993; McGrath et al. 2004; Bowman & Moskowitz 2001). *This aspect has been neglected by the majority of current research.*	**Empirically study the <u>behavioral implications</u> of Real Options-(How do managers value Real Options?)** **Empirically examine the impact of specific <u>parameters of the technology, the organisation and its environment</u> which are proposed from the literature that they influence the recognition of real options in IT justification and adoption.** **Identify and empirically examine important factors (e.g. <u>types of IT projects</u>,** types of stakeholders, stages of IT projects**) which can act as <u>moderators</u> on the impact of Real Options on the IT project value** Conduct studies for the comparison of the two approaches (normative Vs intuitive judgement). Examine the impact of different types of followed IT strategies (a RO- based IT strategy vs. a non RO- based IT Strategy) on firm performance.

3. RFID Technology in the Supply chain	
"Previous literature on RFID evaluation rarely does it take into consideration the flexibility and the different kind of options that an RFID investment can yield" (Curtin et al. 2007)" *Interesting opportunities for new research on RFID: Researchers could test the notion that infrastructure technologies may not be the primary drivers of business value themselves, but rather create real options for additional follow-on investments"…." What future options does establishing an RFID infrastructure create? How can the options be identified? (Curtin et al. 2007)".* *"A research gap exists regarding the subsequent adoption process of RFID technology…Future studies may identify additional factors which contribute to RFID adoption* (Thiesse et al. 2011; S.-I. Chang et al. 2008; C.-Y. Lin & Y.-H. Ho 2009) *Are traditional IT adoption research paradigms appropriate for RFID technology? What new adoption paradigms make sense? (Curtin et al. 2007)* *RFID is an appealing case for applying real options analysis* (Goswami et al. 2008)… *"Future research can be directed towards designing empirical studies to gain a better understanding on the role of Real Options in organisational adoption of IT innovation-such as RFID (Goswami et al. 2008; Goswami et al. 2010)"*	Study RFID investments evaluation through other evaluation approaches which take into consideration managerial flexibility (e.g. Real Options) **Consider in empirical studies RFID technology as an initial investment which can yield future applications.** **Conduct empirical research to examine the impact of Real Options on RFID adoption.** **Examine the impact of several factors which trigger the creation of real options in RFID projects.**

Based on the identified research gaps on the second and main field IT Real Options, this thesis is going to explore the research gaps identified in the intuitive stream of research. The pin illustrates the position of this thesis within the IT Real Options field.

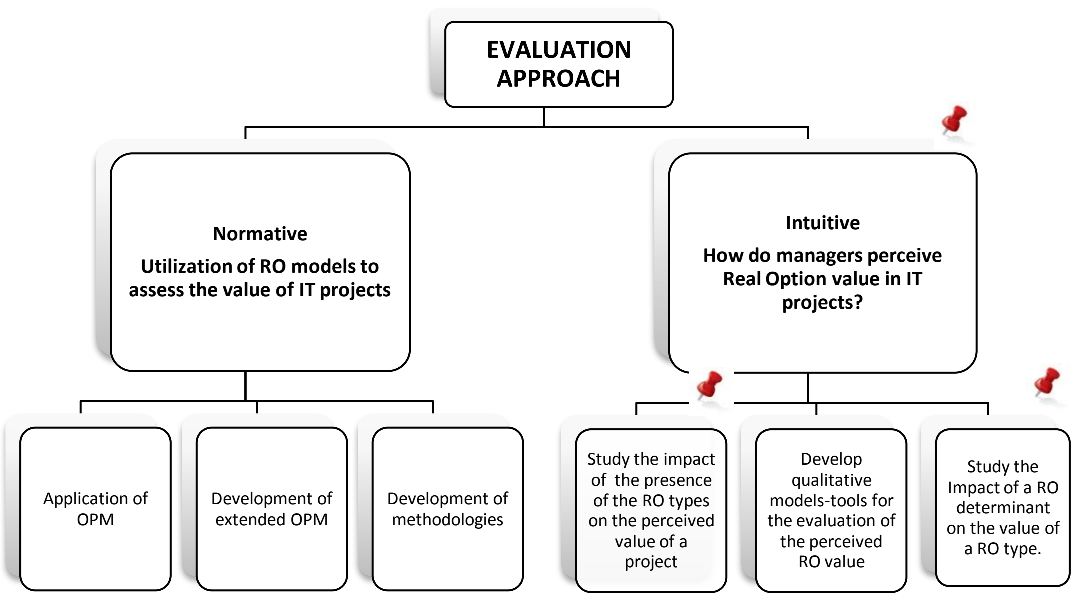


Figure 2.8 The thesis within the IT Real Options field

3 RESEARCH METHODOLOGY

3.1 Introduction

Based on the identified research gaps discussed in the previous chapter, the research objective and the research questions for this thesis are discussed in Chapter 3 and specifically in Section 3.2. The section after that (3.3) includes the research approach and the data collection and analysis techniques that are exploited to answer the research questions. The stages of the overall research plan and design of this thesis will be discussed in Section 3.4. Section 3.5 includes a justification of the RFID technology as the context of the study, while the chapter closes with a synopsis of the research studies conducted in the present doctoral thesis (Section 3.6).

3.2 Research objective and questions

As a result of the previous analysis in the literature review and the identified gaps the research objective of this thesis is to investigate the impact of real options on the value of an assessed IT project. The questions that it is the aim to be answered are the following:

- ***How do real options influence the value of an IT project?***
- ***How does the use of real options in IT capital budgeting affect the behavior and decisions of managers?***

In order to answer this general research objective, this thesis has the aim to investigate the following research questions:

1. *What are the determinants which influence real option recognition in an information technology project?*
2. *What is the impact of real options on the perceived value of returns of an information technology project?*
3. *Is this impact strengthened or mitigated across different types of IT projects?*

The following paragraphs explain the approach that is followed to answer to these questions.

3.3 Research Approach and Epistemological Considerations

Based on the literature, two main types of research can be followed to conduct a study: the **quantitative and qualitative** (Creswell 2003). Quantitative is *"an inquiry into a social or human problem based on testing a theory composed of variables, measured with numbers, and analyzed with statistical procedures, in order to determine whether the predictive generalizations of the theory hold true* (Creswell 2003)." On the contrary, qualitative research *"involves the use of qualitative data, such as interviews, documents, participant observation to understand and explain social phenomena* (M. D. Myers 1997).

In order to answer the research question regarding the role of real options in managerial IT investment decisions, the specific thesis combined the above two approaches (i.e. quantitative and qualitative research) resulting in a "multi-methods" strategy (Creswell 2003). Literature (Bryman 2006) underlines the fact that in the field of evaluation research the case for a multi-strategy research approach has acquired strong support as it provides a wealth of data to researchers.

For the specific study, the **mixed approach of qualitative and quantitative approach** was chosen. The reasons for this choice are based on Greene's typology and were the following: (a) *Development* "*which seeks to use results from one method to help develop the other method"* (Greene et al. 1989). In particular, findings from the initial qualitative study (e.g. dimensions of RFID applications which form an IT project typology) were utilised to refine the research questions and form some of the hypotheses developed and empirically tested in the second part of the research. (b) *Expansion "which seeks to extend the breadth and range of inquiry using different methods for different inquiry components"* (Greene et al. 1989; Bryman 2006). In this study, the qualitative part had the aim to explore the factors (including real options) which contribute to the value of an RFID project. The initial research question was: "How do real options affect the value of an IT project?" However, the case studies revealed specific types of real options and specific types of information technology projects which are generated during the investment evaluation process. Based on these findings, the research questions of the study became more specific resulting in expanded inquiries: e.g. "Do supply chain IT projects include a higher growth option value than internal IT projects?" "How do the organisational learning capabilities influence the recognition of growth opportunities in an assessed IT project?" A quantitative approach was then selected to answer these refined research questions.

At first a **qualitative approach** with the conduction of three case studies took place. In order to explore what are the factors that influence the value of IT innovative investments such as RFID, the qualitative approach was the most appropriate one. One of the first aims was to understand the concept of real options and how real options can be embedded in an IT investment evaluation process. According to the literature (Saunders et al. 2003), qualitative research results in non-standardised data and the analysis is conducted through the use and explanation of concepts and ideas. The concept of the value of RFID innovative projects and in particular real options value had to be explored and understood. Qualitative research fulfilled this aim. Moreover, through qualitative research the ability to probe for these underlying values was covered-a type of underlying reasoning which is difficult to be pursued by quantitative research (Yauch & Steudel 2003). In addition, in contrast to a quantitative approach, a qualitative research can give the opportunity to the researcher to examine participants' perspectives in depth (Creswell 2003). In the specific study, qualitative research gave insights regarding managers' views for the RFID implementation, dimensions of RFID projects which differentiated RFID adoption and real option opportunities which would be difficult to explore through a quantitative study. In addition, the questions "why" and "how" could be easily answered through qualitative research (Creswell 2003). Examples of these questions for this study were the following: "How do managers perceive real options in RFID investment evaluation?", "How and why are growth opportunities generated during an RFID investment evaluation process?".

Following the qualitative research the **quantitative approach** was conducted. Several findings from the case studies helped to refine the research questions and develop specific hypotheses to be tested further. Questions such as: "What is the impact of growth options on the perceived value of returns of an information technology project?, "Is this impact strengthened or mitigated across strategic and transactional IT projects?" were answered with quantitative approach. Quantitative approach was chosen because specific research hypotheses were developed to be tested based on the theory and the knowledge gained from the case studies. According to literature (J.F. Hair et al. 2006) quantitative approach is more useful for testing theory. In addition, in the specific study (chapter 6) one of the aims was to compare different groups of IT projects and examine whether their perceived real options value varies. According to the literature (Yauch & Steudel 2003), numerical data obtained through this approach facilitates comparisons between groups. Furthermore, the thesis had the aim to determine whether real options can influence managerial decision making regarding IT investment decisions. Numerical data helped to determine the extent of agreement or disagreement between respondents in the specific study (Yauch & Steudel 2003).

In addition, regarding **epistemology** (which refers to the theory of knowledge), two main approaches exist in information systems research (Galliers 1992): (a*) Scientific approaches* (or else called: positivist science) which can be characterised by repeatability and assume that observations of the phenomena can be made objectively and rigorously and (b) *Interpretivist approaches* which include the possibility of many different interpretations of the studied social phenomena. This thesis followed both: (a) Surveys and case studies were conducted which are categorised from Galliers (1992) under the scientific stream and (b) a critical review on three main streams (RFID & IT evaluation and adoption, and Real Options) was conducted which is categorised based on the literature under the interpretivist category.

3.4 **Research Design**

Research Design is the overall research plan that is followed to answer their research questions. "*It is the logic that links the data to be collected and the conclusions to be drawn to the questions of the study* (Yin 2009)". The following figure depicts the overall research methodology that is followed throughout this thesis. It consists of three main parts:

1. The critical review of previous studies on three research streams and the motivation and problem definition
2. The conduction of three case studies for an exploratory analysis and
3. The confirmatory stage, where empirical studies were conducted to test the formulated hypotheses

The aim of the research methodology is to:

1. examine and identify with qualitative research any similarities or possible differences about RFID investment evaluation process and real options among three case study organisations and
2. investigate the impact of specific types of real options on RFID evaluation and adoption through quantitative empirical analysis.

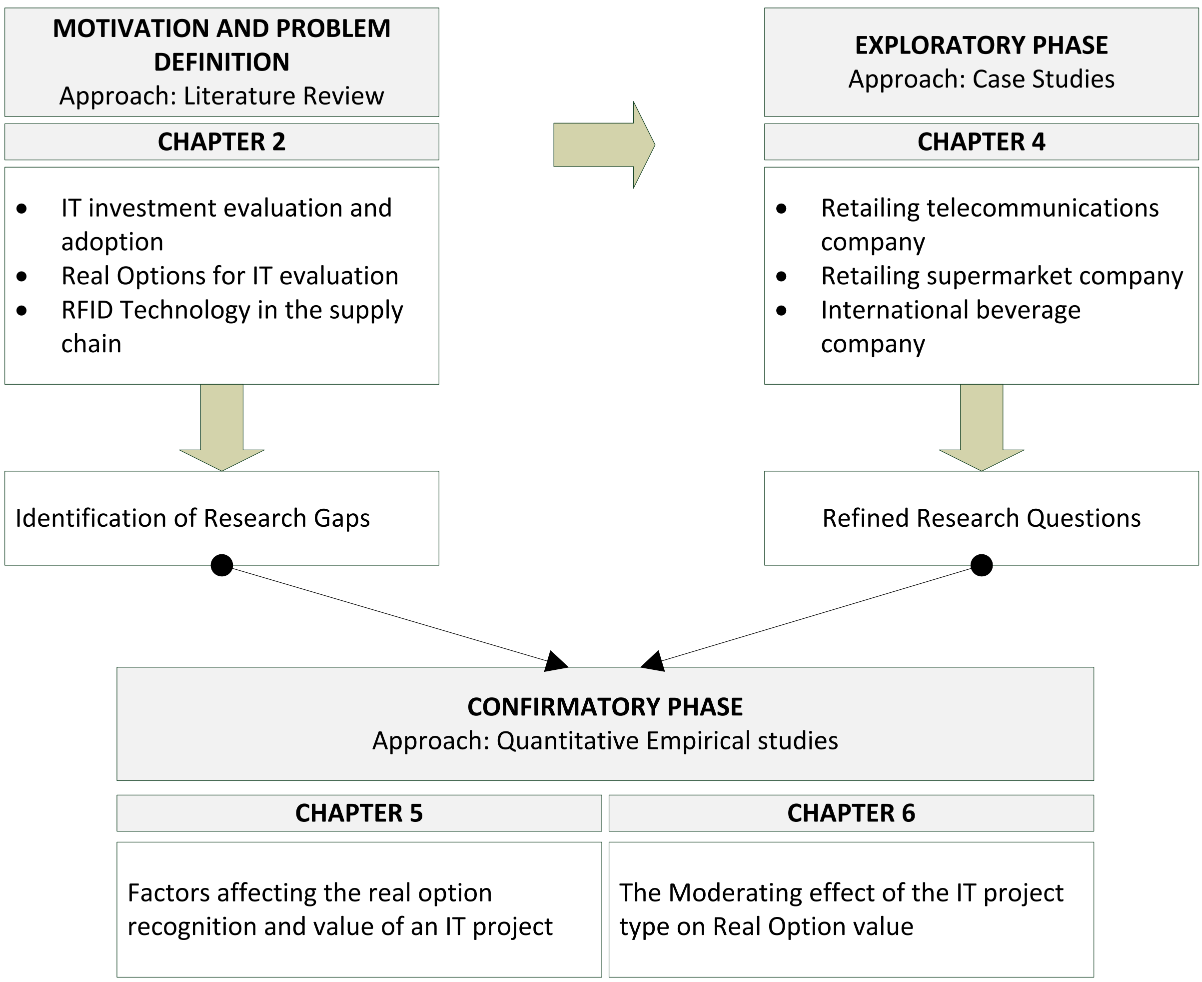


Figure 3.1 Research Methodology

3.4.1 Motivation and Problem definition

The three following research streams are studied: (1) IT investment evaluation and adoption, (2) Real Options for IT investment evaluation and (3) RFID technology in the supply chain. Based on these areas, specific research gaps were identified. These gaps formulated the motivation and the problem definition of the thesis.

A variety of several innovative technologies emerge throughout years. Research has focused on these kind of technologies to explore their new attributes, their complexity level as well as their impact on companies' processes and business performance. One of the most innovative technologies is RFID. Due to its unique attributes (e.g. readers, tags etc.) draw researchers' attention to be studied. One of the main areas of study for RFID and other innovative technologies is investment evaluation. Justification for the adoption of these innovative technologies by companies becomes essential due to firm financial limitations and limited capital budgeting. Based on Thong (1999), the stage of gathering and evaluating information for a technology innovation leads to its adoption stage. Based on the literature review on these two closely related fields (IT innovations investment evaluation and adoption), several methods and factors which are exploited by firms to justify information technology investments are analysed. Although previous studies offer significant understanding for the investment evaluation and adoption process, the majority of the studies is based on static evaluation methods and determinants without considering the dynamic nature (e.g. the flexibility, uncertainty and modularity, divisibility, growth opportunities) of the assessed innovative technologies such as RFID.

In the literature, this kind of dynamic nature has been introduced by the Real Options theory. Based on the pertinent review, Real Options have been introduced from the Financial field into the IS field for the evaluation of information technologies. Real Options analysis takes into consideration the flexibility that managers have when evaluating an investment such as: abandoning, delaying or staging an investment. According to the literature, these options entail value which has to be considered during an investment evaluation process. However, based on a critical review on this field, several gaps are identified. One of the most important gaps is the fact that very little is known about how the use of real options in IT capital budgeting affects the behavior and decisions of managers regarding the value of assessed IT projects (Tiwana et al. 2006; Tiwana et al. 2007; Denison 2009). Pertinent studies are rare, thus there is room for future research. The contribution of this thesis is positioned in this area. RFID has been selected as a basic context to apply this type of analysis for this thesis. Justification for this choice is analysed in the following section 3.5.

3.4.2 **Exploratory Phase-Case Studies**

This part consists of the qualitative part of the research. In order to have a practical insight on the determinants and the factors that influence the assessment of an IT project value (including the real options), three case studies have been examined. The main aim of the case studies was to explore the way the value of an RFID investment could be measured and investigate the factors (including real options) that have an impact on this value.

Each one case study was derived from different fields. The first case study was about a Retailing company in the telecommunications industry which merchandises several products (mobiles, electronic devices etc.) and consists of 150 stores in Greece. The company is one of the biggest telecommunications providers in the Greek market. The second case concerned a Retail Distribution center which is one of the biggest supermarket chains in

Greece. Finally, the third case concerned a distribution center and manufacturer company in the beverage sector in Greece which is part of an international company. Common issue in the above cases was the necessity to assess the value of RFID applications in their companies. A within case analysis and a cross-case discussion resulted in interesting findings that were utilised to form specific hypotheses for the empirical studies and refine the thesis initial research questions. For example, based on the three case studies it was found that RFID deployment varies based on several dimensions. Thus, different types of IT projects were revealed. These types were utilised as moderating factors for the quantitative confirmatory study analysed in Chapter 6.

Data collection and analysis techniques for the exploratory phase

For the data collection for each one case study several techniques were utilised. We refer to them briefly. A thorough analysis of these data collection tools for each one case study will take part in Chapter 4.

- Structured Interviews (e.g. with supply chain managers, employees)
- Archival records (e.g. organisational records regarding the products distributed in the supply chain, ERP reports)
- Direct Observations (e.g. observation of the AS-IS business processes inside a store/warehouse)
- Focus groups (e.g. presentation of the proposed RFID-enabled processes to the company members and evaluation)
- Survey data (e.g. questionnaires distributed to the employees of the organisation)
- Workshop (with supply chain executives)

For the analysis of the case studies, the strategy of using both *quantitative and qualitative data* and drawing a *cross-case conclusions* were the main techniques that were exploited (Yin 2009). A detailed discussion can be found in Chapter 4.

3.4.3 Confirmatory Phase-Empirical Research

The second part of the research concerns the quantitative stage of the thesis. Based on the identified literature review gaps and the findings from the case studies the following hyper research model is designed. The model studies the behavorial implications of real options for decision making on IT investments. Each one hypothesis in the model is theoretically justified and analysed in chapters 5 and 6. The hyper model includes two main studies.

The first study (Chapter 5) had the aim to examine whether real options (and more specifically growth options) are recognised by managers for an IT assessment and whether the recognition of real options can influence the perceived value of an IT project and its overall adoption. In addition, aim of this study was to investigate what are the determinants which can trigger the generation and recognition of real options.

The second study (Chapter 6) investigated the impact of three types of real options (growth option, stage option and deferral option) on the perceived value of returns. The main aim of this study was to examine whether this impact is strengthened or mitigated by IT project type.

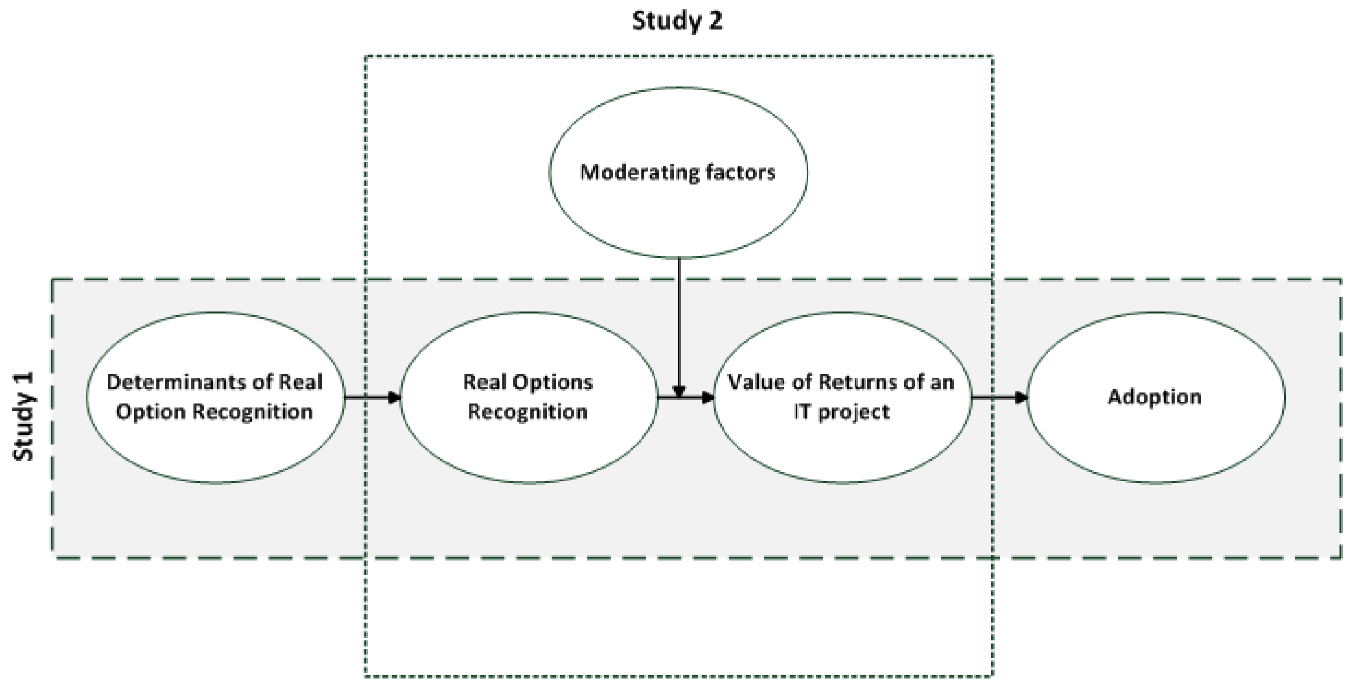


Figure 3.2 Research Hyper Model

Data collection and analysis techniques for the confirmatory phase

(a) Data Collection

The survey method: To test the hypotheses in the model a survey under a generated web-instrument was conducted. The specific data collection technique is utilised as the main aim was to gather data about managerial behavior towards evaluation and adoption of innovative information technology projects. Based on written responses to specific questions and statements participants of the survey were asked regarding assessment of IT projects. In addition, the study had the aim to examine the relationship among specific variables. *A survey based on the literature is a snap shot of views at a particular point of* *time regarding relationships that exist* (Galliers 1992). Thus, the survey was one of the most appropriate techniques to use for this reason.

Pilot Study

Researchers should pretest and/or pilot test instruments (D. W. Straub 1989). Under this perspective, the present doctoral thesis conducted a pilot study in order to examine and test the main data collection instrument which was developed for the investigation of the model presented in the previous section[2] (Mokhlis et al. 2009). Pilot tests provide a testing ground or dry run for final administration of the instrument (D. W. Straub 1989). However, it should be noted that the pilot study was not utilised for the main statistical purposes of this thesis, hence responses from the pilot study are not included in the research findings (Mokhlis et al. 2009). The descriptive and the further statistical analysis were only conducted to refine (where it is necessary) the items and words utilised in the main and final full-scale study.

The context to test the thesis' hypotheses was RFID technology. For this reason, the pilot study was conducted in the course of the RACE Network RFID project in Greece from the 22nd of October until the 19th of November 2010. This survey had the aim to ***monitor the interest and perceptions of the Greek organizations regarding RFID technology***, including real options impact. **98 respondents** answered this survey which was posted on the internet. The respondents participated in a conference on “New technologies for the warehouse” held in Athens on the 22nd of October 2010. 30 of the participants answered the survey on a hard-copy that day, while the rest of the participants (68) answered on-line, visiting the respective website. The respective questionnaire is depicted in APPENDIX 1.

The majority (48%) of the respondents were ***directors/CEOs*** or firm owners, while the 34% of the participants were middle or senior managers. About twenty percent of the respondents (21%) work in the ***logistics industry***. Other sectors included: Retailing, IT, Food and Wine Industry, Wholesale and Services. The majority (60%) of the participated companies were ***SMEs.*** Some indicative results include that: 71% of the participants agreed that RFID technology will succeed in adding value to their firm, while the ***40% of the respondents were willing to invest in RFID technology***. Further, the majority of the respondents (73%) would invest in RFID technology in the near future **due to the growth opportunities** that an initial investment in RFID could yield. Other reasons for investment in the near future are to gain first mover advantages (45% of the participants) and to respond to the high competition of the industry (30% of the respondents). In addition, **waiting for**

[2] The specific hypotheses and measurements of the model will be discussed in detail in Chapters 5 and 6.

the cost reduction of the RFID technology (option to delay investment), is the most important reason for the majority of the respondents (67%) **to delay their investment** in RFID technology. The respective diagrams in APPENDIX 1 depict the above indicative results. Overall, results from the pilot study indicated that respondents recognised Real Options. In addition, results indicated that organisational and technological parameters influence the recognition of growth options. However, the pilot study results as it was previously mentioned will not be utilised for this thesis' hypotheses testing as the aim of the pilot study was to refine and improve the web-instrument.

The pilot study resulted in an item, word and format refinement of the web-instrument. APPENDICES 1 & 2 include the instrument before and after the pilot study. Modifications included the following:

- During the pilot study, the respondents were asked to assess RFID technology. However, academic reviewers of this study expressed the necessity for the web-instrument to be more precise and specific. As a result, the aim of the full-scale instrument was refined to ask respondents regarding the investment evaluation of a specific RFID project, rather than the evaluation of RFID technology in general. For this reason, the questions in the instrument for the full-scale survey were refined to ask respondents to identify a specific RFID project they consider (e.g. inbound/outbound logistics, inventory audit, anti-theft control) and have it in mind for the rest of the questionnaire. This modification was justified by previous studies (Tiwana et al. 2006; Tiwana et al. 2007) on the behavorial implications of IT Real Options, which have included questions regarding the "IT projects" rather than the technology itself.
- In addition, in the pilot study the respondent companies were operating in Greece, where RFID has not yet been applied in a wide scale. Due to the fact that the next stage full scale survey would utilise a European sample, questions which asked respondents to identify their RFID investment status were added (e.g. already investors -pilot or roll out investment) in the modified instrument. In this way, rather than studying the impact of real options on the willingness to invest in RFID, it was possible to study the impact of real options and influenced value of returns on actual adoption.
- In the pilot study the respondents understood the binary variable which asked them to state whether RFID can support a family of applications or only a standalone application. In the full scale study, we wanted to test more types of IT projects regarding their moderating effect on the impact of Real Options. As a result, two

additional questions regarding the identification of the type of the technology project were added. In particular, the questions asked the respondents to state whether RFID is an internal or supply chain implementation and whether it has strategic or transactional aim. These would be tested further in the full scale study as moderating variables.

- Moreover, the variables which measured the real options were refined. In the pilot study the questions included the option for a company to grow its investment combined with the willingness to invest. "My company will invest in RFID in the future due to the future applications that can be generated from an initial investment in RFID". This question was refined in the full scale survey in order to divide the two main variables (i.e. growth option recognition and willingness to invest) into two different and separate constructs. The same was followed for the delay option too. The previous questions were meaningful in the pilot study but for the main study in the European study could not be exploited as the majority of the participants had already invested in RFID.
- In addition, all the variables which included a scale of agreement/disagreement and a level of high or low level response were refined. For example the statement: "The cost of RFID is high" was refined into: "The cost of this RFID project is" and the respondents would scale their answer from low level to high. In addition, the question which measured the perceived value of a technology project was refined into the following question: "The expected value of potential returns/payoffs for my organisation as a result of the RFID project deployment is". The respondents would choose their answer within a scale of low to high level.
- Finally, based on the bootstrap statistical analysis specific items which were not adequately cover the construct validity requirements were translated accordingly to become more clear and precise. For the English version of the following full scale survey, two native speakers reviewed and modified accordingly the respective items.

Full scale study

As the thesis context was RFID technology, the "RFID in Europe" network was utilised to distribute the refined survey instrument. This survey in contrast to the previous pilot study was based on a European sample. RFID in Europe AISBL is a non-for-profit organization established in 2012 with more than 300 members. It is an extension of a EU FP7 Thematic Network called RACE network RFID initiated in 2009. Aim of this network is to increase awareness for the technology and communicate RFID best practices. The participants of the survey have either been members of this network or had been contacted by members of that network. The respondents are expected to be the key personnel in their company involved in the respective RFID project they assess. Representatives from 121 firms participated in the survey coming from 14 different European countries, including United Kingdom, Czech Republic, France, Germany, Sweden, Ireland, Italy and Greece. A web-based questionnaire was used, which was distributed via e-mail to several recipients from 14 country representatives. From the 121 overall responses, 12 answers were discarded due to partial replies, resulting in 109 overall usable questionnaires. The respective questionnaire can be found at APPENDIX 2.

To assess the respondents' involvement in RFID implementations, the survey included questions to examine their familiarity with RFID technology. 80.7 per cent of the respondents stated that they are highly familiar with the technology, while 16.5 per cent stated that they are experts.

Regarding the level of diversity of the company respondents, 73.6 per cent were managers (27.4 per cent CEOs, 21.7 per cent senior managers and 24.5 per cent middle managers), while 26.5 per cent were employees or external partners. Half of the participating firms were small and medium enterprises (SMEs) (54.6 per cent), while the rest (45.4 per cent) were large companies with more than 250 employees and an annual turnover of over 50 million Euros. The participating companies represented several industries including the following with the highest percents: IT (17.9%), logistics (12,3%), retail (11,3%), production (9.4%) and services(8.5%).

Due to the variety of RFID applications, the project leaders and decision makers of such implementations are often coming from many different departments and operations within a firm, such as logistics, sales, personnel management etc., and are not only MIS managers. This diversity is also depicted in the respondents of the survey who represent several departments of a company and not only the IT department. In particular, 49 per cent of the respondents work in the IT or the logistics department, which are the departments with the highest relevance to RFID implementations, while 31.7 per cent of the respondents work in other departments (e.g. marketing, sales etc.).

(b) Data analysis techniques

Several statistical analysis techniques were utilised, such as:

- Descriptive Statistics to understand the attributes of the data and the sample (e.g. SPSS version 19)

- Multiple regressions to examine the predictive ability of specific factors on dependent variables with the utilisation of SPSS and Smart pls software packages
- Binary Logistic Regressions with SPSS to test the impact of a specific variable (perceived value of returns) on a binary one (actual adoption of an IT project)
- Other statistical tests to test differences between specific groups (e.g. Two way ANOVA , Multi Group analysis and t-tests)
- Statistical tests to examine mediation among variables (e.g. Sobel test)
- Structural Equation Modeling (SEM) including Confirmatory Factor analysis (CFA) to determine the reliability and validity of measurements as well as to examine the relationships among latent constructs (path analysis) (use of Smart pls version 2.0).

The above data analysis techniques can be categorised into two main categories based on the literature (Pallant 2005): (a) The techniques, which study the relationships among variables and (b) techniques which examine differences among groups. In the following paragraphs the above data analysis techniques that are exploited in the confirmatory phase of the thesis are discussed. In particular, analysis of each one technique (i.e. its aim, definition, explanation of its steps, formulas exploited), and the justification for their utilisation in this thesis are discussed. Due to the fact that Structural Equation Modeling is a second generation statistic process an emphasis will be given on its analysis, compared to first generation statistics such as multiple regression or analysis of variance.

(A) Statistical tests to examine relationships among variables

Structural Equation Modeling (SEM)

SEM *is a family of statistical modeling techniques that seek to (a) estimate multiple interrelated relationships among independent and dependent variables, (b) incorporate latent variables which are not measured directly (with "manifest" or "indicators") and (c) define a holistic model to explain these relationships* (Hair et al. 2009).

SEM examines the structure of interrelationships expressed in series of equations. 'Latent variables' are the theoretical, unobservable concepts, whereas the 'indicators' are also referred to as the measures of the latent variables or the 'manifest' variables (Joe F. Hair et al. 2012). SEM is a type of multivariate analysis which involves the application of statistical methods that simultaneously analyze multiple variables (Hair et al. 2013). This analysis can explain and test in a holistic model how latent variables can be measured through indicator variables (measurement theory) and examine and test how the latent variables are related to each other (structural theory). The latter is called as 'path analysis'. The path models are diagrams which are utilised to depict the hypotheses and variable relationships (Hair et al. 2013). Thus, SEM foundation lies in two multivariate techniques: factor analysis and multiple regression analysis simultaneously (R. Ho 2006; Joseph F. Hair et al. 2009).

Justification of SEM utilisation for this thesis

For the specific thesis and in particular for Empirical study II (chapter 5) SEM is utilised for the following reasons.

- Some of the "first-generation statistical methods"- (e.g. multiple regression or analysis of variance tests) (Bagozzi & Yi 2011) have a main limitation: they can examine only a single relationship at a time (Hair et al. 2009). However, the specific thesis is faced with a set of interrelated questions such as: "What variables determine technology adaptation?", "How does technology adaptation and organisational capabilities affect the recognition of real options and ultimately managerial decisions towards the adoption of an IT innovative project?" In addition, in the confirmatory part of this research, a dependent variable (i.e. growth option recognition) is at the same time independent for another variable (i.e. value of returns). First generation statistics such as multiple regression do not enable the researcher to test an entire theory (i.e. a set of relationships) with a technique that considers all possible information (Joseph F. Hair et al. 2009). Thus, Structural Equation modeling (SEM) is considered as more suitable as it can address these questions simultaneously with one comprehensive technique and holistic modeling. SEM is considered as more suitable for empirical study II in this thesis as it can test our hypotheses which contain multiple equations to assess measurement properties (e.g. measure of the variable: technology strategy) and at the same time key relationships among variables (e.g. impact of technology strategy on growth option recognition).
- Other reasons for utilising this analysis technique in empirical study II of the thesis are the following. Relationships between constructs with this technique are estimated more accurately (Hair et al. 2009). According to Ho (2006), SEM improves statistical estimation by accounting for measurement error in the estimation process. In addition, another important strength is that it forces the researcher to specify the theoretical model employed more exactly, testing the theory more precisely and yielding a more thorough understanding of the data (R. Ho 2006). Moreover, other reasons for utilising this technique is the more straightforward tests

of mediation and methods to assess construct validity in broader and deeper ways than in first-generation methods (Bagozzi & Yi 2011)

There are two types of SEM: The Partial least squares (PLS-SEM) and the Covariance based SEM (CB-SEM). The second technique (CB-SEM) is basically utilised to empirically test theory (i.e. a set of systematic relationships between multiple variables. This is conducted by determining how well a proposed theoretical model can estimate the covariance matrix for a sample of data (Hair et al. 2013). Thus, its focus is to examine the correlation coefficients among variables. In contrast, PLS-SEM aims at explaining the variance of the dependent variables when examining a model (Hair et al. 2013) and it is especially used to reveal the strength and direction of the relationships among variables. It is exploited to develop theories in exploratory research.

For this thesis we have utilised the PLS method (for the empirical study II analysed in chapter 5) for the following reasons:

- Behavorial analysis of IT investment evaluations based on Real Options approach is a very little researched area which is now developing, thus there is a limited number of formed theories to test. PLS method is better suited to these kinds of cases and it is suitable for exploratory research. PLS in contrast to CB SEM is especially suited to exploratory research where the relationships among constructs have not been previously tested (Jorg Henseler et al. 2009). For this thesis, aim of the empirical research II analysed in chapter 5 is to explore the impact of specific variables on the generation of growth options embedded in an IT project. Although relevant hypotheses have been made by previous studies, these are mainly propositions of theoretical arguments with a limited empirical testing. In addition, aim of the empirical study II is to examine whether the proposed model could explain and predict the variance of the dependent variable (growth options generation). Based on the literature for these cases when the goal is to identify key 'driver' constructs in order to predict target constructs, PLS structural equation modeling is more suitable than the CB technique.

- A second reason for this choice is the fact that PLS in contrast to CB-SEM is more suitable for small sample sizes (Hair et al. 2013). Parameters can be estimated independent of sample size (Jorg Henseler et al. 2009). In this thesis our sample size for empirical research II and III is 109 companies. Thus, PLS-SEM is more appropriate. In addition, PLS-SEM in contrast to CB-SEM has less strict assumptions about the distribution of variables (i.e. normal distribution of data) as it is mainly a nonparametric analysis technique. For this thesis, any violation of normality in the data is not a problem.

- In addition, PLS-SEM can easily handle, incorporate and evaluate reflective and formative measurement models as well as single item constructs with no identification problems (Hair et al. 2013). For this thesis and the empirical research II in particular, we see constructs which can either be expressed as formative or reflective and some of them (e.g. growth option) are measured with a single item.

(i) SEM model specification and estimation

PLS path models are defined by two sets of linear equations: (a) the inner model and the (b) outer model as depicted in the figure below. A PLS algorithm is running in order to solve the respective linear equations. The inner model (structural model) deals with the relationships between the latent (unobserved) variables and can be written as:

$$\xi = B\xi + \zeta$$

- *ξ is the vector of the latent variables*
- *B denotes the matrix of coefficients of their relationships (among the latent variables) and*
- *ζ presents the inner model residuals*

The second part of the model handles the relationships among the latent variables and their manifest variables (indicators). This model is the "outer" or "measurement" model. When the measures (indicators) represent the effect of an underlying construct, then all indicators are caused by the same construct which means that they stem from the same domain. This measurement model is the "reflective" model, because the latent variable is reflected to its indicators. These indicators are highly correlated to each other (Hair et al. 2013). Each indicator is assumed to be generated as a linear function of its latent variables and the residual ε as it is depicted below. Thus, single regressions are conducted which equal to the number of the indicators of one construct.

$$X_X = \Lambda_X \xi + \varepsilon_X$$

- *X_X are the indicator variables (i.e. X11,X12) of each one of the latent variables*
- *Λ represents the loading coefficient (among the indicators and the latent variable)*
- *ε_X represents the outer model residuals (for each one indicator variable)*

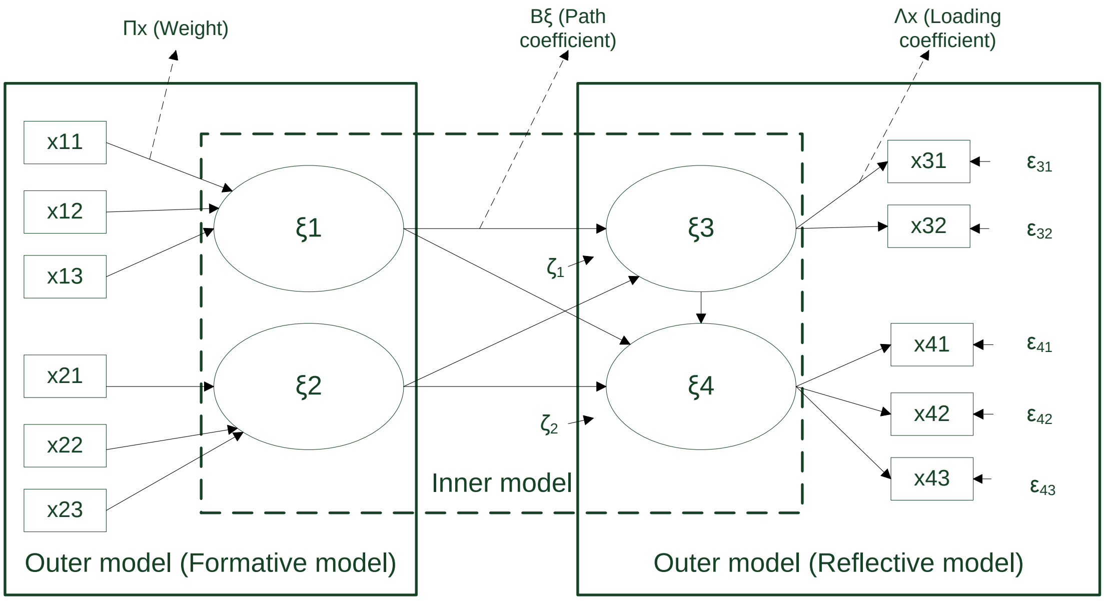


Figure 3.3 Example of PLS Path Model- Adapted from (Henseler et al. 2009, p.285)

On the contrary, when each one indicator captures a specific aspect of the construct's (latent variable) domain, then the items/indicators determine the meaning of the construct which means that they affect the construct and the measurement model is called "formative". In this case the construct is expressed by a multiple regression of its indicators as below. The dependent variable is the latent variable and the indicators are the independent variables of this multiple regression.

$$\xi = \Pi_X X_X + \varepsilon_X$$

- X_X *are the indicator variables (i.e. X11,X12) of each one of the latent variables*
- Π_X *represents the weight of each one indicator on the latent variable*
- ε_X *represents the error term*

Overall, the PLS algorithm includes a set of the above equations. As a first step the latent variable scores are estimated and then the relationships among the latent variables (i.e. path coefficients) and the relationships among the latent variables and their indicators (i.e. loadings/weights) are estimated.

(ii) Model evaluation

After the specification of the relationships among the variables next step is to evaluate the developed model. This evaluation includes two stages (a) evaluate the measurement model and (b) evaluate the structural model. For this thesis the following statistic tests are conducted. For the analysis, the measurement (outer) and the structural (inner) model are tested through the Smart Pls version 2.0 software. To test the construct validity of our measures in the measurement model, we employed **Confirmatory Factor analysis (CFA)** using this software. We have chosen confirmatory factor analysis, as it leads to a stricter and more objective interpretation of validity than the exploratory factor analysis does (Spanos & Lioukas 2001).PLS-SEM programme that is used, automatically computes latent construct scores for each respondent and the researcher does not need to summate scales. In this way construct validity is measured automatically, thus resulting in more robust results.

(1) Measurement model evaluation

(a) For reflective measurement models

Reliability: As a first step for the internal structure of the measurement model, the authors should examine the reliability of all the items of each one factor. Reliability tests the degree of agreement among a set of measures of a single construct (Bagozzi & Yi 2011). “Composite reliability” estimates in order to be satisfactory should be at least 0.70 (Fornell & Larcker 1981; Spanos & Lioukas 2001; Joe F. Hair et al. 2012). This provides a proof that each factor has internal consistency, as the measurement items for each one factor are consistent to each other. In PLS, composite reliability relies on actual loadings to compute the factor scores and is a better indicator of internal consistency than Cronbach alpha (Ranganathan et al. 2004).

$$CR = \frac{(\sum_{i=1}^{n} L_i)^2}{(\sum_{i=1}^{n} L_i)^2 + (\sum_{i=1}^{n} Var\ e_i)}$$

- L_i^2 *represent the standardised factor loadings which relates each indicator to the construct*
- n *represents the number of the indicators/items*
- $Var\ e_i$ *depict the error variances*

In addition, the authors should test “indicator reliability”, i.e. the reliability of the individual items of each one factor (Hair et al. 2011). A factor loading represents the correlation between an original variable and its factor, which according to Hair et al. (Joseph F. Hair et al. 2009), it should be higher than 0.55 for samples with N=100.

Convergent validity: In order to examine if the measurements of each one factor converge and share a high proportion of variance in common, the Average Variance Extracted (AVE) is calculated. It is computed as the grand mean value of the squared loadings of the indicators associated with the construct (i.e. the sum of the squared loadings divided by the number of the indicators) (Hair et al. 2013). AVE for each one factor should be greater than 0.5 which is the threshold point (Bagozzi &Yi 1988) above which convergent validity becomes evident. When AVE is more than 0.50 means that a construct is able to explain more than half of the variance of its indicators on average (Jorg Henseler et al. 2009) However, for the single item measurements the AVE equals to 1.

$$\text{AVE} = \sum_{i=1}^{n} L_i^2 \,/\, n$$

- L_i^2 *represent the standardised factor loadings which relate each one indicator to the construct*
- n *represents the number of the indicators/items*

Discriminant validity: After examining the relatedness among the indicators within their respective factors, the discriminant validity of the measurement model is tested. This measure examines the extent to which a construct is truly distinct from other constructs (Hair et al. 2009). It is tested with two measures. According to the first test, the loadings of each one measurement item on its corresponding item should be higher than their loading on other constructs (Hair et al. 2011). To examine the discriminant validity of the measurement model, the authors conduct another test. According to this test (the Fornell-Larcker criterion) the square root of the Average Variance Extracted (AVE) of each one construct should be higher than its correlation score with all other constructs (Fornell & Larcker 1981). This result indicates that more variance is shared between the construct and its measurement items than with another construct which includes a different set of items.

Table 3.1 Latent variable correlations and square roots of average extracted (AVE) adapted from (Hair et al. 2013)

	Y_1	Y_2	Y_3	Y_4
Y_1	$\sqrt{AVE_{Y1}}$			
Y_2	CORR Y_2 Y_1	$\sqrt{AVE_{Y2}}$		
Y_3	CORR Y_3 Y_1	CORR Y_3 Y_2	$\sqrt{AVE_{Y3}}$	
Y_4	CORR Y_4 Y_1	CORR Y_4 Y_2	CORR Y_4 Y_3	$\sqrt{AVE_{Y4}}$

(b) For formative measurements

If variables are treated as formative measurements this means that indicators are not interchangeable and they cause and influence each one latent variable. In formative measurements it is not necessary that if one indicator change in a particular direction, the others will change in a similar manner (Petter et al. 2007). Based on the literature, (Diamantopoulos & Winklhofer 2001; Bagozzi & Yi 2011) the latent variables are determined by a linear combination of measures of independent variables and thus are termed as formative indicators. In order to report and evaluate the quality of the measurement model the following criteria should be investigated based on the respective literature on formative models (Ringle et al. 2012; Diamantopoulos & Winklhofer 2001; Petter et al. 2007; Joe F. Hair et al. 2012).

Nomological validity: The relationships between the formative index and other constructs in the path model should be strong and significant (Jorg Henseler et al. 2009). ***Content and indicator specification*** refers to defining the scope of the latent variables to be measured. The latent variables should be precisely defined based on the literature and the respective indicators should be defined based on previous works.

Construct validity: Based on Petter (2007), construct validity for formative measurements is examined through the item weights. In addition, the significance of the weights are estimated based on Hair et al., (2011). However, in order to preserve content validity of the measurements, some of the non-significant items in the model can be kept into the model (Petter et al. 2007).

In addition, the ***reliability*** of the formative measurements should be measured based on the estimations of ***multicollinearity*** among the items (Petter et al. 2007). Due to the fact that formative models are based on multiple regression (instead of simple regressions as in the reflective models), correlation between the indicators would affect the stability of the indicator coefficients (Diamantopoulos & Winklhofer 2001). Finally, the **external validity** of the formative measurement model is measured based on the impact of one latent formative variable on another latent variable which is expressed with a reflective measurement model. The aim is that the formative index should explain a big part of the variance of the alternative reflective measure (Jorg Henseler et al. 2009).

(2) Structural model evaluation

To test the formulated hypotheses and the significance of the independent variables, PLS algorithm is conducted in the Smart PLS software programme. The **explanatory power of the model** is examined by testing the R^2. This coefficient is a measure of the model's predictive accuracy and is estimated as the squared correlation between a specific endogenous construct's actual and predicted values (Hair et al. 2013). It represents the amount of variance in the endogenous construct explained by all the independent variables which are linked to it.

$$R^2 = 1 - \frac{Var(e)}{Var(y)}$$

- $Var(e)$ *is the variance of the measurement error in the regression*
- $Var(y)$*is the variance of the dependent variable*

Predictive power of the model is tested by examining the magnitude of the standardized parameter estimates (path coefficients) and the respective level of significance. The estimation of the path coefficients and their respective T value comes as a result of the PLS algorithm and the bootstrapping analysis. Whether a coefficient is significant or not it depends on its standard error that is obtained by means of bootstrapping.

$$t = \frac{p_{13}}{se_{B_{13}}}$$

- p_{13} *represents the path coefficient of one latent variable on another and*
- $se_{B_{13}}$ *is the standard error (the measurement error)*

<u>*Multiple regression*</u>

For this thesis and more specifically for empirical study III (chapter 6) in order to investigate what is the impact of three types of real options on the perceived value of returns of an assessed IT project, multiple regression is considered as the most suitable technique. Due to its wide exploitation we are not going to analyse the main aspects of multiple regression. On the contrary we refer to the reasons of utilising it for this thesis.

Justification of the utilisation of multiple regression for empirical study III of the thesis

- One of the main aims of empirical study III in this thesis is to predict the variable: perceived value of returns based on whether the respondent companies understand the value of real option types or not.

- In empirical study III, the examined variables (three types of real options) are not measured as latent variables. Thus the need for utilising a more advanced technique (e.g. structural equation modeling) which deals with the measurement properties of latent variables is not justified.

- Due to the aim of the empirical study III, there is no need of exploiting a method for the simultaneous estimation of factor analysis and regression analysis. The real option types are not operationalised as constructs with many indicators. Thus, a multiple regression is adequate and mostly appropriate.

- The independent variables of the model in empirical study III are not correlated to each other based on the respective statistical test. This attribute makes suitable and justifies the utilisation of multiple regression in this case.

Logistic Regression

In order to examine the impact of the perceived value of returns on actual adoption of an IT project, logistic regression is conducted (empirical study II, chapter 5). Logistic regression is a form of regression which is conducted to predict and explain a binary (two group) categorical variable (Hair et al. 2009). The two groups of the dependent variable are represented by as binary with two values. For this thesis, 1 represents that the respondent company has already invested in the assessed RFID project, whereas 0 indicates that the respondent company has not implemented the examined project. The coefficient of a logistic regression reflects the impact of the independent variables on the likelihood of a company being an adopter of the RFID technology.

Justification of the utilisation of Logistic regression for this thesis

Overall, logistic regression is preferred method for a two-group (binary) dependent variable due to its robustness, ease of interpretation and diagnostics (Hair et al. 2009). More specifically:

- Logistic regression is the appropriate statistical technique when the dependent variable is a categorical variable with two values and the independent variable is a continuous or categorical variable. In empirical study II of this thesis (chapter 5) the status of adoption takes a binary value depending on whether the respondent company is an adopter or not of RFID technology. In addition, the independent variable (i.e. value of returns) is a continuous variable which takes values from 1 to 7. As a result, logistic regression is appropriate to be exploited.

- Logistic regression in contrast to other techniques (e.g. discriminant analysis) is chosen as it does not face the strict assumptions of multivariate normality and equal variance across the examined groups. Logistic regression is developed to deal with these issues (Hair et al. 2009).

- In addition, logistic regression is similar to multiple regression and thus it is uncomplicated to interpret its results.

The logistic regression utilises the logistic curve to represent the relationship between the independent variables and the binary one. For each observation the logistic regression predicts a probability value between 0 and 1. The figure below shows that in very low levels of the independent variable (i.e. perceived value of returns for the empirical study III of this thesis) the probability approaches 0 but never reaches it. As the independent variable (i.e. perceived value of returns) increases the predicted values increase up the curve but then the slope starts decreasing. We can restate the probability that a company can be adopter as the odds (probability i/(1-probability i). The odds variable is transformed to the **logit value** which is calculated as the logarithm of the odds. Odds less than 1.0 will have a negative logit value and odds greater than 1.0 will have positive logit values.

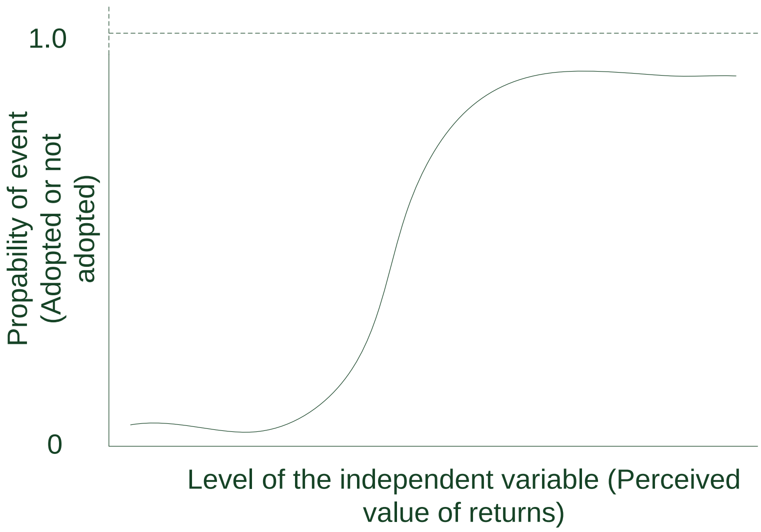


Figure 3.4 Form of the logistic relationship between dependent and independent variables (Adapted from (Hair et al. 2009)

The goodness of fit of the estimated model can be assessed based on a **"pseudo" R^2** value similar to the one of the multiple regression. The **Cox and Snell R^2** values indicate the amount of variation accounted for by the logistic model. The **Omnibus test of model coefficients gives** an overall indication of how well the model performs. We would like to get a high significant value (p value< 0.05).

Regarding the impact of the **variables in the equation, the outcome of a logistic regression is** the original values (B) which are the logit/logistic coefficients (log of the odds). Because of the fact that the logit coefficients are difficult to interpret, the computer transforms this value to the "exponentiated logistic coefficient" values (Exp)B which are the odds (=antilog of the original values). Direction of the impact of the independent variables is explained as following. When the odds equal to 1, this means that its log is 0. This means that when the odds value is 1, the independent variable has no effect on the dependent variable. Thus, when the exponentiated value is more than 1 (and the logit values are negative) then the relationship between the independent and the dependent variable is positive. Under the same perspective, when the Exp (B) is less than 1 (and the logit values are negative) the relationship is negative. Regarding the significance of the impact that the independent variables have on the dependent variable, we take into consideration the Sig. level which is depicted in the respective table results, as it happens with multiple regression.

(B) Statistical tests to compare groups

Multi group analysis (MGA)

According to Hair et al. (2013), respondent companies can be heterogeneous in their perceptions which can yield to significant differences of path coefficients among different groups. Considering heterogeneity, one of the aims of the thesis is to examine whether the strength of the impact of real option types on the perceived value of returns of an IT project depends on the type of the IT project. For this reason the Multi-Group Analysis (MGA) method is utilised.

Justification for its utilization in this thesis

- Multi-Group analysis is applied to cases, where the moderating variable is categorical and not continuous (Hair et al. 2013). In this case (empirical study III, chapter 6) the moderating variable is the IT project type which takes from 2 to 3 values (e.g. supply chain or internal IT project, strategic or transactional IT project). If the moderating variable was continuous (e.g. taking variables from 1 to 7) then the MGA would not have exploited. Instead the interaction effects of the moderating variable with the independent would have been estimated.

- MGA is suitable when the researcher has the aim to assess the differences of path coefficients among different groups of data. The aim of empirical study III in this thesis is to compare the coefficients of different groups of data. The grouping of data is based on how the data are divided based on whether the assessed IT project is strategic, supply chain or family application. Thus MGA is appropriate.

- MGA can investigate the moderating impact, when the independent and dependent variable are continuous. In empirical study III, the real option types and the dependent variable (i.e. value of returns) are continuous. If this was not the case, and the real option types were variables with a categorical value, then other approaches could have been utilised (e.g. Two way ANOVA)

To conduct the MGA the proposed steps by the literature (Chin 2000) are followed. The basic idea is that a t-test is conducted to compare path coefficients among groups. In particular, the following parameters have to be specified in order to estimate the MGA outcome (Hair et al. 2013).

1. The number of observations ($n_{1\,,}\, n_2$) in Group 1 and Group 2,
2. The path coefficients $(p_{1\,,}\, p_2)$ of Group 1 and Group 2 (for the impact of the independent variable on the dependent) and
3. The standard errors($se_{p_1\,,}\, se_{p_2}$) of the path coefficients of Group 1 and Group 2.

The above numbers are the input for the following t-test and the respective formulas. Based on whether the variances are different in the compared groups, the researchers can utilise the formulas below respectively. Formula (1) follows a t-distribution with $n^{(1)}+ n^{(2)}-2$ degrees of freedom, whereas formula (2) is utilised when the two variances $n^{(1)} \cdot se^2_{\theta(1)}$ and $n^{(2)} \cdot se^2_{\theta(2)}$ are assumed different.

$$t = \frac{\theta^{(1)} - \theta^{(2)}}{\sqrt{\frac{(n^{(1)}-1)^2}{n^{(1)}+n^{(2)}-2} \cdot se^2_{\theta(1)} + \frac{(n^{(2)}-1)^2}{n^{(1)}+n^{(2)}-2} \cdot se^2_{\theta(2)}} \cdot \sqrt{\frac{1}{n^{(1)}} + \frac{1}{n^{(2)}}}} \qquad (1)$$

$$t = \frac{\theta^{(1)} - \theta^{(2)}}{\sqrt{\frac{n^{(1)}-1}{n^{(1)}} \cdot se^2_{\theta(1)} + \frac{n^{(2)}-1}{n^{(2)}} \cdot se^2_{\theta(2)}}} \qquad (2)$$

- *θ:the path coefficients for group 1 and group 2,*
- *n:the sample size for each one group 1 and 2 and*
- *se: standard error for each one path coefficient*

Two way ANOVA

In order to conduct an additional analysis regarding the differences of the impact of real option types among the different groups and validate the above results, another statistical test: Two way ANOVA (Analysis of Variance) is conducted. Two-way means that there are two categorical independent variables and one continuous dependent variable. In this case, for empirical study III (chapter 6) the dependent variable is continuous (i.e. value of returns), whereas the independent variables are the grouping variable (IT project type) which is categorical and the real option types which are measured as continuous variables. In order to be able to utilise this approach we transformed the continuous variables (i.e. real option types) into categorical ones with the aim to test whether the type of IT project type moderates the relationship between real option types and perceived value of returns. Based on the SPSS software, for this thesis the Two way ANOVA is conducted indicatively for one case as an additional analysis to the MGA.

The main steps of this analysis are the following (Pallant 2005):

1. Conduct the Levene's test of equality of error variances. The Sig. level should be not significant, in order to have the same variance among the compared groups and to support the H_o that the variances are not different. In empirical study III, this assumption is met.

2. Run the analysis and interpret the outcome based on the interaction effect between the grouping variable (i.e. the IT project type in this case) and the independent variable (i.e. real option types in this case). Consider the significance of the interaction effect which should be <0.05.

3. Conduct multiple comparisons among the examined groups in order to investigate where exactly the difference among the groups is occurred (i.e. between which exact groups)

The following table summarises the main data analysis techniques utilised in the confirmatory phase of the thesis. An analytic reference of the above techniques and their results will take part in Chapters 5 & 6.

Table 3.2 Synopsis of the main data analysis techniques in the confirmatory phase of the thesis

Data Analysis technique	Aim of the analysis	Chapter /Study	Justification of its use for this thesis
Analysis to test relationships among the variables			
Multiple regression	Study the impact of the presence of real option on the perceived value of returns of an IT project.	6 (Empirical study III)	• Prediction of perceptions/decision making • No need of exploiting a method for the simultaneous estimation of factor analysis and regression analysis (e.g.SEM). The real option types are not operationalised as constructs with many indicators. Thus, a multiple regression is adequate and mostly appropriate.
Logistic binary regression	To study the impact of perceived value of returns on the status of adoption.	5 (empirical study II)	• Dependent variable is a dichotomous/binary variable. • Free of assumptions (normality and no difference in the variance of the groups)

			• Similar to multiple regression, thus not complicated to interpret the results.
Structural Equation Modeling (SEM) Including confirmatory factor analysis (CFA)	To study the variables which drive the generation of growth options embedded in an IT project.	5 (empirical study II)	• Simultaneously test a holistic model which examines and estimates the relationship of latent variables with their indicators and the relationship among independent and dependent (endogenous) variables (i.e. drivers of growth option generation) (Hair et al. 2009) • Examine the model as a whole (confirmatory factor analysis and path analysis) • Robust technique to assess construct validity and understand the data (Ho 2006; Bagozzi & Yi 2011)
Analysis to compare groups			
Multi-group analysis (MGA)	To study whether the impact of real option types on the perceived value of returns is strengthened in particular types of IT projects.	6 (Empirical study III)	• Assumptions met: the moderating variable is a categorical one and the independent and dependent variables are continuous. • Aim to compare the path coefficients across the different groups of data (i.e. IT project types)
Two way ANOVA	To study the moderating effect of IT project type on the relationship between the presence of real option types and managers' perceptions for the value of an IT project.	6 (Empirical study III)	• Validate the above results of the MGA. • Graphically represent the results.

3.5 Justification of the Study Context-RFID Technology

For the specific thesis (both the exploratory and the confirmatory phase), RFID technology has been utilised as the context of the study for the following reasons.

1. RFID technology is an innovative technology

Since, the majority of relevant research on the real options field concerns the evaluation of innovative IT platforms, RFID technology which is an innovative and infrastructure (platform) technology is considered as a highly related context where the proposed from the literature real option determinants can be applied to and explored.

2. Few empirical studies on the utilisation of Real Options for the RFID evaluation

A second reason for this choice, is that although RFID is a highly suitable context for Real Options analysis, very few empirical studies (Goswami et al. 2008; Goswami et al. 2010) have been conducted to evaluate RFID technology based on this approach. Although there have been conducted a lot of studies (C.-Y. Lin 2009; Thiesse et al. 2011; S. Leimeister et al. 2009; S.-I. Chang et al. 2008; Vijayaraman et al. 2008; Roh et al. 2009; S. Kim & Garrison 2010; Tsai et al. 2010; Tsai et al. 2012; I. Brown & Russell 2007) which examine the determinants of RFID adoption and the antecedents of RFID investment evaluation, studies on the examination of real options as a motivation of RFID adoption are rare. However, recognition of options in the case of RFID can have a significant impact on its perceived value and willingness of adoption (Goswami et al. 2008; Goswami et al. 2010). Thus, the application of real options in the case of RFID can give interesting insights. Curtin et al. (Curtin et al. 2007) argue that interesting opportunities for research on RFID emerge and that “researchers could test the notion that infrastructure technologies may not be the primary drivers of business value themselves but rather create real options for additional follow-on investments”.

As it was discussed in Section 2.2.2, attributes of the RFID technology i.e. **irreversibility, uncertainty and flexibility** justify the utilisation of real options approach. In particular, previous studies (Bottani & Rizzi 2008) have shown that the cost undertaken with the implementation of RFID is high and irreversible in specific circumstances such as the implementation of the technology based on tagging per item. Regarding uncertainty, studies have underlined that *"technical uncertainties over possible configuration for tags and tag-readers, differences in available frequency bandwidths, social concerns regarding loss of privacy and security, etc. are some of the factors that result in uncertainty over the future destiny of the technology and its outcomes* (Goswami et al. 2008)". In addition, RFID technology is highly flexible and modular. For example, the technology can support several applications for a series of business processes with many alternative configurations based on several issues such as: the level of tagging, the placement and the number of the readers etc. Based on the literature, in the cases where we have irreversibility, uncertainty and managerial flexibility traditional discounted cash flow methods are not appropriate for the valuation of investment projects (Dixit & Pindyck 1994) and Real Options becomes a better alternative.

One of the very few studies which examines empirically RFID adoption under the option lens is Goswami et al. (Goswami et al. 2008; Goswami et al. 2010). Our study is differentiated with Goswami's study as following. Goswami's study explores a set of institutional factors which affect the recognition of real options and ultimately RFID adoption, while this study examines the impact of a different set of technology and organisational parameters. In addition, Goswami's study is focused on non-RFID adopters. On the contrary, this study takes into consideration not only adopters but also companies which have already adopted and implemented RFID technology. Comparison of these two groups gives interesting results. Another difference between Goswami's study and this one is that the focus of this study is the examination of determinants of growth option value, while Goswami's study examines more than one type of options. In addition, our study collects data derived from a European network and several countries rather than focusing on one country as Goswami's study.

3. RFID technology can support many different types of Information Technology Projects

RFID technology is utilized in this study as it is considered one of the most suitable contexts to test our hypotheses regarding the moderating effect of the different IT project types (Chapter 6). RFID technology, due to its modularity and flexibility, can yield to several different types of investment projects according to different business needs. Thus, RFID implementations can take several different forms of investment projects. In particular, an RFID project can be utilized as an infrastructural project which supports several business applications or a stand-alone project which supports mainly one basic business process. In addition, RFID technology, depending on the way it is implemented, can be utilized for strategic, transactional or informational purposes. Moreover, there are RFID projects which necessitate the collaboration of several supply chain partners but also others that are developed internally in a firm, without the need for collaboration. One example of an internal RFID project is the utilization of the technology for access control. For instance, an employee’s RFID tagged card is identified by a reading device which allows the access of the employee to a building. This application can be utilized solely by one company and requires investment by one business entity internally. On the other hand, an example of a supply chain RFID project is collaborative promotions management (Bardaki et al. 2012). In this case, supply chain partners need to collaborate, as the product supplier is the one to attach RFID tags on the products and the retailer is the one to exploit RFID technology in the store to offer enhanced promotion service to the consumers.

3.6 **PhD Research Studies**

The following table depicts the overall research studies that were conducted for the aim of the present PhD thesis.

Table 3.3 PhD Research Studies

Study	**Date**	**Research Method/Sample/Case**	**Title/Aim**	**Method of Analysis**	**Thesis**
Case Study 1	November 2007-April 2008	Retailing Telecommunications Company	Investment evaluation of RFID supply chain applications for a retailer	Case Study analysis (within and cross-case findings)	Chapter 4
Case Study 2	October 2008-June 2009	Retailing Supermarket Company	Investment evaluation of RFID collaborative supply chain applications	Case Study analysis (within and cross-case findings)	Chapter 4
Case Study 3	November 2010-November 2011	Retailing beverage company	Investment evaluation of supply chain RFID for a supplier	Case Study analysis (within and cross-case findings)	Chapter 4
Empirical Study 1 (Pilot Study)	October-November 2010	Survey on RFID in Greece, N=98	-Pilot survey test-Pre test the survey instrument and refine it -Examine the impact of Real Options	SPSS, Smart pls	Chapter 3
Empirical Study 2	February-March 2011	Survey on RFID in Europe, N=109	-Examine the factors that influence (growth) real option recognition -Examine real options recognition as a mediator between IT innovation adoption determinants and overall value of an IT project	SEM (Smart pls) for Bootstrap analysis, Mediating tests (Sobel test), SPSS for descriptive and Logistic regression	Chapter 5
Empirical Study 3	February-March 2011	Survey on RFID in Europe, N=109	-Investigate the impact of real option types on the perceived value of returns of IT projects -Investigate the real option value in different IT project types	SEM (Smart pls) and (SPSS) Regressions Moderating tests (Multi-Group analysis, Two-way ANOVA)	Chapter 6

4 RFID INVESTMENT EVALUATION IN THREE CASE STUDIES

4.1 Introduction

Based on the previous chapter on the Research Methodology, the first part of this thesis is the exploratory phase. Chapter 4 has the aim to analyse this phase which refers to the analysis of the three examined case studies. Section 4.2 includes details regarding the case study research design. Sections 4.3, 4.4 and 4.5 include the analysis of each one of the three case studies respectively, whereas section 4.6 consists of the cross-case findings. The chapter ends with the final section 4.7, where the refined research questions based on the case study findings are discussed.

4.2 Case study research design

4.2.1 Multiple cases design

Based on the questions derived from the literature gaps, the aim of the case studies was to refine the research questions of the study, make them more specific and develop specific hypotheses which could be later tested with the confirmatory part of this thesis, under empirical research.

In particular, the research questions of the study had the aim to explore the role of real options in the investment evaluation of IT innovative projects. The three sub-questions (Section 3.2 in the Methodology Chapter) included the identification of the determinants which trigger the generation of real options and the investigation of the impact of real options on the IT project value of returns. Finally, the third sub- research question had the aim to explore whether different types of IT projects include different types of real options. Before answering these types of questions, case studies helped to make these questions more specific. As a result, the aim of the case studies was to answer the following questions:

- What types of real options occur during an IT investment evaluation and adoption process? How do these types of real options occur? How are these related to the assessed value of returns of an assessed IT project?

- What dimensions differentiate Information technology projects and generate different types of projects? How are these different types related to the business value (including real options value) of an IT project?
- What organisational or technological parameters influence the value of IT investments? How are these parameters related to the generation of real options during an IT investment evaluation and adoption process?

To address the above questions a **multiple-cases study design** was followed. Multiple case studies were utilised for the following reasons. First, aim of the case study was to result in an IT project typology based on which the comparison of the real option value in different IT projects would follow in the second part of the study (the confirmatory approach). For this reason, more than one case was needed to explore the different dimensions that RFID technology could take and compare the results. Second, another aim of the case study was to explore the types of real options that occur during the investment evaluation and adoption of an IT innovative project. To accomplish this aim a single case study would not be beneficial, as the exploration of more than one case study it was expected to reveal additional types of real options. Third, according to the literature, the evidence from multiple cases is often considered more compelling and the overall study is therefore regarded as being more robust (Yin 2009). Multiple cases augment external validity and help guard against observer biases (Leonard-Barton 1990). Under this perspective, the analytic benefits from having two or more cases may be substantial. This is the case for this study too. Each one case gave interesting insights for the role of real options in investment evaluation and adoption processes and at the same time the comparison of these case studies reinforced or contradicted previous findings.

A **replication logic** was followed under which, for each one case study specific steps and procedures were followed and data were gathered (Section 4.2.3 Data collection protocol). In addition, the **units of analysis for the multiple case studies were** the organisations and the technology applications and their attributes.

4.2.2 **Case selection**

The organisations which were selected for analysis had a common aim: to estimate and assess the value of RFID technology. Three case studies are selected to be studied based on our involvement in research projects.

Case I refers to a retailing organisation in the telecommunications industry. This organisation is one of the largest companies in Greece which offers telecommunications products and services. Aim of this organisation was to assess the opportunities offered by

RFID technology for its supply chain. This case study was conducted from November 2007 until April 2008. As this case study was the first one to be conducted it can be considered as the pilot study. Based on a list of candidate RFID applications, specific applications were assessed which were introduced and examined in the other two following organisations and cases. In addition, the cost-benefit assessment model which was created for this case was also utilised for the other two organisations with the required amendments and modifications. The specific organisation was chosen as the aim of the thesis is to explore the value of real options in an IT investment evaluation process. As the emphasis is given on innovative information technology projects, the specific case which had the goal to assess the value of RFID technology in the supply chain was considered very relevant. In addition, this case covered the need to examine one of the parts of a supply chain which is the retailer.

Case II refers to one of the biggest retailing supermarket companies in Greece. The aim was to assess the value of RFID technology implementation in collaborative supply chain initiatives. This case was conducted during the period October 2008-June 2009. One of the main aims of this study was to examine the value including the real option value of IT innovative investments and investigate whether this value varies across different types of IT projects. This case was chosen as it offered the opportunity to evaluate RFID investments which had a completely new aim -mainly strategic-characterised by the collaboration among several partners within the supply chain. In addition, the specific case offered the opportunity to study a larger scale investment with new RFID applications than the one in the first case. It was expected that these differences derived from the comparison with the first case would make our findings more robust with the potential to be generalised.

Case III was conducted from November 2010 until November 2011 and it refers to an organisation which merchandises and manufactures products in the beverage sector. Aim of the organisation was to assess the value of specific RFID technology applications for the enhancement of its supply chain processes. What differentiates this case from the previous cases was the fact that this organisation is a supplier rather than a retailing company as in the two previous cases. This was one reason for the choice of this case to be studied. Another difference was the fact that RFID technology was implemented in a "pallet" level instead of "item" level. Thus, the respective assessment of the value of the technology it was expected to vary.

Cases are selected based on literature (Eisenhardt 1989) which underlines the fact that "*the selected cases have to be those which replicate or extend theory by filling conceptual categories*". In this study, the three selected cases refer to different parts of a supply chain (e.g. retailers and suppliers) and different types of RFID projects (e.g. transactional vs. strategic, small scale vs. large scale projects etc.) which form several categories.

4.2.3 Data collection protocol

The protocol established for this study included the main variables which were studied, the main questions asked, the data gathered and the procedures which were followed to answer these questions. The two main parts of the protocol included the data and the procedures for (a) the study and analysis of the current business processes of each case/organisation and (b) the assessment of the value derived from the RFID-enabled business processes. The following sections include details of this protocol.

4.2.3.1 *Case study questions*

Several questions were utilised within the specific case study protocol. The questions were divided in two main parts (a) questions regarding the current business processes and the operation of the examined organisation in order to feed the cost-benefit analysis model and (b) questions for the evaluation of the RFID proposed applications by the company and other executive members. These questions were posed mainly in survey instruments and as well as in interviews, workshops, and focus groups. Below are some examples of questions answered by the companies. For the full documentation of the instruments utilised to collect data please see APPENDICES 3-5.

<u>Indicative questions for the current business processes of the company:</u>

- How many warehouses does the company own?
- How many stores operate in the specific retailing company?
- What are the business processes your company would exploit RFID technology for? Why?
- How long does it take for one employee to pick an order and store it in the warehouse?
- How often an employee picks and stores orders per day/week/ month?
- How many workers are involved simultaneously in a picking and storage business process?

<u>Indicative questions for the assessment of the proposed RFID applications:</u>

- How you would value this RFID enabled application?
- Rank the following RFID applications based on the perceived value for your company.

- What is the level of business process reengineering for the deployment of this RFID application?
- Would you invest in this RFID application?
- Would your company invest in future RFID applications based on an initial investment?
- How do you interpret the implementation of the proposed RFID application in stages?
- Would you delay RFID investment in this application? If yes, why? For how many years?

4.2.3.2 *Data gathered and sources of data*

To answer the above questions **multiple sources of evidence** were utilised to get access to data from the three case organisations. Multiple sources of evidence were utilised to enhance *construct validity* of the case study analysis (Yin 2009).

- **Interviews** (structured and unstructured) was one of the first techniques which were utilised to collect data. Interviews with key personnel- retailers and supply chain managers- in the three case studies were exploited to understand the aim of each one separate organisation regarding the exploitation of RFID technology (e.g. Case III: the supply chain manager expressed the goal of RFID for the automation of the current processes in his organisation). In addition, through the interviews it was possible to understand in depth the business processes of the examined organisations and their possible flaws (e.g. Case study II: an interview with one of the biggest suppliers of the retailing company revealed problems for the current promotion events management process). Interviews were utilised in order to have a direct focus on the above topics for the research.
- **Archival records** were utilised for the case studies in order to gain access to quantitative and precise data. For example, in case study III (distribution center/beverage manufacturer) we gained access to ERP data regarding the number of the pallets which are distributed among the nine distribution centers of the company. In addition, in case study I we had access to records with financial data regarding previous sales, number of the sold telecommunication products. These archival data were a basis for the calculation and the estimation of the cost-benefit analysis and Net present value calculations of the RFID investment evaluation.
- **Survey data.** Specific questionnaires were distributed to the employees and managers of the three case organisations which were working in the retailing stores, backroom, warehouses. This data was one of the most important source of evidence.

In the three case studies we have asked specific questions regarding objective information for the current examined business processes such as: time processing, arrival times, number of workers required for each one process. Based on statistical analysis this data was utilised to draw conclusions as well as to feed the cost-benefit analysis model. In addition, the survey questionnaires had a second aim: to ask the respondents about the proposed RFID applications to support the examined business processes. As a result, through the surveys we gained access to perceptions towards the RFID enabled business processes (e.g. perceived value of returns, perceived level of required business process reengineering). For case I the survey was distributed to 39 stores of the company, for case II to 24 supply chain executives and for case III to 9 distribution centers of the beverage company. APPENDICES 3-5 include the questionnaires distributed for each one of the three case organisations.

- **Direct observations** were conducted to examine the premises of the companies, and investigate each one of the current examined business processes. During this observation we gained insight regarding the flow of information and products within each one process and identified the bottlenecks and the problems inside a process which justified the RFID deployment. In addition, during these observations questions to the employees were made in order to get detailed information regarding the business processes (time processing etc.)
- **Focus Groups.** In case I a focus group was conducted. The current (as-is) business processes and the RFID enabled business processes were presented to the company's members and executives in order to be discussed and evaluated. Focus groups gave the opportunity to the company members to discuss with each other the proposed RFID enabled processes and express their attitude towards implementing them. In addition, in all the case studies focus groups with IT experts were conducted to examine and estimate the RFID impact on the as-is business processes (e.g. decrease of the processing time for each one business process because of the RFID automation)
- A **workshop** with 24 supply chain executives was held for Case II in the premises of the Retailing Supermarket Company. During this workshop the proposed RFID applications were presented and the executives evaluated these applications and expressed their perceptions towards implementing them.

4.2.3.3 *Followed procedures/Methodology*

A specific methodology was followed for the analysis of the three case studies, in order to establish replication *logic*. In particular, at first the current business processes of the examined companies were analysed and studied. The current problems and flaws were studied in order to justify RFID investments. In some of the cases an analytical business process modeling was conducted. The second step was the identification of the candidate RFID applications which can be implemented by the company for the improvement of their current business processes. Afterwards based on an initial qualitative evaluation, specific RFID applications were chosen to be analysed further regarding their value for the company. During the following step the evaluation criteria were specified (e.g. cost savings, capital cost as a result of the RFID deployment, real options opportunities etc.). Based on the identified criteria, the next step included the collection and the analysis of the data. Finally, an overall evaluation based on monetary criteria (e.g. net present value of the RFID application) and qualitative criteria (e.g. level of business process reengineering, level of collaboration with supply chain partners, growth or stage opportunities) was made regarding the proposed RFID project. The following figure depicts the followed procedures.

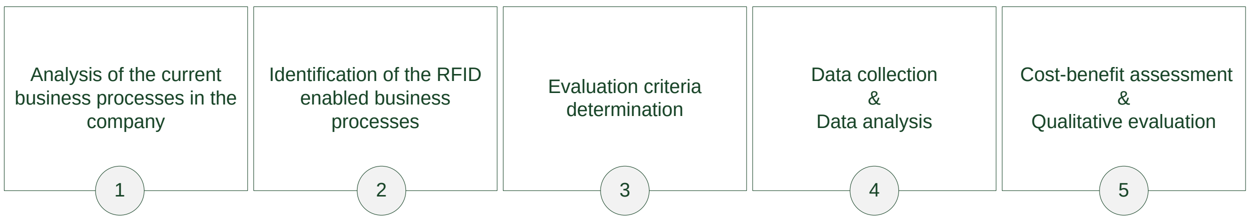


Figure 4.1 The followed procedures for the case studies

4.2.3.4 *Outline of case study reports*

With the completion of each one case study, a report with the main results of each case was written. This report was written based on the settled questions and the gathered data. Each case report for each one case study had the three (3) main following sections.

(a) Objective and scope of the RFID utilisation

In order to have an insight of the objective, the scope and the aim of the specific case studies, a discussion regarding the specific RFID applications which are evaluated was made. This discussion was made in the first part of each one case study report. In this section, we analyse the business processes where RFID is examined to be deployed to. The aim of the business processes and their characteristics are described in detail. In some cases, a detailed business process modeling for the current and the RFID enabled processes was also conducted. Apart from the RFID exploitation this section included information regarding the company which is studied.

(b) IT typology and project value

Based on the literature, the research gap and the research objective of the study, there is room for research to explore whether real option value varies in different assessed IT project types. Thus, as a first step, the study had the aim to explore and define the different types of IT projects that are generated when evaluating an IT innovative project such as RFID. Thus, based on an IT typology derived by the literature, specific dimensions of IT projects were revealed and explored within the case studies' analysis. Aim of this section was to examine whether we have evidence from each one case study for these IT project dimensions. Each one RFID project per case study was described and analysed based on these dimensions.

(c) Assessment of value of returns

Real Options based on the literature is an extended value of the net present value. Thus, we wanted to analyse at first net present value and then to discuss the real option value which is generated for each one case based on two parameters: (a) the type of the real options and (b) the factors that may influence the value of these options. In addition, it was expected that NPV approach would generate interesting insights for real options too. For the first part of the NPV, an extended and thorough analysis is made about the estimated cost and the benefits of the RFID implementations. For the second part, the observed real option types that were occurred in each one case study were analysed. Finally, organisational and technological parameters which are proposed from the literature that influence the option value were analysed in the last part of the case study reports. These factors were analysed only where we had evidence from the respective cases that they are apparent.

4.2.4 **Data analysis**

The analysis of the case studies included two main parts: (1) a within-case analysis and (2) a cross-case pattern analysis (Eisenhardt 1989).

Within case analysis involved detailed *case study write-ups and descriptions* (Eisenhardt 1989). In particular, after the conducted interviews, focus groups, workshops and direct observations, a detailed report with the key points of these qualitative data sources were written. In addition, quantitative data which were mainly derived from the distributed survey questionnaires and the archival data were entered into an analytical cost-benefit assessment model which was created as a *database collection tool* for each one case study separately. The within case analysis followed the *outline case study report* (Section 4.2.3.2).

Cross case pattern was established to detect communalities and differences in patterns of RFID deployment and real options across the studied cases (Blome & Schoenherr 2011). For the specific study a cross-case analysis was focused on the selection of dimensions which differentiated each one RFID deployment regarding the IT project type (e.g. the aim, the scope and the span of each one RFID deployment within each one separate case study) or the different types of real options that were occurred in each one case (e.g. option to delay, grow or stage the investment). These dimensions were suggested by the literature and were revealed during the within-case analysis. This type of analysis is based on the pertinent literature on case study research (Eisenhardt 1989).

Finally, the main case study analysis strategy is the utilisation of *qualitative and quantitative data* (Yin 2009). The qualitative data were utilised to explore how innovative IT projects are assessed and how real options may be embedded within this assessment, whereas quantitative data were exploited to fill in the cost-benefit database model per case study. In addition, quantitative data were utilised to estimate on average the company's respondents' attitude towards the proposed RFID applications. Quality of the case study research design

Based on the literature on case studies (Yin 2009), there are several metrics that assess the quality of a case study research design. The table below depicts the tactics which were followed in this study to fulfill these research design qualifications.

Table 4.1 Quality of the case study research design -adapted from Yin (2009)

Quality Criteria	Definition (Yin, 2009)	Stage	Case Study tactic in this study
External Validity	Defines the domain to which the case study's findings can be generalized	Research Design	• *Theories* (e.g. real options theory, IT project typology) are tested in the three case studies. • A *replication logic* which is followed for each one case study (e.g. similar questions and data were utilised, replicate analysis based on specific procedures, case study reports, comparison of results) • Multiple case studies utilisation which offer high generalisability (Leonard-Barton 1990)
Construct validity	Identifies correct operational measures for the concepts being studied	Data collection	• *Multiple-case studies* exploitation which offered the opportunity to validate stability of constructs (i.e. real options) across different situations (*Leonard-Barton 1990)* • Derived *constructs and respective measurements (e.g. types of real options, types of IT projects)* from the literature/previous studies • Utilise *multiple sources of evidence which encourage convergent lines of inquiry* (e.g. interviews, direct

			observation, archival records, interviews with structured questions, workshop) • Follow a *chain of evidence (Each single case report has citations from the database* which is inextricably connected to the research questions. Gathered data support the conclusions.) • Key *informants reviewed th*e draft and the final case study reports (e.g. supp*ly chain* managers in the companies)
Reliability	Demonstrates that the operations of the study can be repeated with the same results	Data collection	• Documentation (*case study protocol)* of the followed field procedures, gathered data and questions • Prepare *case study reports* based on the utilised protocol for each one of the single cases • Develop a *case study database* to collate all the required data from the three cases
Internal validity	Establishing a causal relationship	Data analysis	• Not applied in exploratory studies • Potential confusion for cause and effect in multiple case studies (Leonard-Barton 1990)

4.3 Case Study I: A retailing company in the telecommunications service

4.3.1 The Context

The specific case study refers to one of the largest organisations which merchandise telecommunication services and products in the Greek market. It operates under a leading integrated telecommunications operator which provides mobile and broadband services in southeastern Europe. The organisation is interested in improving customer service inside its stores and considers RFID technology as tool that can support this objective.

4.3.2 RFID project objectives and scope

Based on the managers' interviews, live observations, focus group, business process modeling and questionnaire survey (APPENDIX 3), specific inefficiencies are revealed in the company's business processes. Some of these inefficiencies include:

- Duplication of work
- Difficulties and delays for the location of the required documents and products in the inventory
- Lack of information on the products received and sold
- Customer delay in the checking out area
- Incomplete and inadequate product and promotion information during sales service

Given the identified flaws, the aim of the organization for customer service improvement and the variety of the RFID applications derived from the literature, a list of potential RFID applications for the specific organization emerge as presented in the table below. Porter's (1985) categorisation of the primary business activities of an organization into logistics, sales, operations and after sales service is utilized to group these applications.

Table 4.2 The list of candidate RFID applications in the retailing organization.

Category	RFID application	References	Description
Logistics	Order receiving	(Bottani & Rizzi 2008; A. Karagiannaki et al. 2007)	The ordered products which enter the inventory room are automatically and massively identified by the readers which are placed at the entrance of the inventory room. The number of the products in the inventory is automatically updated.
	Inventory audit/count	(E Fleisch & Tellkamp 2005; Rekik et	The products which are stored in the inventory room are automatically and massively identified and counted at a real time basis.

		al. 2008)	
	Inventory replenishment	(S.-J. Wang et al. 2008; Kok et al. 2008)	The RFID system gives an instant alert to the inventory managers notifying that the stock in the inventory has reached a certain point and needs replenishment.
Sales	Check out	(Moon & Ngai 2008; Uhrich et al. 2008)	The products which are sold at the check-out point are automatically and massively identified. The number of the products in the inventory is updated.
	Product information to the consumer	(Roussos et al. 2002; K. L. Moon & E.W.T. Ngai 2008)	The consumer gets information for the characteristics of the products in the store on an information terminal or a display screen inside a shopping cart.
	Product and promotion information to the consumer	(Uhrich et al. 2008; Jones et al. 2004)	The consumer gets information for the characteristics of the products in the store and information for specific promotions, on an in-store information terminal or on a display screen inside a shopping cart.
	Personalized product and promotion information to the consumer	(Roussos et al. 2002; Ngai, K. K. L. Moon, J. Liu, et al. 2008; Moon & Ngai 2008)	The consumer gets personalized product information and promotional offers on an in-store information terminal or on a display screen inside a shopping cart.
Operations	Anti-theft	(Jones et al. 2005; K. L. Moon & E.W.T. Ngai 2008)	The products which leave the store are automatically identified. Automated alert of the system in case of stolen goods.
After sales service	Automated service	(L. S. Lee et al. 2008; S.-F. Tzeng et al. 2008)	The products brought for service by a consumer are automatically identified.
	Service traceability	(L. S. Lee et al. 2008; S.-F. Tzeng et al. 2008)	The products which are sent to the service companies can be tracked and traced during their transportation.

From the above list of RFID applications, two main RFID applications were chosen to be examined and analysed further. This choice is justified based on the pre-evaluation process of the proposed RFID applications by: (a) the organisation (through focus group and questionnaires) and (b) an RFID expert team. Data (derived from the statistical analysis of the questionnaires that were distributed to 39 retail stores of the company for the evaluation of the proposed RFID applications), show that the "orders receiving process" has been ranked first with the highest priority for the organisation to be implemented. The 92%

of the respondents found this RFID-enabled process as very important for the retailing company. The checking out process has been also evaluated by the organisation as very important (85%).

Also, based on the RFID expert team's evaluation, the required level of business process reengineering and the level of the required hardware and software for the support of the RFID applications were taken into account for the initial evaluation of the RFID. The two applications (orders receiving and automatic checking-out process)- which are chosen- had a medium level regarding these two above parameters in contrast to the rest of the proposed applications. Moreover, another reason for which these two applications were chosen was the fact that we were able to collect quantitative data to measure and quantify the impact of these RFID applications on the company's business processes. Finally, for this choice the IT expert team has considered that the automation of the "checking out process" could complement the benefits derived by the "orders receiving process". The organisation by implementing these two processes, could gain information about the inventory status of the products. In particular, the RFID system could provide the organisation with automated information by the RFID system about the products that enter and "leave" each one retail store and calculate the remaining inventory status of the retail stores.

4.3.3 IT project value based on the IT typology

This case study gave us evidence that specific dimensions of the assessed RFID project can be related to the project's business value.

What is the aim of the project? In particular, this case study gave support that the purpose of the examined RFID applications can be correlated with the overall value of the IT project. The examined RFID enabled: (1) orders receiving and (2) checking out business processes have a transactional nature, as they involve basic organisational transactions based on the products that the company receives from its partners and products that it sells to the consumers. As a result of the implementation of these two RFID applications, the company can have information regarding its inventory status. However, if one of the specific RFID applications (e.g. the RFID enabled checking out process) included other characteristics such as the utilisation of RFID real time information to support loyalty or cross selling activities, then the IT project would have rather a strategic business value than a transactional one.

Standalone or family applications? In addition, this case study gives us evidence about another characteristic of the IT project which seems to influence its overall value. This attribute refers to whether the RFID applications are going to be implemented by the organisation separately as standalone applications or jointly. In the specific case, different implementation options occurred. For this reason, the orders receiving and the checking out process are examined first as standalone applications, with their own cost and benefits and then as family applications when the two applications are considered to be implemented together. As the following section reveals, based on the cost benefit analysis and NPV calculations, the overall value of the IT project when the RFID applications are considered jointly is higher than the value of the applications when they are assessed separately from each other as "standalone" processes. According to the pertinent literature (Pendharkar 2010), this is due to "cost interdependencies". When the two applications are considered as family applications, the common cost related to the warehouse cost (e.g. cost of the printers, tagging cost etc.) is shared between them. In this case, the option for the initial RFID project and the established RFID infrastructure to grow and lead further to the second RFID application is occurred.

Internal or supply chain implementation? Furthermore, we have evidence from the specific case study that another characteristic of the specific RFID project is related to its overall value. This characteristic refers to whether the company's partners will participate or not into the RFID implementation process. The retailing organisation's partners can be involved by undertaking the tagging cost of the products which are transferred. In particular, the suppliers of the retailing organisation's products can own the tagging cost by being responsible for the tagging process and the respective cost. In this case, the RFID project is a "supply chain" project as the collaboration among the retailing company and its partners is required. Alternatively, the retailing company can undertake itself the tagging cost and the respective tagging process, without its suppliers' involvement. In the latter alternative, the RFID project is an "internal project", as it does not require the involvement of the company's partners. In the first case, based on our analysis it is shown that the overall value of the IT project is different than the value which occurs in the second case. More specifically, when the suppliers are involved in the RFID implementation process, it is shown that the overall value of the project would be higher for the retailing company as the tagging cost now is shifted to the supplier. Furthermore, in this case the value of the IT project would be influenced positively as the retailing company would be able to track the tagged products in the whole supply chain, rather than only inside the organisation internally.

As a result, we have evidence from this case study that the value of an IT project is related to the category this project belongs to (Internal or supply chain project, Standalone or family application, Strategic or transactional project).

4.3.4 Assessment of Value of Returns

In order to gain further insight from this specific case, an assessment of the value of returns was conducted. Based on the literature (Tiwana et al. 2007), the value of an IT project is the sum of the traditional net present value (NPV) plus the option value. In the case of growth options, the true value of a first stage IT project is the NPV of the first-stage project's cash flows plus the value of the second-stage projects (Dos Santos 1991). For this case, we have estimated first the project's NPV based on quantitative measurements and then we have examined its option value based on qualitative determinants.

4.3.4.1 *Net Present Value (NPV)*

An analysis and estimation of the anticipated cash flows and cost as a result of the RFID implementation are undertaken. For the quantification of the RFID investment cost for the two applications, market prices and the Delphi approach of IT experts are used. This cost encompasses capital (Table 4.3) and operational expenses (Table 4.4).

(a) Estimation of the capital cost: The capital cost includes the cost for the RFID equipment, installation and the required software. Each application has its own cost. However, during the estimation of the cost it is shown that some cost categories are common for the two examined RFID applications. This means that there is a type of cost which is required regardless of the number or the type of the RFID applications which will be implemented. The following table shows the total capital cost of the investment which includes the common one which is shared among the two applications and the individual one for each application separately.

Table 4.3 Division of the capital cost (in €) into the shared and the individual one

Capital Cost	Shared Cost	Application 1 Cost	Application 2 Cost	Total Cost (Applic.1 +2)
RFID equipment (store type 1)	145,000	46,400	69,600	261,000
RIFD equipment (store type 2)	237,500	76,000	76,000	389,500
Equipment for the central warehouse	13,800			13,800
Installation Cost	77,800			77,800
Servers cost	1,500			1,500
Central infrastructure cost (PCs)	50,000			50,000
S/W Commercial licenses	61,200			61,200
S/W customisation for each application		64,000	40,000	104,000
ERP Systems Adjustment Cost		18,000	16,000	34,000
Total cost	586,800	204,400	201,600	992,800

Note: For the assumptions and calculations behind the capital cost estimation, see APPENDIX 3.

(b) Estimation of the Operational cost: The operational expenditures include the following categories:

- RFID tags cost, the cost of the tagging process and training which remain the same for both applications, regardless of the implemented type of application and
- The cost for the HW maintenance and SW upgrades which is calculated separately for each one application and it is aggregated if the applications are implemented together.

Table 4 illustrates the calculated values, if both applications are implemented.

Table 4.4 Estimation of the operational cost (in €) of both RFID applications.

Operational expenses (OPEX) for both applications	Year 1	Year 2	Year 3	Year 4	Year 5
RFID tags cost	144,000	129,600	116,640	104,976	94,478
Equipment maintenance	-	85,896	85,896	85,896	85,896
SW updates and maintenance	-	12,480	12,480	12,480	12,480
Training	73,440	11,016	11,016	11,016	11,016
Tagging cost	100,00	100,00	100,00	100,000	100,000
Total cost	317,440	338,992	326,032	314,368	303,870

Note: For the assumptions and calculation behind the operation cost estimation see APPENDIX 3.

(c) Quantification of the cost savings due to the RFID implementation: For the quantification of the estimated benefits of the two RFID applications a questionnaire survey is carried out. The questionnaire is distributed to 39 retail stores of the organization (out of the 153 stores which were the basis for the calculations). The aim of this survey is to collect information about the performance of the current business processes for orders receiving and checking out. The questionnaire consists of specific questions mainly regarding the average time it currently takes for the orders receiving and checking out, without the use of RFID technology. The average time is a key performance indicator as it is shown in Table 4.5. Using the Delphi approach with interviews of IT and business people, an estimation regarding the decrease of the identified time of the current business processes, due to the introduction of the RFID is made. This estimation is exploited for the assessment of the operational cost reduction as a result of the RFID technology. The main benefit which is considered for the two applications is the operational cost. Nevertheless, RFID implementation is not only about cost saving but it can also create additional types of benefits such as sales or competitiveness increase which are however difficult to adequately anticipate and quantify.

Table 4.5 Estimation of the cost saving effect of RFID

RFID application	Key Performance Indicators	As -Is Without RFID	To-Be RFID enabled	Unit
Orders Receiving	Average time needed for the processing of one received order	70	15	minutes
	Average number of employees occupied with the receipt and the processing of one received order	2	1	Units
Check out	Average time needed per checking-out for one sales receipt (pricing of the bought products)	5.00	2.00	minutes
	Average time needed for finding out the product code ("KAY") in case of not being included on the product package	5.00	0.00	minutes
	Frequency of the above incident occurred within one year	104.00	0.00	Units

For the cost saving estimation the following three types of cost savings are considered (see Table 4.5):

1. Annual operational cost saving due to the decrease of the time needed for the orders receiving process, due to the RFID implementation. This process includes the identification and documentation of the received products. It also contains the examination of the received products in order to determine conformance to what was ordered via a purchase document.
2. Annual operational cost saving due to the decrease of the time needed for the check out process and specifically for the production of one sales receipt, as a result of the RFID implementation.
3. Annual operational cost saving which is derived from the elimination of the time needed currently from the employees to locate the missing code of one product, during a check-out process.

Based on the formulas which are illustrated below and the respective calculations, the cost savings are estimated. The time decrease is multiplied with the average man-hour rate which is 15 €/hour for the employee who is responsible for the orders receiving and 10 €/hour for the employee at the check-out points. The figures are multiplied either by the number of the stores or the number of the received orders or the sales receipts, according to each separate application. These numbers are taken from the accounting department of the retailer and they are included in the APPENDIX 3, titled as: "assumptions for the cost saving estimation". The respective table in the APPENDIX 3 depicts the calculations that have been made for the cost saving estimation.

Table 4.6 Cost saving estimation (in €) due to the introduction of RFID

RFID application	Cost saving category	Store type 1[3]	Store type 2	Cost saving per year	Calculation Formula
Orders Receiving	Annual operational cost saving due to the decrease of the time needed for the orders processing	409,688[(1)]	186,875	596,563	[(Time (as is) × number of employees (as-is) occupied)- (time (to-be) x No of employees (to-be) occupied)]/60 × man-hour cost x Total annual number of orders
Check Out	Annual operational cost saving due to the decrease of the time needed for the check out process (product pricing)	427,500[(2)]	195,000	622,500	Time reduction per sales receipt/60 × man-hour cost × Annual total number of sales receipts
	Annual operational cost saving due to the decrease of time needed for locating the product code when it is not included on the product package	5,027[(3)]	8,233	13,260	Time reduction per incident x total annual number of incidents/60 × man-hour cost × Number of stores
Both RFID applications				1,232,323	

NPV estimation: After the identification of the cost and benefit for the two applications, the NPV method is used for the financial evaluation of the investment (Table 4.7). The joint NPV of the RFID application for the "order receiving "and its interdependent follow-on investment "check out" proved to be positive (886,585 €) in contrast to the negative separate NPV (-466,789€) of the RFID application "order receiving" and the NPV (-356,173€) for the "check out" application, if these are considered as stand-alone and independent applications (Table 4.7). This occurs because of the fact that these RFID applications when implemented as a group and share common resources as their capital and operational cost, based on the "resource interdependence" (Santhanam & Kyparisis 1996; Verma & Sinha 2002; Liesio et al. 2008). Because of the cost sharing, the total expenditures decrease (Santhanam & Kyparisis 1996). In addition, these two applications create a "value synergy" (Liesio et al. 2008) and a "benefit interdependence" (Santhanam & Kyparisis 1996) because when implemented together create an extra benefit for the organisation, rather if these applications are implemented separately. In particular, when these two applications are considered as interdependent investments and evaluated jointly, then the savings per year (1,232,323 €) in the organisation, thus the decrease of the operational cost is higher than

[3] For the detailed calculations regarding (1), (2) and (3) and the exploitation of the formulas see the APPENDIX 3.

that which is conceived when the two applications are evaluated separately. This synergetic effect could not be exploited if these two applications were developed and evaluated as stand-alone ones.

As a result, it is worthwhile for the organisation to invest in the RFID application for the orders receiving, taking into consideration the value that is offered by the other related and sequential application for the automated checking out, rather than to invest in one of these applications separately. If the organisation had evaluated only one of the two applications in isolation from the other, then based on the negative NPV, it would have rejected the investment.

Table 4.7 . Estimation of the Joint NPV for the two applications and the NPV for each application separately

	Year					
	0	1	2	3	4	5
NPV estimation for the RFID application: "Order Receiving"						
TS		596,563	596,563	596,563	596,563	596,563
TC	791,200	317,440.00	316,720.00	303,760.00	292,096.00	281,598.40
GM	-791,200	41,762.50	42,482.50	55,442.50	225,346.50	314,964.10
NPV	-466,788.64					
NPV estimation for the RFID application "Check Out"						
TS		635,760	635,760	635,760	635,760	635,760
TC	788,400.00	317,440	316,624	303,664	292,000	281,502
GM	-788,400.00	81,800	82,616	95,576	264,920	354,257
NPV	-356,173.11					
Joint NPV estimation (both applications)						
TS		1,232,323	1,232,323	1,232,323	1,232,323	1,232,323
TC	992,800	317,440	338,992	326,032	314,368	303,870
GM	-992,800	617,043	595,491	608,451	818,675	928,452
NPV	886,585					

The NPV is estimated based on the discounted value of the Net Cash Flows of the investment (*Total savings - Total cost - Depreciation-Taxes*).
Here, TS: Total Savings, TC: Total Cost = CAPEX+OPEX, GM: Gross Margin = *Total savings - Cost - Depreciation*) (All amounts are expressed to the nearest €).

4.3.4.2 *Option value*

Apart from the NP value as mentioned above, the real option value is also considered. The NPV however, gives us some evidence for the generation of growth opportunities, as it is discussed below.

(I) Real Option types

For this case study growth and stage options occur under the investment evaluation approach of the RFID technology. The growth and stage options that are revealed were based on the following data:

- The statistic analysis of the distributed to the organisation questionnaires with the ranking and the evaluation of the RFID proposed services by the firm members
- Interviews with IT and business experts on RFID technology implementation regarding the interconnection of the RFID services and
- Literature review on the list of RFID applications

In particular, the grouped RFID applications which were proposed initially to the company are arranged in a sequence in order to identify the applications which are required for the operation of others, based on the “follow-on or technical synergy” (Liesio et al. 2008; Santhanam and Kyparisis, 1996). Interviews are utilised as a means to gather information from IT and business experts for this purpose.

An example of the applications arrangement is the following, which deals with applications that concern the inventory of a store. In order for the “inventory replenishment” application to operate and notify that the stock has reached a specific point that needs replenishment, the “inventory audit” application, monitoring the real-time inventory level, is required. Based on the same perspective, in order for the “inventory audit” to operate, the “orders receiving” and the “check-out” applications are required. These applications automatically update the inventory level when the products enter and leave the retail store. These updates play an important role for the accurate inventory audit. As a result of the grouping and the sequential arrangement an evolution path for the inventory is generated, as depicted in Figure 4.2. According to this “evolution path”, a firm can invest initially in RFID for supporting the “orders receiving” activities. This company can invest further in other related applications for the checking out process and the inventory audit or replenishment. These follow-on applications build on the technological capabilities yielded by the initial investment in the “orders receiving” application.

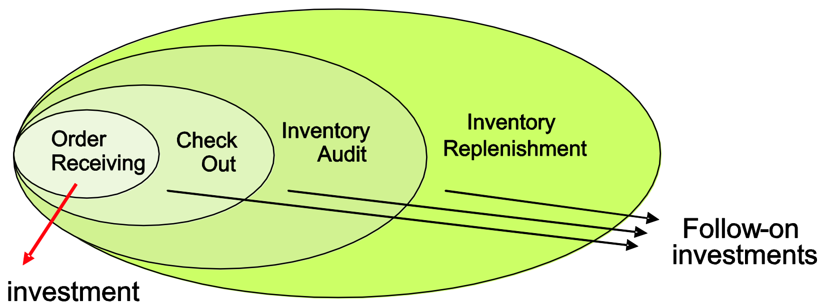


Figure 4.2 RFID Evolution path for inventory management

Under the same perspective, other "RFID evolution paths" can be created, consisting of initial and follow-on interdependent applications in other areas of activity, such as sales and promotions management, as shown in Figure 4.3.

In particular, the retailing organisation can invest initially in an RFID application which involves the installation of RFID- enabled information terminals around its store. These terminals can inform shoppers about the characteristics of the products or promotes specific products on display screens (Jones et al. 2004).

In particular, a reader and antennas can be located at each one of these information kiosks. Consequently, every time a customer passes a tagged product through one information terminal, he can receive information on this product on the display screen. Alternatively, product information can be displayed on a screen located inside a shopping cart which is equipped with RFID reader to detect the tagged goods inside the cart as Ngai et al. (2008) discuss.

However, the organisation can invest further in other relevant subsequent RFID applications. For example, the company can add some required features in the initial RFID infrastructure and support personalised offers and promotions to the consumers. As Ngai et al. (2008) present in their article, a consumer can use an RFID- enabled shopping cart which is connected with system databases such as CRM. For example, every time one consumer enters a store, he can use his loyalty card in his shopping cart and after being verified he can receive personal recommendations for products on a display screen inside the cart. Antennas inside the card can detect the in and out movement of the items in the shopping cart and the connected application systems can present to the shoppers other associated brands or products on the display screen. Marks and Spencer stores, Prada Epicenter stores, Gap, Benetton and DHL fashion are some examples of retailers who have implemented RFID pilots with the above applications (Ngai et al. 2008). These applications can be considered as follow-on investments based on the initial RFID application.

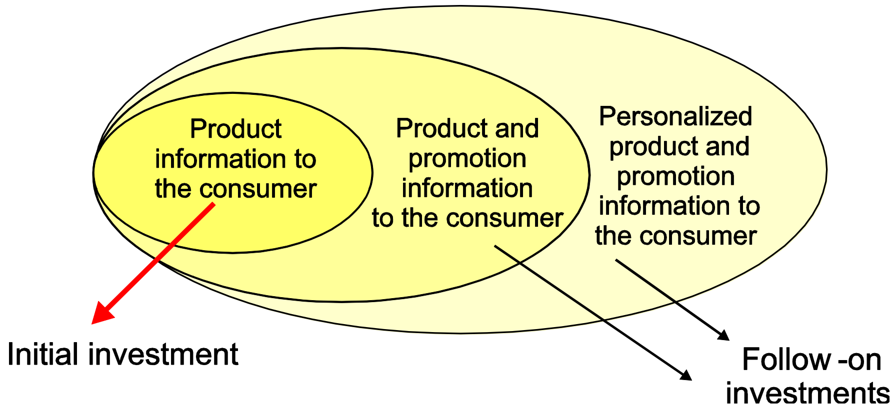


Figure 4.3 RFID evolution path for sales and promotion management

(II) Factors that affect option value:

Based on the literature, the value of future investments is greatly influenced by project characteristics (Dos Santos 1991). This case study gives us evidence that specific technological and organisational determinants derived by the pertinent literature (Fichman 2004; Scarso 1996; Benaroch 2001; Goswami et al. 2008; McGrath & MacMillan 2000; Angelou & Economides 2009a; Bowman & Hurry 1993) can be related to the business value and real option recognition of the assessed IT project.

Technology adaptation: In the specific case study, the implementation of the RFID technology could involve several applications with different interpretations. The aim of the organisation was to improve its customer service. As it is shown in the previous sections, an established RFID infrastructure, in order to enable customer service could support a variety of applications from logistics, sales to after sales services. Different interpretations of the RFID technology implementation were given by the interviewed managers of the organisation. Thus, a list with candidate applications was presented in the retailing company. In addition, in the specific case, RFID could have been implemented in stages. In the first stage the orders receiving application could be implemented and then the RFID enabled checking out process could follow.

In this retailing organisation, the above attributes of the RFID implementation are found in the literature as parts of the factor:"technology adaptation", which according to Fichman (2004) includes the "interpretive flexibility" and the "divisibility" of the IT implementation. According to the author, this factor affects IT project real option value. Based on the theory (Scarso 1996; Angelou & Economides 2009a), flexibility and modularity are determinants and sources of growth options. In addition, based on the literature (Bowman & Hurry 1993), an incremental and stage-wise strategy can be later lead to full scale investments. In this case we have evidence that the above propositions are meaningful. We have seen in this retailing organisation that the proposed modular and flexible RFID infrastructure could at first support an application from the logistics category (orders receiving) and then support another application from the sales category (check out) process within the organisation. Thus, the initial investment in the orders receiving process could later yield to the second application. In addition, as it has been supported by the data utilised for the quantitative cost and benefit calculations, the value of an RFID stage-implementation considering both the applications is higher than implementing one application in isolation. As a result, there is evidence from this case study that the value occurring from the option to grow and stage the RFID investment can be higher when the evaluated technology is modular and divisible. Although we do not value these kind of options based on real options formulas, NPV approach can be considered as the basis to extend the particular cost benefit analysis to estimations based on option pricing modeling.

Organisational learning and innovative capabilities: Based on the interviews with managers, the focus group and presentation of the candidate RFID applications in front of the managers, it is revealed that the retailing organisation possesses a technologically up-to-date staff with skills to accommodate such a technology implementation. The retailing company wanted to experiment with RFID technology. As a result, they were positive to undertake a pilot testing feasibility study to test the RFID technology reading ability and capture any technical problems. In addition, managers involved in the RFID experimentation were positive to dialogue and were interacting with the RFID implementation team to ask questions regarding the technology and propose any interesting ideas regarding its applications. In addition, several members from the organisation participated in the meetings held in the retailer's premises, where the presentations of the RFID proposed applications took place. This showed that the RFID investment was a participative decision making process. The above characteristics are parts of a measurement instrument developed by previous studies (Chiva et al. 2007) for the measurement of the "organisational learning" capability. As a result, this organisation has high learning capabilities. In addition, its ability to exploit the gained knowledge is high. The company already exploits the barcode technology and the IT department of the retailing company would to like to exploit this knowledge to future domains and more specifically to RFID implementation. Furthermore, the retailing company possesses human and technical capabilities which contribute to the abilities of the organisation to innovate. Based on the organisation's operational overview: *"The company is in leading market position from 2001 with a focus on innovation, quality and customer care"*. The company has offered a lot of innovative solutions to customers.

Based on Fichman (2004), the learning and innovative capabilities of the organisation and the ability to exploit this knowledge into other future domains which is referred as "absorptive capacity" in the literature, would trigger the generation of growth opportunities. In the specific case, the organisation was able to understand and recognise the growth options that one initial investment in RFID could lead to. Thus, we have evidence that these organisational characteristics are related to the overall value of an IT project and more specifically its real option value. The impact of these proposed option value determinants and its significance will be tested further through a quantitative approach (chapter 6).

Technology bandwagon: Moreover, in the specific case, the organisation operates within a network which influences its decisions regarding IT investments. The specific company made hard efforts to cut the cost of the existing business processes and improve customer service. As it has been revealed by the interviews and meetings with managers, the organisation has received a high pressure from its competitors. Due to the high level of competition, investment in high tech technologies which could yield further innovative applications was a priority for the specific company. This characteristic is related to the "network externalities" which according to the literature (Katz & Shapiro 1986; Strader et al. 2007) refers to the added value which is derived as a result of the increase of the technology adoption from other companies within the same network .

In addition, the specific organisation believed that the RFID technology would dominate over barcode and 2d barcode technologies. The IT department of the specific company had created a table with differences among the above technologies, considering RFID as superior for the company's business processes. Due to the belief that the RFID technology would dominate, the variety of the candidate technology applications which were presented in front of the decision makers of the organisation was high. This high number of RFID applications gave the incentive to the retailing company to support investment in a basic RFID infrastructure which could support further the development of future functionalities.

Based on the literature (Fichman, 2004) the above discussed variables: "network externalities" and "network dominance" form the factor: "technology bandwagon" which can influence the recognition and ultimately the value of growth options. The specific case study gives us evidence that the above attributes of technology bandwagon are quite related to the option recognition and value of the examined technology. The way they are influenced and the significance of this impact are going to be examined through the quantitative study which is going to be described in the next chapters.

Technology Strategy: During the assessment of the RFID applications in order to choose the ones which are going to be analysed further, the RFID expert team followed a specific approach. In particular, the team evaluated the level of the changes that the two RFID applications required. For the specific retailing company, the level of radicalness of the RFID enabled processes (orders receiving and check-out) was assessed as medium. Although, the RFID enabled processes entail process changes, they do not completely transform the existing business processes. In addition, the value of IT depends on the level of competitive advantage and its sustainability that it can offer to an organisation (Porter 2001). Although, the retailing company has a strategic aim to improve customer service, the RFID examined applications do not have a high level of strategic impact on the organisation, as they refer to transactional activities. In addition, the sustainability of the competitive advantage that RFID can offer in the specific case is not very high because the specific RFID enabled business processes can be easily imitated by others as they do not offer a radical and complete change of the existing business activities. Based on the literature (Fichman 2004) the above characteristics form another factor: the "technology strategy" which is proposed to increase the option value of the IT. As it has been discussed, the level of this factor for the specific case is not very high. However, if we consider the initially proposed to the organisation RFID applications, some of them can be more strategic. Investment in the proposed and economically assessed RFID infrastructure for the support of orders receiving and check out processes, can be the basis for other proposed RFID applications leading to a growth option opportunity. Although from this case, we have evidence that this factor is related to the value and real option value of an IT project, its impact is going to be tested empirically within the next chapters.

4.4 Case Study II: A retailing company in the supermarket chain

4.4.1 The Context

The specific company is one of the biggest retailing supermarket companies in Greece with 234 supermarket stores around the country. Aim of the organisation was to assess the value of an RFID enabled project and system which offered innovative collaborative practices for the improvement of the company's current supply chain business processes.

4.4.2 RFID project objective and scope

The RFID enabled system which is proposed for the company's business processes enhancement included the following applications:

(a) Promotion Management Service

The respective analysis and the interview (with one of the suppliers of the retailing organisation) revealed some important issues and problems regarding the way promotions are managed in the organisation. Addressing these problems was the motivation for developing the Promotion Management service in the course of the RFID enabled project. These problems included:

- Lack of information about the availability of products in shelves and promotion stands
- Lack of evaluation of the effectiveness of a promotion activity
- Lack of information regarding the real time sales of the products on the stock
- Lack of information regarding the real time comparison between the sales of products on the promotion stand with the ones sold from the shelf

Due to the above problems, the aim of the RFID enabled service was to offer real-time monitoring and reporting of the promotions held inside a store, enhance strategic planning and support a collaborative promotion management scheduling.

In particular, the RFID enabled promotion management service had the goal to monitor promotion effectiveness. The RFID enabled System aimed to provide useful information to retailer’s store manager and employees, as well as supplier’s marketing managers, so that they can monitor at real time critical variables to verify proper execution, such as promotional products replenishment, delayed promotion launch, etc. Based on real-time RFID enabled information, the retailer or the supplier could get reports with charts regarding the real-time stock or sales of the promotion products on the shelves, stands or the backroom. Accordingly, the respective managers could get reports with this information for each promotion event, each store, its one product etc. Based on these reports the users could propose actions for the improvement of a promotion event. As a result, this service could also be exploited as a promotion evaluation tool that supports the decision making for future promotional events.

(b) Dynamic Pricing service

Due to the revealed problems in the organisation such as the lack of information about the availability of products on shelves and in stock in the coldroom and the necessity to reduce waste along with labour costs associated with manual dynamic pricing, an RFID enabled dynamic pricing service is proposed to the company. The RFID enabled dynamic pricing service aimed to provide useful information to retailer's store managers and employees, as well as suppliers, so that they can monitor at real time critical variables and make informed decisions of dynamic pricing on the basis of product stocks available in the coldroom of the store (i.e. quantities by expiry date). These variables included: the information of the real-time availability of the products in the coldroom and on the shelves and real-time sales of the products. The user of the system could then attribute different weighting to each of these variables and the system (based on an algorithm) would suggest a discount price. The user could accept or reject the system proposition and suggest manually another price. As for the consumers, the Dynamic Pricing service has been revised to include an innovative consumer application. The consumers are informed about the discount and the availability of the products by expiration date on the shelf via a screen display.

4.4.3 IT project value based on the IT typology

Internal or supply chain implementation? Case study I provided evidence that the type of the RFID project (whether it is internal or supply chain) is related to its overall business value. Case study II comes to reinforce this evidence. In particular, the specific RFID enabled project in case II was supported based on supply chain collaboration. In contrast to case study I, the RFID enabled project cannot be supported by the retailing company only. For the implementation of both applications (promotion and dynamic pricing service) the synergy among the retailers and the suppliers was needed. The business value of the overall RFID project encompasses not only the value that it is gained for the retailers but also for the suppliers too. For instance, regarding the promotion management service, the retailer was able to evaluate the performance of the promotion activities on a web platform. In addition, suppliers could audit the performance of the promotion activity with a click of a button. The retailer which hosts the promotion activity and the supplier who introduces the promotion activity were able to share promotion performance information through the web platform. Based on the promotion performance information, when the supplier would reveal a problem with the promotion activity he/she could change the existing promotion policy and alter the promotion activities in collaboration with the retailer. On the contrary, if this activity was based on only internal actions and decisions the business value of the assessed RFID enabled project would be different and concern only the retailing company.

To examine the added value of the specific supply chain activity, an analysis for the promotion management service when the supplier is involved is undertaken in the next section (4.4.4.1-Cost-Benefit Analysis- "Hidden benefits" of the service). More specifically, the value of returns is estimated for the retailers to be increased if the supplier would like to have access to the real time information for the promotion activities inside a store. More specifically, the specific retailing organisation can sell information to the supplier regarding for example: the real time stock of the promotion activities, the exact time when the promotion is launched and the performance of the promotion activities in a real time basis per promotion stand/store. The analysis is based on the interview that is undertaken with the Head Buyer of the specific Retailing Supermarket company. The analysis includes the amount of money that this supplier would be willing to pay the retailer to gain access to RFID-enabled information. This amount is estimated on average by the interviewee. Approximately it is estimated that a supplier would give an amount of 1,500-2,000 Euros per year, per retailing store to gain access to this kind of information. Considering the number of the stores a retailer owns and the number of the suppliers the retailer collaborates with, we can conclude on the total profit that a retailer can gain by implementing the RFID enabled system (please see the respective calculations in the following section 4.4.4.1). If the specific RFID project was considered as an internal application the value of returns would be decreased for the retailing company.

Standalone or family applications? In addition, this case study supports the evidence which was collected in the first case study regarding the fact that the type of the IT project (whereas is a standalone or family application) is related to the overall value of the project. In contrast to the first case study, in this case study we have standalone applications. The dynamic pricing activity and the promotion management service are applications which can be implemented separately. The specific applications do not complement each other as they concern different business processes and different aims. For this reason, the cost benefit analysis is undertaken for the two RFID applications separately. However, as it is revealed in the case study I, if the two applications are implemented together, they can share one type of cost such as: the tagging cost of the products, the printers' cost, the internet infrastructure cost. Thus, in this case, the estimated value of returns will be altered. However, due to the standalone nature of these applications the shared cost would be less than the one in the first case study organisation.

What is the aim of the project? This case study reveals that the aim of the project (whether it is a strategic, transactional or informational project) can be related to the project's business value. In contrast to the previous case study, this organisation aims to implement RFID technology for strategic and informational applications. The strategic and informational nature of the promotion and dynamic pricing services alters the business value of the assessed RFID project. The collaboration of the retailing company with its suppliers in order to put into force the specific RFID applications results in a different value than that in the previous study. On the contrary, the previous case study involved transactional processes enabled by the RFID technology.

The retailing organisation in this case study aims at gaining a strategic advantage by enabling innovative collaborative RFID enabled techniques. The retailing company can "lock-in" its suppliers by giving them the opportunity to collaborate with the supermarket stores and get RFID based information for the products in a real time information. This can create a competitive advantage for the retailing company, thus increase the business value of the specific RFID applications.

4.4.4 **Assessment of Value of Returns**

An assessment of the value of returns was conducted. Based on the literature (Tiwana et al. 2007), the value of an IT project is the sum of the traditional net present value (NPV) plus the option value. In the case of growth options, the true value of a first stage IT project is the NPV of the first-stage project's cash flows plus the value of the second-stage projects (Dos Santos 1991). For this case, we have estimated first the project's cost and benefit based on quantitative measurements and then we have examined its option value based on qualitative determinants.

4.4.4.1 *Cost-Benefit Analysis*

This section has the aim to present the quantitative results of the cost-benefit analysis of the promotion management application. In addition, this section encompasses the main assumptions that have been made for the cost- benefit analysis. Based on these assumptions a dynamic cost-benefit analysis model has been generated. The benefit estimation has the aim to explain in a monetary basis what gains *a retailer* can draw from the implementation of the PM Service. In this section, the basic steps of the cost-benefit analysis and the most important results are going to be discussed. For brevity reasons, the full cost-benefit analysis and the data collection questionnaire can be found in APPENDIX 4.

1. Assumptions for the CB analysis

Several assumptions have been made for the estimation of the cost-benefit derived from the service for promotion management. Some of these assumptions refer to real data gathered through the interviews with the personnel from the retailing stores. For example, all the calculations are based on the number of the stores of the examined retailer which run promotions (150 retailing stores). Furthermore, the retailer has on average 2500 promotion points at these 150 stores. We assume that on average 16 promotion points are placed at every store. In addition, in order to estimate time and cost savings because of the RFID implementation, an average amount of salary had to be taken into account. In particular, the main assumption is the fact that one hour of the Sales Floor manager is charged in 10 Euros. Furthermore, it is assumed that the working days per year are 312. The table below includes the main figures based on which the cost-benefit estimations were made.

Table 4.8 Assumptions

Stores, suppliers and promotion stands	
Number of suppliers for the retailer	80
Total number of stores	200
Number of stores which run promotions	150
Promotion stands of all the stores	2,500

On average promotion stands per one store	16
Number of orders	
Number of orders with products for promotion received per month per store	3
Number of orders received per year per store	36
No of orders received per year for all the stores	5,400
Other variables	
Time period that one promotion event runs (weeks)	3
% of sales which comes from promotions (min and max)	30%
Sales come from the promotions per year (for all the stores)	200,000,000.00 €
Labor hourly rate	10.00 €

2. Benefit analysis

The main categories of the benefits derived from the promotion management service that were expressed in a monetary basis are the following:

- Direct benefits
- Indirect benefits
- Hidden benefits

(a) The direct benefits are considered as the benefits of the RFID-enabled service which come as a result of the expected cost savings. These cost savings come from the estimated decrease of time that currently employees need to (a) check the orders which are received (b) check the inventory stock and (c) check the stock on the promotion stands of each one store. Based on the location of the readers the direct benefits are estimated for these three business processes separately and are divided in two main stages: 1st stage: RFID is implemented in the inventory room for the business processes (a) and (b) and 2nd stage: RFID readers are placed on each one promotion stand.

After the respective calculations: the direct benefit for all the stores per year if RFID is applied to the backroom is 9,000 Euros from the business process of orders receiving and 156,000 from the inventory check process. When the second stage is implemented and the RFID is implemented in the sales floor, the direct benefits are estimated to be increased to 1,101,000 Euros (7,340 Euros per store). The respective tables in the APPENDIX 4 depict the main values of the key performance indicators for the direct benefit estimations and the overall results.

From the direct benefits, the opportunity for the retailer to *grow RFID investment* and utilise the technology not only for the backroom but also for the sales floor is shown. It is shown that in this case, the direct benefits are increased. In addition, through the estimation of the direct benefits the opportunity for the retailer to *scale RFID investment* to more than one stores is revealed and taken into consideration.

(b) Indirect benefits include two types of indirect benefits. The first type is the sales increase due the decrease of the time deviation between the programmed and the actual time of the launch of all the promotion events per year. The average time deviation based on the interview is 3 days per promotion event. This delay generates sales loss. It is estimated that this loss can be avoided with the RFID exploitation. The sales increase due to the time deviation decrease is estimated by the interviewee to be 700,000 Euros per year for all the stores.

The second type of benefits refers to the cost saving per year for all the stores due to the reduction of the out-of-stock occurrences only for promotion products. RFID implementation is considered to be one of the factors which can lead to this reduction. Based on the interviewee, the cost saving by such a reduction is estimated to be approximately 3,500,000 Euros for all the stores per year. This calculation refers to 1%-2% of the total sales for promotions per year which are lost due to out of stock occurrences (200,000,000 Euros). Please see APPENDIX 4 for the detailed discussion.

(c) Hidden Benefits are those which be derived through the service by selling RFID-enabled information to the suppliers. They include the amount of money that a supplier could pay the retailer to gain access to RFID- enabled information as it is estimated on average by the interviewee (Head Buyer of the specific retailing company Supermarket). This information is categorized based on the RFID implementation stages in the backroom and the Sales Floor. Based on the interviewee, a supplier could give from 50,000 to 70,000 Euros for each one different type of information (e.g. information for the exact time of the promotion products receipt by the retailer, information for the real-time inventory stock, stock on the promotion stands, real-time sales on the promotion stands, comparison of the sales on the stand and on the shelves and comparison with other stores to find the "hot spot" of promotions). If we sum up the above amounts for each bit of information, then the retailer could gain a total amount of 250,000 Euros per year by one supplier. Considering that the specific retailing company collaborates with overall 80 suppliers the amount that the retailer could gain is much higher. For the detailed calculations please see APPENDIX 4.

The specific type of benefits shows the fact that the value of *supply chain IT projects* is different from projects which do not entail the collaboration with other supply chain partners. Internal IT projects which are implemented within the limits of an organisation (see case study I and III) do not include the value which is derived by the partners' collaboration, such as the hidden benefits discussed above.

2. Cost estimation

RFID deployment for the support of the Promotion Management service requires the following two main types of cost for the retailer: (a) Capital Cost and (b) Operational Cost. The following table shows the main categories.

Table 4.9 Cost Categories

Cost	Categories
Hardware	• RFID equipment (RFID gates, RFID readers and antennas per promotion stand) • Server cost (one per store) • Networking equipment (per store) • Training for the service (per store)
Software	• Assessment of the retailer's store architecture • SW customisation (for the orders receiving and the promotion audit modules separately) • Integration with legacy systems (for the orders receiving and the promotion audit modules separately) • SW installation (for the orders receiving and the promotion audit modules separately)
Operational Cost	• HW and SW maintenance • License for the RFID enabled service programme • Cost of the tagged item-products (it is estimated for the supplier) • Tagging (programming, tagging and encoding) cost (estimated for the supplier)

As a result of the cost-benefit analysis, when only the first stage of investment is implemented the model results in a capital cost of 2,615,000 Euros and direct benefits 165,000 Euros per year for all the stores, while when the second-stage investment is applied the capital cost is increased to 7,700,000 Euros and also the direct benefits to 1,101,000.

An important issue during the modeling of the cost analysis that is revealed is the fact that these two stages of the RFID application share an amount of cost. In particular, the cost for the RFID gates, networking equipment, training and the tagging is going to be paid by the retailer regardless of whether the *second-stage investment* (e.g. adding RFID readers on the promotion stands) is undertaken by the retailer. Thus, if the retailer considers to grow investment in RFID and apply it not only to inventory management purposes but also for promotion auditing, then this kind of cost is shared between the two applications and the value of the overall RFID applications changes. The two sub-applications have *interdependencies* which have to be considered during an RFID investment evaluation, as they have an impact of the overall value of the assessed RFID application. The interdependencies can play an important role when managers consider to stage or grow their investment. In the particular case, investment in inventory auditing can be considered as a first-stage investment and initial application which can lead to further applications with an additional cost for the implementation.

NPV results: From the data above, it is concluded that the retailer will payback the RFID expenses after 2 years and will start to gain profit. If the hidden benefits are considered and the retailer starts "selling" the service to its suppliers, then the payback period will be sooner. In addition, if the indirect benefits (sales increase and out of stock decrease) of the RFID implementation for the Promotion management service are not taken into consideration then the investment will be paid back after many years (12 years).

For a detailed representation of the cost-benefit analysis please see APPENDIX 4. In addition, based on the promotion management service, a cost-benefit analysis for the dynamic pricing service was undertaken for the study. The way of thinking and the analysis of the dynamic pricing service followed the same steps with the ones for the cost benefit analysis of the promotion management service. For reasons of brevity and because of the fact that the findings are similar, this analysis is placed in APPENDIX 4 of the thesis.

4.4.4.2 *Option value*

(I) Real Option types: The specific case study gives us evidence that RFID technology implementation in the retailing organisation can yield to different types of options which according to the literature add to the existing business value of the examined RFID applications.

In particular, the retailer can break up and **stage investment** in the first RFID application for the support of the promotion management. The retailer can break up investment in three main stages: (1) orders receiving (2) inventory audit and (3) promotion stand stock audit. If only the first stage of investment in the orders receiving performs well, the retailer can invest further into additional RFID infrastructure to check the stock in the inventory room at a real-time basis. Under the same perspective, the retailer can pay for additional readers on each one promotion stand in order to be able to check the product availability on each one promotion stand inside the store. These three stages involve three different business processes with different benefits and additional cost. The company has the **option to grow** its investment and pay the additional cost only if it is covered by the anticipated additional benefits. Interviewed retailers and suppliers expressed the perception that a pilot implementation can give the incentive to invest further to additional RFID applications. The pilot implementation can be considered as an initial RFID application which then can lead to a further growth investment. As a result, the specific RFID case study gives us evidence that the adoption and implementation of the RFID technology can be influenced by the growth and stage options that a retailer has.

In addition, it is revealed that the organisation has the option to scale its investment by adding RFID readers to additional promotion stands/or fridges inside each store or adding RFID readers to additional stores for the promotion management and dynamic pricing respectively. Thus, the **scale option** can be exploited by the company. We have evidence from this case study that the scale option alters the overall value of the investment. In particular, from the cost-benefit analysis we can conclude that when additional stores are added for the RFID implementation, the overall value of the assessed applications changes. This happens because specific types of cost (e.g. the software customisation cost, the cost for the integration of the RFID system with the legacy systems and part of the hardware cost (e.g. cost of servers) are shared among the several stores. At the same time, with the addition of stores the savings as a result of the RFID implementation are multiplied. The overall value and result is a matter of whether the additional cost savings can cover the store/warehouses additional cost.

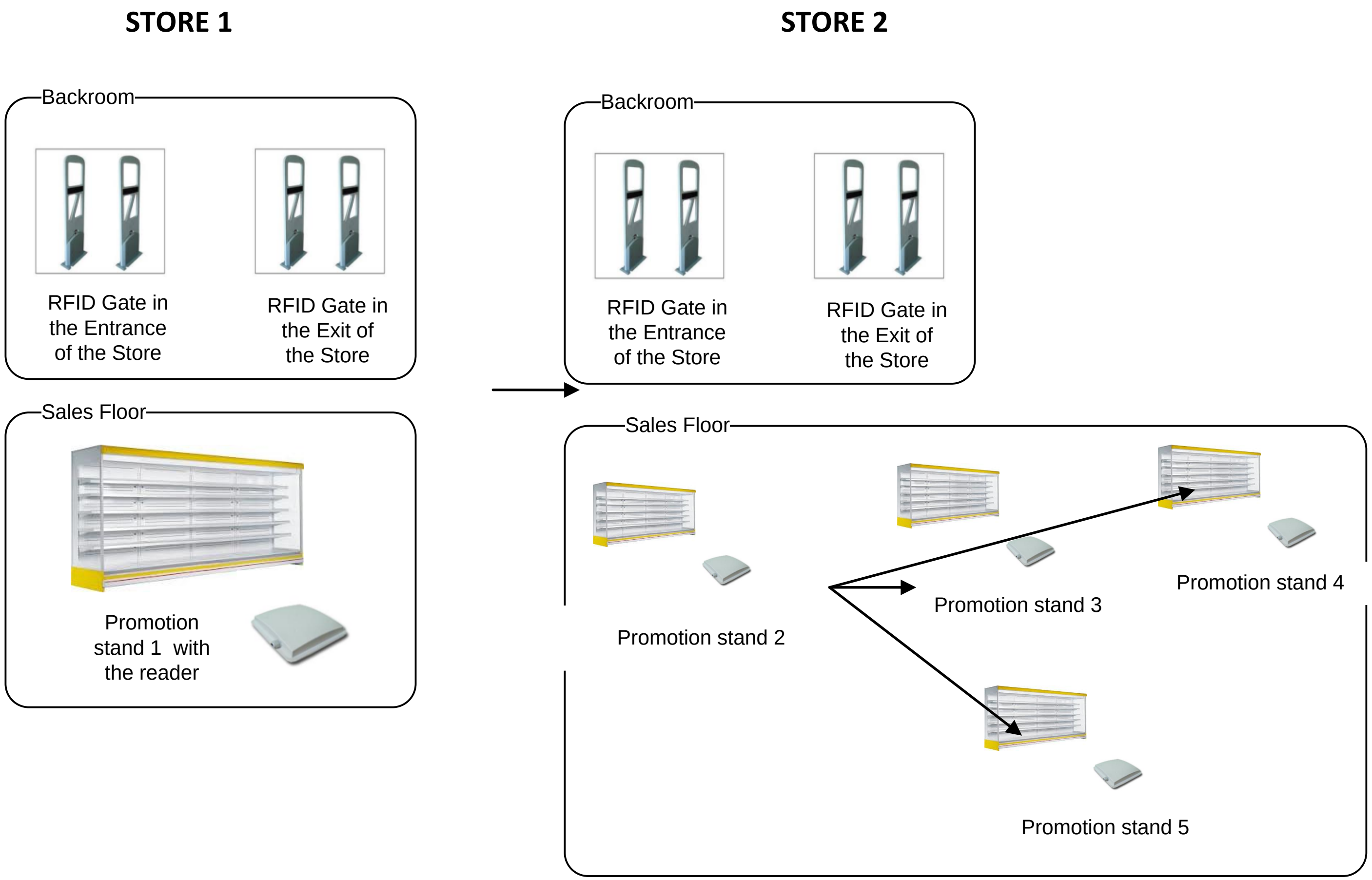


Figure 4.4 Scale Option to additional promotion stands and stores

Moreover, the retailing company has the option to **defer investments** in the full-implementation of the promotion management service (stages 2 and 3) or even in the second application: dynamic pricing application, if the first stage of the investment proves to be unsuccessful. For the option to delay the investment we have evidence from this case study and the workshop that was organised in one of the retailer's stores in Agia Paraskeyi, in Athens. Members from the ECR Hellas and other business contacts were invited to evaluate the RFID enabled system. Overall, 24 executives from multinational companies (from which 50% were suppliers) participated in the workshop. The promotion management and dynamic pricing activities were presented to the executives. The executives had the opportunity to see a live demonstration of the RFID enabled system and the promotion stand inside the specific store. Afterwards, a questionnaire and discussion regarding the executives' opinion on the RFID enabled services took place. What is interesting is the fact that the majority of the participants expressed their ***reluctance to invest in RFID technology on at least a 3-year horizon***. The main reasons for the expressed reluctance and the willingness to delay such an investment were the following:

- Very high procurement and deployment costs of RFID technology and support infrastructure;
- Lack of standardized procedures for tagging products and sharing of information;
- Uncertainty regarding ROI, payback of the investment;
- Immaturity of the technology;
- Lack of a "technocentric" culture by consumers and small companies which might lead to a ‘resistance to change’ attitude

However, the majority of the participants believed that the assessed technology will be deployed later in the forthcoming years. According to the participants' perceptions: pilot implementations such as the specific RFID enabled applications will drive the incentives for the market to invest in the technology at a later point of time. In summary, participants were able to see the value of returns coming from this technology but were reluctant to invest in it now.

(II) Factors that affect option value:

Technology strategy: Based on the analysis of the current business processes of the retailing supermarket company regarding promotion management and dynamic pricing, it was concluded that the proposed RFID enabled applications will have a radical impact on the firm. The proposed RFID applications are introduced to the involved retailer and supplier as innovative collaborative initiatives under completely new business processes. We have evidence from the case that supports the high degree of the required business transformation. In particular, to test the level of business transformation due to the RFID implementation, we asked the 24 executives participated in the workshop which was held in the retailer's premises. A questionnaire was distributed to the executives who were asked to evaluate the RFID system and its applications (promotion management and dynamic pricing). The majority of the respondents stated that:

"The *level of the required business process reengineering is high"* (mean=5.23).. *"The RFID system which will support these two applications will contribute to the competitive advantage for our companies".*

The question was based on a Likert point measurement (from 1 to 7). The majority of the answers agreed at a high level with this statement resulting in a mean of the answers equal to 5.50 and a Standard Deviation equal to 1.06. In addition, the sustainability of this competitive advantage is evaluated by the RFID experts as high. The specific RFID applications when implemented require the collaboration among the retailer and its suppliers. The retailer can "lock-in" its suppliers with this collaboration. As a result, for their suppliers will be very costly to switch to other retailers in order to be provided with the specific RFID service. The strategic impact and the required business process reengineering as a result of these RFID applications will create a sustainable advantage for the retailer which will be difficult to be imitated by the competitors. On the contrary, in the first case study the level of radicalness and sustainable strategic impact of the RFID applications was evaluated by the RFID expert team as medium to low.

Based on the literature (Fichman 2004) the above parameters are part of the factor "technology strategy" which is expected to increase the option value of an IT. This case provides us with evidence that technology strategy is related to the option value of the specific RFID project. In particular, the participants in the workshop (based on the analysis of the respective workshop survey) realising the radical changes that are required for the implementation of the specific RFID system, expressed their attitude towards the delay of such an investment (i.e. option to defer). The following quotation from the workshop supports the above argument:

"The technology is immature.. there is lack of standards …..lack of a technocentric culture… probable resistance to change"…There is the uncertainty regarding the ROI coming from the RFID implementation".

However, at the same time they stated that the RFID system will provide the company with a sustainable competitive advantage which will be facilitated by pilot implementations. These pilot implementations can be considered as initial investments for additional applications and investments (option to grow and option to stage the investment). The actual impact of this parameter on the option recognition and value is going to be empirically tested in chapter 5 by a quantitative study.

Technology bandwagon: In the specific case, the interview with one of the biggest suppliers of the specific retailing company revealed that the current promotion management operation is not adequate as the supplier is not provided with relevant on-time information (e.g. exact time of the initiation of the promotion event, distinction of the sales coming from the promotion and the ones coming from the supermarket itself, out-of-shelf information, comparison regarding the performance of the promotion stand with the performance of the products on the shelves of the supermarket). In addition, the 24 executives and the distributed questionnaire in the workshop revealed that the degree of information quality of the current promotion events is low (with means -for each information type- from 2.76 to 3.91). Suppliers win the workshop and the supplier in the interview expressed their desire for the promotion management improvement. This parameter reveals that the retailer receives pressure from its suppliers to enhance the promotion event service. Due to this pressure, the retailing company wanted to implement RFID technology. The characteristic refers to the "network externalities" (Katz & Shapiro 1985) which can be related to the pressure coming from a company's network to adopt a technology. In addition, this kind of pressure in the specific case study is high as the evaluated applications are based on the improvement of the supplier-retailer collaboration and require the involvement of both partners. The workshop revealed that the higher perceived net benefit due to the RFID system implementation was the improvement of the supply chain visibility (mean=5.71) and supply chain collaboration (mean= 5.58).

In addition, the retailing supermarket company believed that RFID technology would dominate over other technologies. As a result, the "network dominance" of the technology is perceived as high for the retailer, based on the interview which was held. According to the literature (Fichman 2004) the above two parameters: "network externalities" and "network dominance" form the factor "technology bandwagon" which is expected to influence real option recognition and value. We have evidence from the case study that these attributes are related to option value. In particular, the retailer recognised the opportunity to invest initially in RFID technology for one simple scenario of RFID implementation and then invest further in additional applications (i.e. growth option). The way the growth option recognition and value are influenced by these two attributes is going to be analysed in the next section of the thesis with an empirical study.

Technology adaptation: In the specific case study, the investment evaluation was considered in stages. Investment in the RFID for the support of the promotion management collaborative service was divided into three main stages. First, the retailing company could invest in the RFID infrastructure to audit the receipt and the exit of the products on promotion. At a second stage, the company could place RFID readers in the inventory to check the inventory status. Finally, the company could add RFID readers on each promotion stand inside the store to check the availability of the products on each one promotion store. The first two steps refer to backroom activities, whereas the third stage to the sales floor activities. This parameters shows that RFID technology has a high level of divisibility. According to the literature (Fichman 2004) divisibility is a parameter that can create growth option value.

In addition, this parameter is related to the modularity and the flexibility of the RFID implementation. For example, for the RFID evaluation assessment for the dynamic pricing application, three scenarios were presented to the organisation which show the modularity of the technology. The first scenario included the RFID implementation in only one store, placing readers on all the fridges inside the store. The second scenario included the implementation of RFID in all the stores and the placement of RFID readers in only one fridge for each one store, where the third scenario presented to the organisation the full implementation (all the stores and all the fridges inside each one store). These different scenarios show that the technology is composed from components that can be separated and recombined. As a result, different interpretations of the RFID implementation can be assigned to the applications. This parameter according to the literature is a source of growth option (Scarso 1996; Angelou & Economides 2009a).

As a result, we have evidence that these two parameters: "Divisibility" and "modularity/interpretive flexibility" are meaningful in this case. According to the literature (Fichman 2004) these two technological characteristics form the factor "technology adaptation". Their impact on the growth option recognition and value is going to be empirically tested with an quantitative study in the following chapter 5.

4.5 Case Study III: An international Beverage Company

4.5.1 The Context

The organisation is one of the biggest international manufacturing companies and distribution centers in the beverage sector. The analysis below refers to the part of the company which produces and distributes products in Greece. The specific company in Greece has to decide whether to adopt the RFID technology in any of its nine warehouse units. The firm is interested in assessing RFID technology regarding its implementation in its warehouse's day-to-day business processes. These processes include: (1) the process of automatic identification of the orders received in the warehouses of the company (PR), (2) the process of preparing and checking product shipments (PS) to customers and selling points and (3) inventory auditing (IA).

4.5.2 RFID project objectives and scope

The examined business processes are depicted in the next figures before and after the utilization of RFID technology. In the receiving and shipping process, the pallets inside the trucks are identified automatically when they pass through an RFID gate, without the need to scan and examine each one of the pallets separately. In addition, regarding the RFID implementation for inventory audit, RFID gates are going to be placed inside inventories in each warehouse. The inventory audit with the RFID technology can be automatically undertaken without the need of physical checks.

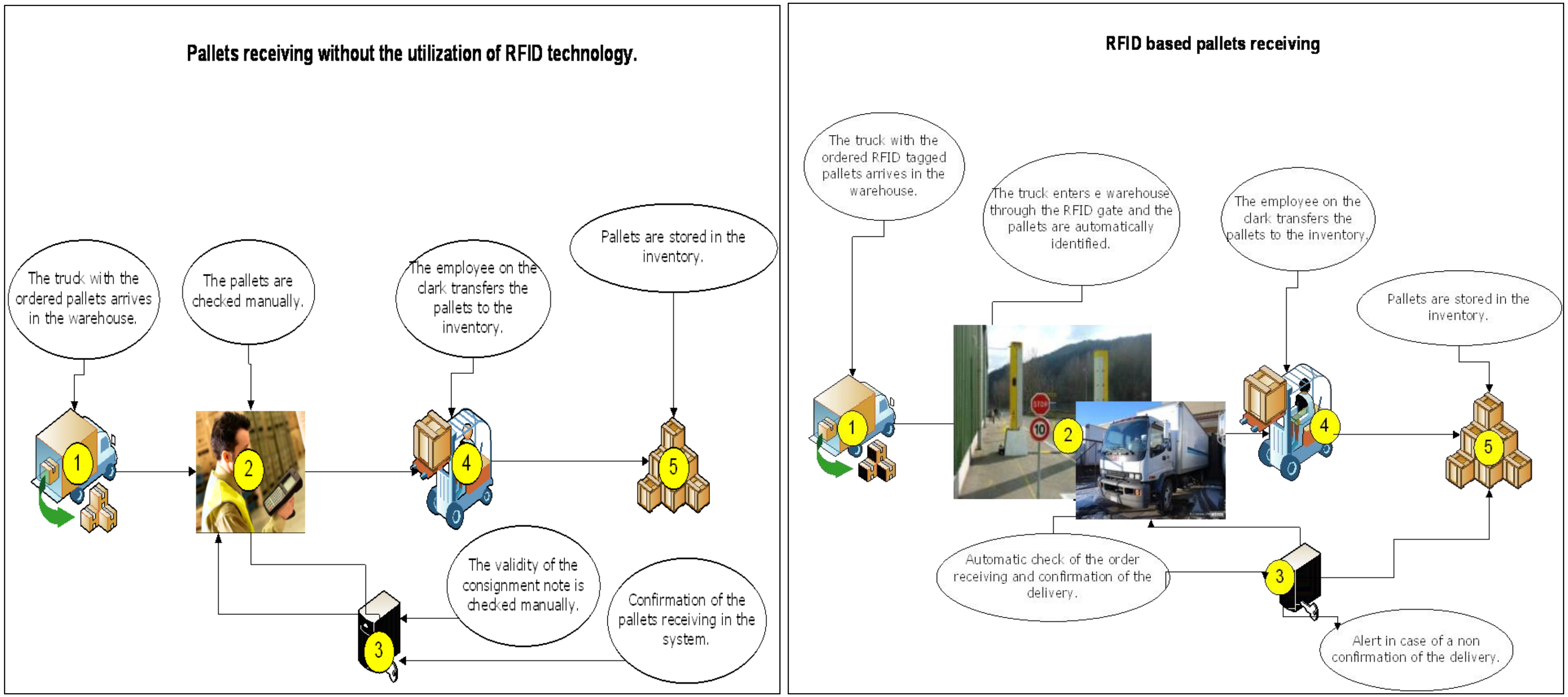


Figure 4.5 RFID deployment for the pallet receiving process (PR)

Pallets shipping without the utilization of RFID technology

RFID based pallets shipping

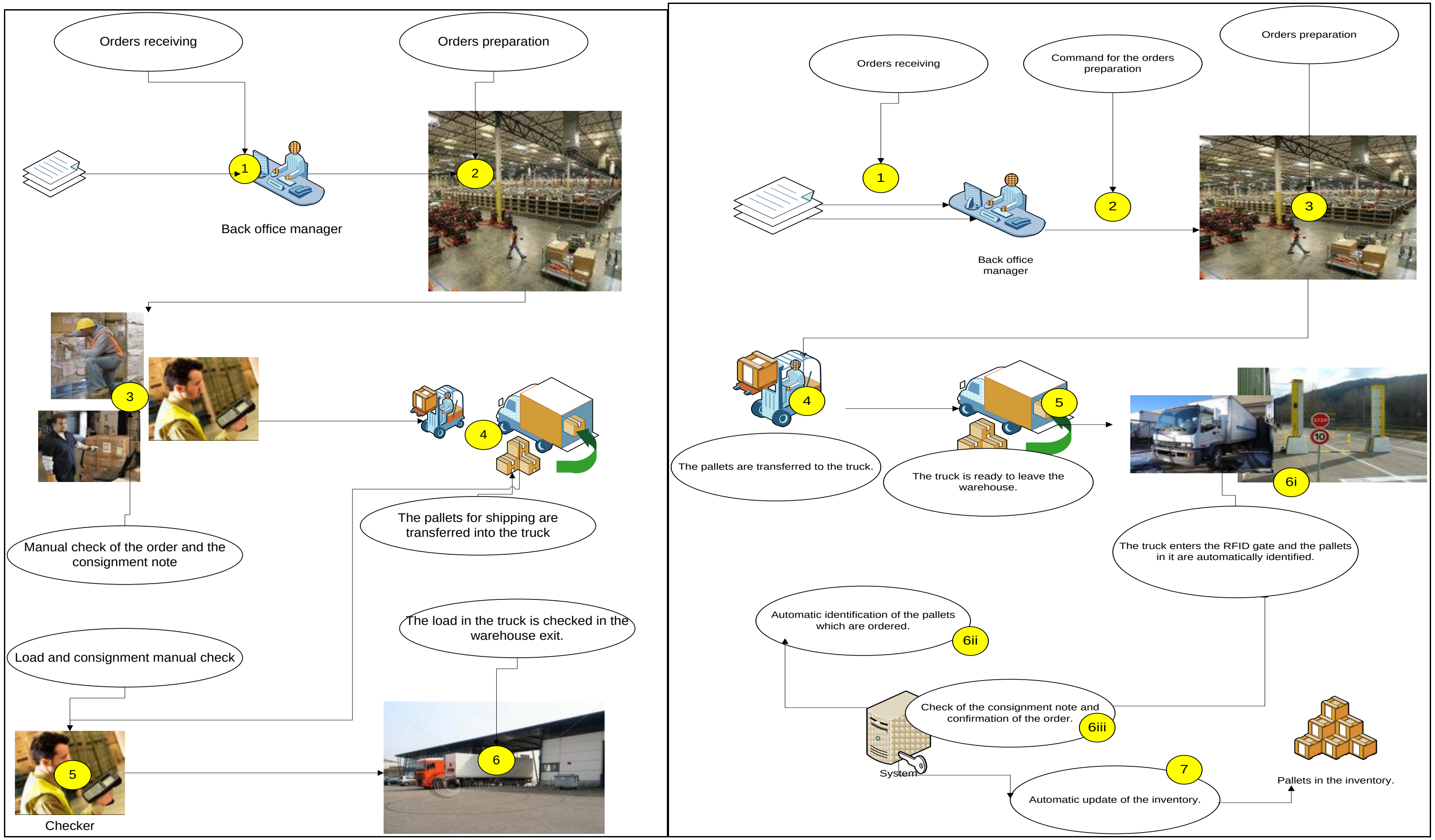


Figure 4.6 RFID deployment for the pallets shipping (PS)

4.5.3 IT project value based on the IT typology

Internal or Supply Chain projects? The specific case resembles case study I, because the type of the assessed IT projects are quite similar. However, the difference is that in case study I RFID were considered to be implemented in the retailer's stores, whereas in this case study, RFID is considered to be implemented inside the supplier's distribution centers and warehouses. In this case study, evidence reinforces the fact that whether the project is an internal or supply chain alters its overall value. The specific IT applications for pallets receiving, shipping and inventory auditing can be put into force internally in the supplier's warehouses, without the involvement of its partners. Therefore in this case we have an internal RFID project (as in case I). However, the value of the specific RFID applications is different than the previous case studies, because the supplier owns the cost of the tagging pallets plus the capital cost of the printers. In particular, based on the quantitative NPV analysis, if the supplier decides to implement the RFID technology in all its nine warehouses (regardless of the application) he will have to pay a cost of 80.000 Euros totally. A supplier is the one who generates the products sold and put into pallets after the production. Therefore, he is the one who will bear the tagging cost and the cost of the printers. On the contrary, a retailer (such as in case study I) does not have to bear this cost. As a result, in this case the cost is internal and is not shared between other members of the supply chain. The overall value of the assessed RFID project diminishes based on this kind of cost.

Standalone or family applications? This case study reinforces the evidence from the previous two case studies, according to which the type of applications (whether they are standalone or family applications) influences the overall value of the RFID project. In particular, based on the quantitative sensitivity analysis, if the supplier considers an application as a standalone one and implement RFID only for example for the orders receiving business process, then the NPV will be 126,000 Euros with a capital expense which equals to 254,300 Euros and savings 226,170 Euros. On the contrary, if the supplier considers to implement RFID simultaneously for the automation of pallets shipping, then the NPV increases (236,000 approximately). In this case, the capital expenses are more, but they are covered from the additional cost savings that the second application offers to the organisation. The specific RFID applications are family applications as they can share an amount of cost (e.g. cost of printers, cost of networking in a warehouse, cost of tagging, cost of training, cost of maintenance) and offer additional benefits to the company. This amount of cost is going to be undertaken regardless of the numbers of the applications applied. Thus, if more applications are implemented the more the firm can share and distribute this cost among the different applications.

The fact that these applications can be considered as a series of family applications can create the opportunity for growth options, compared to standalone applications. The impact of the options' influence on the perceived value of returns in RFID family projects will be tested with an empirical study and discussed in the next chapters of the thesis.

Aim of the project: The specific supplier is interested in applying RFID technology for the automation of the transactional business processes of (1) orders receiving (2) orders shipping and (3) inventory auditing. In contrast to the second case study, the specific RFID applications do not have a strategic aim but a transactional one instead, as they involve the daily business transactions of the specific beverage company. It is assumed that the perceived value of the specific RFID implementation would be different if the supplier added another RFID application with a higher strategic impact, such as collaborative RFID enabled processes such as: tracking the products distributed in the supermarket stores in the whole supply chain and getting information for their real time sales, real-time basket analysis etc.

4.5.4 **Assessment of Value of Returns**

As in the previous cases, the overall value (net present value plus real options value) is going to be examined.

4.5.4.1 *Net Present Value (NPV)*

To conduct the passive NPV approach for the RFID investment evaluation the following steps are followed.

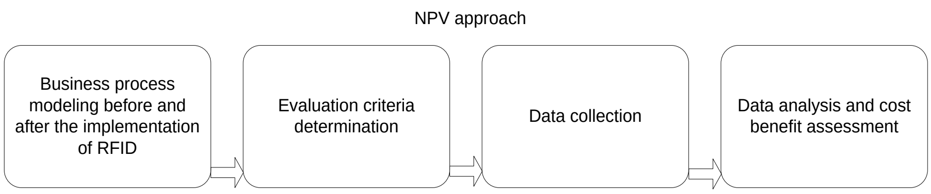


Figure 4.7 The NPV approach process

In particular, business process modeling before and after the implementation of RFID technology is required in order to capture the difference among the two different processes and understand the impact of RFID technology. This step is based on the

As-is and the To-be business processes after the implementation of RFID technology. This process has been proposed by other similar studies on the RFID investment evaluation through the NPV approach (A. Karagiannaki et al. 2010; Bottani & Rizzi 2008). Then the evaluation criteria are determined. In this step, the criteria which will estimate the savings and the cost of the RFID investment evaluation are identified (e.g. cost of the tags attached to the products, savings derived from the cost of manpower required to receive or ship products which are distributed in the supply chain) (Bottani & Rizzi 2008). Next, the required data are collected in order to estimate the specified criteria. Several data collection tools (e.g. questionnaire, interviews, historical ERP data) were utilised in this case. The last step entails the analysis of the data and the cost benefit assessment.

Criteria for the evaluation of the cost: Based on the business process modeling, the criteria for the evaluation of the RFID implementation are specified. The cost is categorized into two main categories: into the capital expenses of RFID and the operational expenses.

Table 4.10 Evaluation criteria for the cost

Evaluation criteria for the cost	
CAPEX	• *Warehouse networking cost (server in the central warehouse, networking, PCs)* • *RFID infrastructure cost (RFID printer, RFID gates)* • *Integration with legacy systems* • *Software development cost for the RFID* • *Testing and SW installation*
OPEX	• *Training cost* • *RFID tags cost* • *Hardware and software maintenance and update cost*

Criteria for the evaluation of the benefits: For the benefit estimation the focus was on the estimation of the cost saving that will be derived from the RFID technology implementation separately for each of the three examined business processes. For example, for the cost saving of the PR (pallets receiving) process the "as-is" time needed for the checking of one truck with received pallets compared to the "to-be" time of this process after the RFID implementation is the main evaluation criterion. Based on the cost of manpower before and after the RFID implementation, the cost saving is estimated. The same evaluation criteria were identified for the second business process. The numerical interpretation of the benefits and cost are analyzed in the next section for the research model development.

The adoption of the RFID technology will provide our firm financial benefits (or more accurately, cost savings) due to the reduction of

(a) The time and resources needed to receive and store the products sent by the producing factories to the warehouses, and

(b) The time and resources needed to prepare orders, and ship them to customers and sale points.

(c) The time and resources needed to audit inventory in each one warehouse.

For example, let $S_{j,t}^{i}$ denote the cost saving/financial benefit the firm will earn in year t, from installing the RFID technology for process i in warehouse j. For the product receipt (PR) process, the financial benefit or cost saving $S_{j,t}^{PR}$, is given by

$$S_{j,t}^{PR} = \left(e_{PR,j}h_{PR,j} - e_{PR,j}^{*}h_{PR,j}^{*}\right) \times L \times D \times TS_{j,t}^{PR}$$

where

$h_{PR,j}$	:	Time (in hours) needed to receive and store the product pallets received in warehouse j, per truck shipment;
$h_{PR,j}^{*}$	:	Estimate of time (in hours) it will take to receive and store the product pallets received in warehouse j, per truck shipment after the adoption of RFID;
$e_{PR,j}$	:	Number of workers employed in the receipt and storage of product pallets per truck shipment in warehouse j;
$e_{PR,j}^{*}$	:	Estimate of number of workers that will be employed in the receipt and storage of product pallets per shipment in warehouse j after the adoption of RFID;
L	:	Labor cost (per hour) for warehouse workers;
D	:	Number of working days per year;
$TS_{j,t}^{PR}$	:	Average number of daily truck shipments (with product pallets) received by warehouse j in year t.

Equation (1) implies that the benefit $S_{j,t}^{PR}$ stems from less workers and time needed to receive and store the product pallets per truck shipment. The same calculations were done for the second process for the pallets shipping.

You can see below the overall results (NPV) of the cost-benefit analysis. For a detailed analysis for all the results please see APPENDIX 5. Due to the fact that the calculations are the same like in the previous studies the next section includes only the differences with the previous cases.

For the estimation of the cost saving coming from the inventory auditing process, it is assumed that only one physical auditing will be held per year, as the inventory audits per month will be conducted automatically. For the data collection instrument and the respective calculations for the Net Present Value please see APPENDIX 5.

Table 4.11 NPV if RFID is implemented for all the 9 warehouses and the three applications

	YEARS					
N/A	0	1	2	3	4	5
SAVINGS						
Inventory audit cost savings		81,650.80 €	81,650.80 €	81,650.80 €	81,650.80 €	81,650.80 €
Pallets receiving cost savings		226,170.68 €	226,170.68 €	226,170.68 €	226,170.68 €	226,170.68 €
Pallets shipping cost savings		72,948.83 €	72,948.83 €	72,948.83 €	72,948.83 €	72,948.83 €
TOTAL SAVINGS		380,770.30 €	380,770.30 €	380,770.30 €	380,770.30 €	380,770.30 €
CAPEX						
RFID infrastructure (RFID GATES,PRINTERS)	*362,000.00 €*					
SERVERS/PCS/NETWORKING	*24,300.00 €*					
SW DEVELOPMENT	*102,000.00 €*					
OPEX						
RFID TAGs Cost		93,848.17 €	84,463.35 €	76,017.02 €	68,415.31 €	61,573.78 €
Maintenance HW		38,630.00 €	38,630.00 €	38,630.00 €	38,630.00 €	38,630.00 €
Update and Maintenance SW		10,200.00 €	10,200.00 €	10,200.00 €	10,200.00 €	10,200.00 €
New employees training		4,320.00 €	648.00 €	648.00 €	648.00 €	648.00 €
TOTAL COST (CAPEX+OPEX)	488,300.00 €	146,998.17 €	133,941.35 €	125,495.02 €	117,893.31 €	111,051.78 €
Depreciation		146,490.00	146,490.00	146,490.00	48,830.00	0.00
Total cost (Cost+Depreciation)	488,300.00 €	293,488.17 €	280,431.35 €	271,985.02 €	166,723.31 €	111,051.78 €
Profit (TOTAL BENEFIT-TOTAL COST)	- 488,300.00 €	87,282.14 €	100,338.95 €	108,785.29 €	214,046.99 €	269,718.52 €
Tax (23%)		20,074.89 €	23,077.96 €	25,020.62 €	49,230.81 €	62,035.26 €
Net profit (after tax)	- 488,300.00 €	67,207.25 €	77,260.99 €	83,764.67 €	164,816.18 €	207,683.26 €
Net cash flows (net profit+ depreciation)	- 488,300.00 €	213,697.25 €	223,750.99 €	230,254.67 €	213,646.18 €	207,683.26 €
PRESENT VALUE	- 488,300.00 €	190,801.11 €	178,372.92 €	163,890.73 €	135,776.01 €	117,845.06 €
CUMMULATIVE PRESENT VALUES	- 488,300.00 €	- 297,498.89 €	- 119,125.97 €	44,764.76 €	180,540.77 €	298,385.83 €
NET PRESENT VALUE OF THE INVESTMENT	298,385.83 €					
PAYBACK PERIOD	2.7					
ROI		39.07%	75.60%	109.17%	136.97%	161.11%

Differences with the NPV estimation of the previous studies

The specific case study has several differences regarding the estimation of the net present value in contrast to the previous case studies which influence the assessed overall value and option value of the RFID applications.

1. The supplier owns the RFID cost regarding the RFID printers and the tagging of the pallets

The implementation is undertaken for the supplier and not the retailer. This aspect has an impact on the value of the RFID project evaluation as the cost of the implementation is higher due to the tagging cost and the cost of the RFID printers. In particular, a total cost of the printers is estimated based on the number of the palletisation units that are places in each one warehouse. A total cost of 20,000 Euros for all the warehouses is estimated. Relevant to this is that the tagging cost is based on the number of pallets and not the number of items that are distributed. If RFID is implemented in all the warehouses, the tagging cost per year will range between 60,000 and 94,000 euro approximately for the supplier (The cost ranges based on the estimated annual decrease of the tag per pallet cost).

2. Different data for each one warehouse

This is a very important issue compared to the previous case studies. In particular, the total cost savings and the total cost is based on different data for each one warehouse. Data regarding the time that is utilised for the execution of a business process in each one warehouse separately is given. In addition, different numbers of pallets are distributed between the warehouses. Based on that, different amount of cost savings are estimated for each one separate warehouse.

In addition, the cost which is calculated is different for each one warehouse, as each one warehouse has a different number of palletisation units (for the RFID printers cost) and a different number of inventory units (for the RFID gates cost). As a result, of the above, the overall value of RFID technology is not estimated in one warehouse and then multiplied based on the number of warehouses. On the contrary, the value of the RFID application is different for each one different warehouse.

3. Sensitivity analysis

Due to the fact that we had got different data for each one warehouse, it was shown in this case study that for specific warehouses RFID is more meaningful and worthwhile the cost than for other warehouses. This is explained by the fact that the amount of pallets that each one warehouse manages varies. It is concluded that for the warehouses were the distribution of pallets is high, RFID technology has a higher value. In addition, for the analysis different scenarios are examined based on the number of the applications that are implemented and the number of the warehouses that RFID is going to be applied to. Three groups of warehouses are examined together in order to find what is the optimum investment scenario for the organisation. The groups which are examined are chosen because of the high number of pallets that are distributed among the warehouses of the same group.

Table 4.12 1st scenario -Each one group of warehouses only for the pallets receiving and shipping

Groups of warehouses	NPV	Payback period	Total Cost CAPEX	Average Cost per year(OPEX)	Total Savings
1st group (Schimatatari,Aigio,Patra,Athens,Rentis)	165,996.98 €	2.4	199,500.00 €	74,494.01 €	194,584.02 €
2nd Group (Thessaloniki,Volos)	95,924.57 €	2.3	113,400.00 €	27,502.58 €	95,963.76 €
3rd Group (Irakleio,Malia)	-104,588.51 €		97,400.00 €	17,279.34 €	8,571.73 €

Table 4.13 2nd Scenario -Each one group of warehouses and all (3) of the business processes

Groups of warehouses	NPV	Payback period	Total Cost CAPEX	Average Cost per year(OPEX)	Total Savings
1st group (Schimatatari,Aigio,Patra,Athens,Rentis)	190,708.90 €	2.6	277,500.00 €	82,294.01 €	234,320.42 €
2nd Group (Thessaloniki,Volos)	102,099.94 €	2.6	161,400.00 €	32,302.58 €	117,162.96 €
3rd Group (Irakleio,Malia)	-99,756.57 €	12	145,400.00 €	22,079.34 €	29,286.93 €

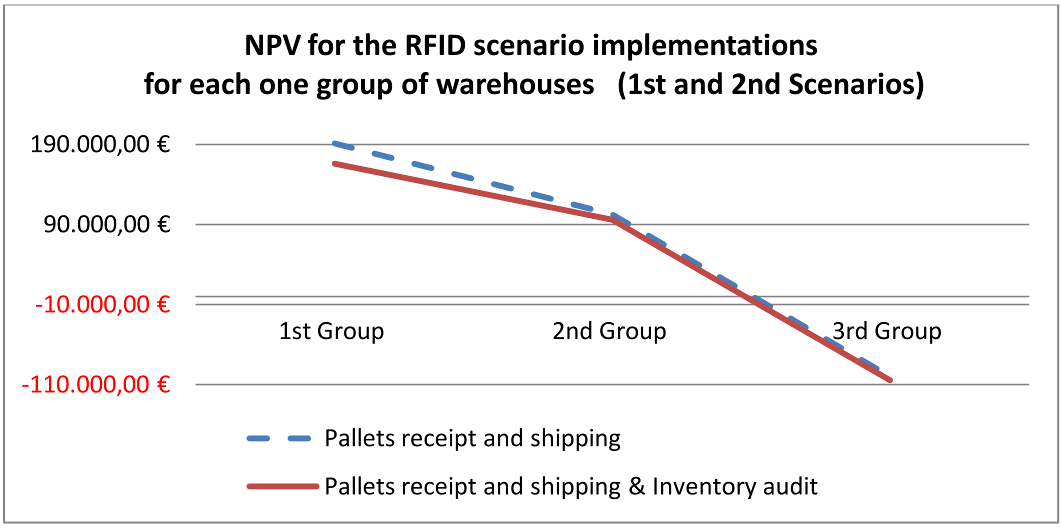


Figure 4.8 NPV for the RFID scenarios

Table 4.14 3rd Scenario -All the warehouses for the two and then the three business processes

Groups of warehouses	**NPV**	**Payback period**	Total Cost CAPEX	Average Cost per year(OPEX)	Total Savings
Scenario 3 All the warehouse only for Pallets receiving and shipping	236,333.20 €	2.6	338,300.00 €	112,075.93 €	299,119.50 €
Scenario 4 All the warehouses and all the processes	298,385.83 €	2.7	488,300.00 €	127,075.93 €	380,770.30 €

Table 4.15 Comparative analysis for the scenarios above

Groups of warehouses	**NPV for pallets receiving and shipping**	**NPV for all the processes**
1st group (Schimatatari,Aigio,Patra,Athens,Rentis)	165,996.98 €	190,708.90 €
2nd Group (Thessaloniki,Volos)	95,924.57 €	102,099.94 €
3rd Group (Irakleio,Malia)	-104,588.51 €	-99,756.57 €
All the warehouses	236,333.20 €	298,385.83 €

Results show that if the supplier considers RFID as a *family of applications* (i.e. implementing the three applications simultaneously) then the NPV is higher than considering only the two applications. Thus, the supplier if considers to grow its investment for each one group of warehouses and exploit RFID for more than the two applications, the value of the investment gets higher. This happens because, the applications have synergies and share an amount of cost (Warehouse networking, RFID printers cost, integration with legacy systems, SW installation). Moreover, the addition of the third application for inventory auditing gives further cost savings for the company.

In addition the opportunity that the supplier has to scale its investment to additional warehouses depends on the cost savings and the cost which is added for each one additional warehouse.

4.5.4.2 *Option Value*

(I) Real Option types

Growth opportunities: During the evaluation of the RFID applications in the specific beverage supplier we had evidence which support the fact that several types of options can alter the overall value of the assessed technology. First of all the quantitative sensitivity analysis which is conducted shows that the overall value of the RFID project changes based on whether the supplier will implement RFID in all the processes or only in the two processes (orders receiving and orders shipping). If for example the supplier considers the opportunity to grow its investment (growth opportunity) and apply RFID in all its warehouses adding the process of inventory auditing, then based on the NPV sensitivity analysis, the payback period will be a little higher (2.7 years) than the respective one (2.6 years) when only the two processes are implemented. This is explained by the fact that the addition of the third RFID enabled process creates additional cost for the company. The supplier based on the data we received can grow its investment and apply RFID technology in additional business processes such as "inventory auditing" based on the success of the implementation of the other two processes.

Opportunities to scale the investment: We have evidence from the case that the supplier can scale RFID investment in additional warehouses. The difference with the previous two case studies is that for this case study we have data that differentiate the impact of RFID in each one different warehouse. Thus, the significance of the opportunity to scale the investment in this case study is more meaningful and elaborate. The different impact depends on the number of the pallets which are distributed from and to each one warehouse. Based on the conducted sensitivity analysis, considering to implement RFID technology in only two specific warehouses (i.e. Hrakleio and Malia) the NPV approach is negative. On the other hand, if the supplier considers scaling the investment and exploiting RFID in the rest of the warehouses, then NPV becomes positive. This happens because the distribution of the pallets in only these two distribution centers is not adequate to justify such a costly investment in RFID. The cost savings coming from the investment are not high enough to cover the high cost. This is a result of the low level of distribution of pallets between these two centers.

Opportunities to stage the investment: Under the same perspective and the above analysis, the supplier can break up its investment into specific stages. Based on the success of each one stage (whether this is the type of application or the number of the warehouses) the supplier can invest further.

Note: Although these options are evident, their value is only considered through the NPV approach. Thus, the variance of the pallets distribution in not considered. However, specific formulas which are developed in the Real Options field can entail the value of the variance of the pallets distribution in each warehouse and assess the value of each one option. This thesis underlines this as future research and not as a part of the research as this aspect does not fall into the aim of the specific study.

4.6 **Cross-Case findings and discussion**

1. RFID deployment varies in terms of specific IT dimensions (scope, purpose and span).

Cross-case findings reveal specific dimensions of an IT project that differentiate RFID implementations. Each one RFID implementation varies among these dimensions between low and high points. The following table depicts the characteristics of each one RFID deployment each one of the three cases.

Table 4.16 RFID deployment categories

Case Study	Business Processes	Unit of analysis	IT project type						
			Span		Purpose			Scope	
		Retailer: 1 Supplier:2	Supply Chain	Internal	Strategic	Transactional	Informational	Standalone	Family
I. A retailing company in the telecommunications industry	✓ Orders receiving ✓ Check out	**1**		**x**		**x**			**x**
II. Retailing company in the supermarket industry	✓ Promotions management ✓ Dynamic Pricing	**1**	**x**		**x**		**x**	**x**	
III. An international Beverage company producer	✓ Orders receiving ✓ Orders shipment ✓ Inventory check	**2**		**x**		**x**			**x**

The RFID implementations in the three case organisations referred to either <u>standalone applications</u>- which serve mainly one business activity- or <u>family applications</u>- which entail interdependent business processes and applications. In case study I (Retailing telecommunications company) and III (International Beverage Company) the organisations assess RFID applications which share cost and benefit synergies and can be implemented as a sequence-as a "bundle of interrelated investment projects (Panayi & Lenos Trigeorgis 1998)". We have shown evidence that in these two case studies, the RFID applications for the orders receiving and shipping, check out process and the inventory audit can work as a chain of initial and follow on applications. On the contrary, in case study III (International Beverage company) the RFID project consists of two separate standalone applications (promotion management service and dynamic pricing) which share a lower amount level of cost and benefits compared to the other two case studies. The one application (e.g. promotion management service) can be implemented independently of the second one, as they refer to very different aims and business processes. Thus, in this case, the scope of these applications in case study III is low. For this classification we utilise the term **"scope"** to indicate family applications as having high scope and applications which are deployed in a standalone basis as applications with low level of scope.

Second, in terms of the **purpose** of the examined RFID applications, the three case studies were different. In particular, the first and the third organisations examined and chose RFID applications for the automation of the existing business processes. According to the literature (Weill 1992) this kind of investment is a transactional. On the contrary, in case study II we came across strategic innovative RFID applications which required the generation of new business processes in the company for their execution. In addition, these applications in the second case study had a higher level of innovation with the aim to rather gain competitive advantage than enhance the already existing business processes.

Accordingly, the three case studies revealed that the RFID implementation could be different based on the level of supply chain collaboration that it requires. In the retailing telecommunications organisation (case study I) and the international company in the beverage sector (case study III) the implementation of the applications could be deployed internally within the organisations without the need for the companies to collaborate with other partners in the supply chain. On the contrary, in the retailing supermarket company (case II); the two assessed RFID applications were based on a supply-chain collaboration. Based on the term **"span"** which according to the literature (Mejza & Wisner 2001) refers to the point of integration among a firm and other organisations, the three case studies show a different level (how or low span). In addition, literature in RFID (Roh et al. 2009) makes this differentiation referring to internal or multiple RFID applications based on whether the application is deployed within a single organisation ("internal application") or in collaboration with other organisations (multiple applications").

Based on the above dimensions the following classification scheme is generated. The three examined case organisations are positioned within a classification matrix based on whether they are internal/supply chain and standalone/family applications. The diagonal which crosses each one quadrant differentiates the RFID implementation based on whether is a transactional or strategic/informational technology project.

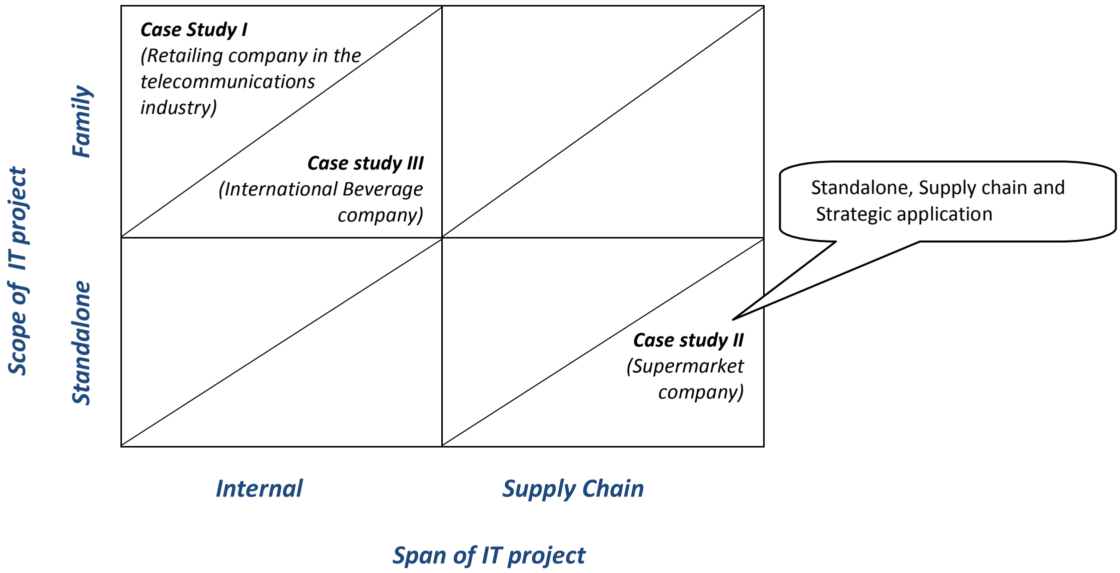


Figure 4.9 A classification matrix for the RFID deployment

2. The value of IT projects varies based on the above IT dimensions and typology.

(a) Cost synergies

The different types of RFID deployment based on the classification scheme discussed above are related to a different kind of value. In particular, the analysis of the net present value for case studies I and II and III have shown that when the RFID applications are considered in a standalone basis, the respective NPV is lower than that when the RFID applications are considered as family applications which are deployed simultaneously. In Case study I when the decision maker decides to implement RFID only for orders receiving the NPV is lower than the NPV when RFID is implemented for the check out process too. Accordingly, in case study II when considering the application for promotion management service as a two-stage RFID service (RFID is firstly implemented for the inventory auditing and then RFID readers are placed on the sales floor), the NPV is higher when the two stages are implemented in a sequence as a family of applications. The same is revealed for Case III. The supplier can implement RFID either in one application o all the three

RFID applications (orders receiving, shipping and inventory auditing). It is shown in the sensitivity analysis that when only one application is considered the value of the implementation is lessened.

There are specific types of capital cost (such as the networking cost, the cost of the RFID printers (only for case study III), the cost for the integration of the software with the legacy systems) and types of operating cost (such as the tagging cost, the training cost for the RFID technology and the maintenance cost for the update of the RFID infrastructure) which can be shared among the implemented RFID applications. Even if only one RFID process is implemented, the above types of cost will be generated. It is shown that if this cost is shared among examined two or three RFID proposed processes, then the value generated is higher than the value of only one RFID application. RFID deployment got higher value when synergies (e.g. shared cost, additional cost savings) among the RFID applications were exploited. On the contrary, when the synergies are not considered (e.g. promotion management service and dynamic pricing service) the cost of implementation is higher and the total benefits are diminished.

(b) Supply Chain visibility

Another category of benefits which varies among the derived (from the case studies) types of RFID adoption is the level of supply chain visibility. In case studies I (retailing telecommunications company) and III (international beverage company) the RFID applications are internal applications, as they do not require the involvement of other organisations in the supply chain. The companies had the aim to enhance the and automate the business processes related to the tracking of products (case I) or pallets (case III) within their organisations. As a result the level of the supply chain visibility was not high in these two case studies as it was limited within each one organisation's borders. On the contrary, in case study II, the two RFID enabled applications for promotion management and dynamic pricing services required the collaboration of the supermarket's supply chain partners. Aim of these RFID enabled applications was to support both the retailers and the suppliers of the same supply chain and enhance the supply chain visibility. In this case supply chain visibility was high. In addition, in case study III high supply chain visibility offered to the organisation additional hidden benefits for the supplier (e.g. income for the retailing supermarket company from selling supply chain information to its suppliers).

(C) Benefits/Cost savings synergies

Based on the analysis of the case studies a lot of interdependencies were revealed among the examined RFID applications which refer to the total benefits that are generated. In particular, when family applications are implemented together such as in Case study I and III the cost savings per year are maximised in contrast to the benefits which are generated when the applications are implemented in a standalone basis. Thus, the cost savings synergies are higher in the type of RFID deployment which concerns family applications.

The importance of understanding the above differentiation (IT typology) and the respective value is high, as based on these revealed dimensions of scope, purpose and span for an IT innovative supply chain application such as RFID, a "typology that classifies patterns of RFID implementation into separate parts can be generated (Roh et al. 2009)". Based on this typology managers and decision makers can position RFID exploitation in an implementation map and compare their company's RFID deployment with other types of deployment. In this way, they can choose the types of RFID applications that suit the best to their organisation's goals. Realising the benefits of each one category, managers can exploit RFID with the greatest way. Realising for example the RFID attributes of family applications, decision makers can share cost among the RFID applications and result in higher overall value. The proposed typology in this thesis can be combined with other types of typologies in RFID adoption by other authors, such as the one below. The authors, classify RFID adoption based on whether RFID is applied together with other technologies (integrated application) or not (solo application) and based on whether RFID adoption requires only the involvement of one organisation (internal application) or multiple organisations (multiple application). Combination of these typologies can help decision makers to understand the unique feature of each one RFID application and apply the one that is customised on the organisation's needs.

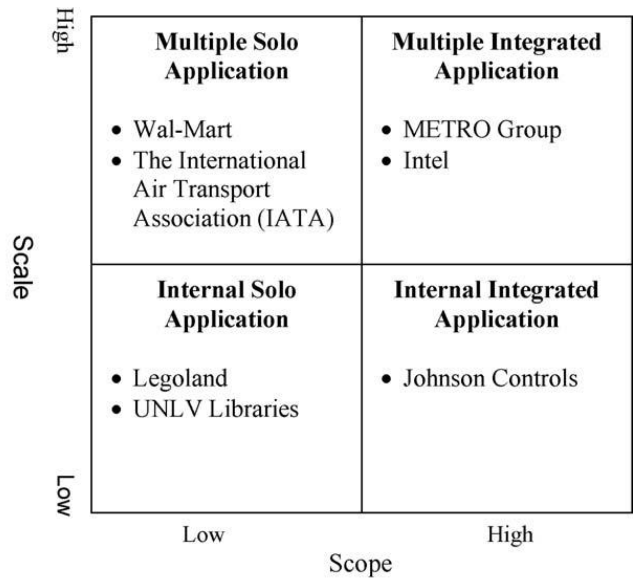


Figure 4.10 A classification for RFID adoption by (Roh et al. 2009)**.**

3. Real Option types occur during the evaluation of an RFID project

The exploration of the three case studies revealed that RFID deployment embeds several types of real options, based on specific evidence. In particular, growth and stage opportunities were generated in all the three cases. Based on several sources of evidence (e.g. NPV calculation, workshops, focus group with IT experts) initial investments in RFID (e.g. for the automation of the orders receiving process) were considered as initial investments which generated future RFID applications (e.g. automation of the product shipment, inventory auditing, check-out processes). For example, in case II during the workshop, supply chain executives expressed their willingness to implement pilot RFID applications, which shows their attitude towards the option to grow and stage investments in RFID. These future investments and the option to stage investments entailed additional value for the three organisations.

In addition, it was revealed that the organisations had the opportunity to scale their investments into additional stores, warehouses, distribution centers. With the NPV calculation we could see that scaling these investments influenced the objective value of the RFID investment. From the three case studies scale option was more apparent in case III (international beverage company). Because of the different data that we had for the organisation's each one distribution center (different number of distributed pallets, palletisation units and inventory units) the option to scale was more meaningful. Data show that when the organisation decides to scale its investment and implement RFID in more than one distribution center the value of the investment (based on the NPV calculations) alters.

Finally, out of the three case studies an interesting finding was the fact that another type of real options occurred: the option to delay investments. In particular, in case study II there is evidence that RFID investment may entail the option to delay its investments. In the workshop held in the Retailing supermarket company's premises the interviewed supply chain executives expressed their reluctance to invest in RFID technology on at least a 3 year time horizon due to the identified very high procurement and deployment cost, perceived lack of standardised procedures for RFID, uncertainty regarding ROI , immaturity of the technology.

The following table includes the overall real option types that were revealed in the examined case studies based on specific evidence. The real option types in bold are those which were perceived as more meaningful in each one of the specific case studies.

Table 4.17 Real Option types in the case studies

Case Study		Real Option types
I.	A retailing company in the telecommunications industry	✓ **Growth** ✓ Stage
II.	Retailing company in the supermarket industry	✓ **Defer** ✓ Growth ✓ Stage ✓ Scale
III.	An international Beverage company producer	✓ **Scale** ✓ Growth ✓ Stage

4. There are different levels (high, low) of the option value determinants across the case study companies which are related to the value and real option value of the assessed IT projects.

Literature on the behavorial implications of IT Real Options proposes specific organisational and technological parameters which trigger the growth option recognition embedded in an IT investment. In the two first case studies (as for third we did not have any relevant data), we have got evidence that these parameters are evident and might be related to the overall value including the growth option value of an assessed IT application.

In particular, as far as the **"Technology strategy"** is concerned we have evidence that the two organisations had a low and a high level of characteristics which measure this variable. In the first organisation (Case study I) the IT expert team estimated that the RFID enabled applications (RFID enabled orders receiving and check out processes) do not require a high level of business process reengineering. Thus the level of radicalness of the RFID applications which is one of the measurements of the technology strategy is low. In addition, due to the fact that the chosen RFID applications are characterised by the company and the IT expert team as transactional processes with the aim to mainly automate the current business processes of the company, the level of their competitive advantage and sustainability is low.

On the contrary, in case II the RFID applications which were assessed (RFID enabled promotion management and dynamic pricing) were characterised by the interviewed executives during the workshop as highly radical with a high level of required business process reengineering. In addition, the level of the generated competitive advantage and sustainability was characterised by the executives in the workshop as highly strategic with the opportunity to offer high competitive advantage and sustainability.

Although in the two organisations we have different levels of radicalness and competitive advantage and sustainability, we have evidence that the managers in each one case recognised the opportunity to grow initial RFID applications and invest in future related applications. The level of the impact of this parameter on the recognition of growth options will be however tested in the second part of the research (chapter 5).

In addition, as far as the variable **"organisational learning and innovative capabilities"** we have evidence only for the case study I that this parameter is meaningful and may be related to the overall value of the assessed RFID project. In particular, the interviews which were held revealed that the retailing organisation had a technologically-up to date stuff which interact and have a dialogue on the implementation of the RFID. In addition, data showed that the absorptive capacity capabilities of the firm was high as the organisation revealed that it already exploit barcode technology and stated that the organisation would like to exploit this kind of knowledge for the implementation of RFID. Finally, the interviews revealed that the innovative capabilities of the firm were high. The organisation had the aim to offer a series of innovative services to the consumers based on the RFID technology.

The specific organisation recognised the option to grow initial investments in RFID (for orders receiving) into additional future RFID applications which can support customer's transactions (e.g. RFID enabled promotion services etc). The level of the impact of these organisational capabilities on the recognition of growth option is going to be empirically tested in the following chapter.

Furthermore, regarding the third factor **"technology bandwagon"** both companies have shown high levels of network effects. In particular, interviews and the focus group with the retailing organisation in the telecommunications industry (case I) revealed that the organisation receives high pressure from their competitors to enhance the current business process, save costs and offer advanced and innovative services to the consumers. Therefore, the level of "network externalities" was high for this company. The same level of network externalities was revealed for the retailing supermarket company (Case II). Interviews with the suppliers of the specific company expressed their desire for an improvement of the way promotions management is currently undertaken. The interviews revealed existing problems in the current promotion management business processes. Therefore, the pressure from the supply chain partners of the retailing supermarket company was evident. In addition, the second organisation had shown the perception that with the increase of the RFID adoption network the value of RFID technology will increase too. This is more evident in this case as the examined RFID applications were based on collaboration. This pressure and the high network effects may have influenced the willingness of the retailing supermarket to implement RFID technology to enhance promotion management practices.

In addition, both companies have shown the belief that RFID technology would dominate over other technologies. The retailing organisation in case I and its IT department have created a comparative table for 2D and RFID technologies, justifying the superiority of the RFID technology.

The above discussed two parameters based on the literature influence the recognition of growth options. In both companies, the attitude of managers towards investing in RFID further in future applications was evident. The level of this impact is going to be examined with a survey in the confirmatory part of the research.

The last determinant of value and growth option value based on the literature which was examined in the two case studies was the factor: **technology adaptation**. This factor refers to the level of interpretive flexibility and divisibility of the technology itself. In both organisations we had evidence for these two measures. In particular, in case study I the interviewed managers gave different interpretations for the RFID utilisation which resulted in a list of several RFID candidate applications. This shows that the company understands that RFID technology can be implemented in different and multiple ways. From the second organisation in the supermarket retailer, we also had evidence for high levels of interpretive flexibility.

Finally, in both companies the fact that the RFID technology implementation could be easily implemented in phases (divisibility) was understood by the interviewed managers and other executives. In case I, during the focus group it was understood by managers that the RFID scenarios that are presented entail many components which can be separated and recombined. In addition, in case II the two proposed RFID applications for promotion management and dynamic pricing were assessed based on their division into two main processes (one for the back office RFID implementation and one for the sales floor).

It seems that this technology attributes were related to both companies' recognition and awareness of the growth opportunities of the assessed projects. The specific impact will however be empirically investigated and tested in the next chapter.

The following table summarises the above metrics.

Table 4.18 RO determinants in the three cases

Variables	Organisation A- Retailer in Tele/ions	Organisation B- Retailer in Supermarket industry	Organisation C- Manufacturer in the Beverage industry
RFID Applications	Orders receiving Check out	Dynamic pricing Promotion management Orders receiving Inventory check	Orders receiving Inventory check Orders shipment
Technology strategy (TS)			
TS1.Radicalness	LOW	HIGH	ne
TS2.Strategic importance of affected products/processes	LOW	HIGH	ne
TS3.Sustainability of advantage	LOW	HIGH	ne
Organisational capabilities (OC)			
OC1.Learning-related endowments	HIGH	ne	ne
OC2.Contributions to exploitable absorptive capacity	HIGH	ne	ne
OC3.Innovative capabilities	HIGH	ne	ne
Technology Bandwagon (TB)			
TB1.Recognition of network externalities	HIGH	HIGH	ne
TB2.Network dominance	HIGH	HIGH	ne

Technology Adaptation (TA)			
TA1.Interpretive flexibility	HIGH	HIGH	ne
TA2.Divisibility	HIGH	HIGH	ne

ne: No evidence

5. The NPV calculation is the basis for the option value

One important issue that has to be highlighted is the fact that NPV estimation can give us insights for the option value of an evaluated IT project, although the NPV approach does not take into account volatility- which is a centric parameter in real option analysis and modeling. For example, in the first case study the comparison of the NPV results between the standalone and the family applications gave us the opportunity to consider that the implementation of RFID and its value can vary according to whether several RFID applications are implemented together and share the implementation cost or in a standalone basis. It is shown that family applications offer us a higher monetary value (in the first case study) than the NPV when only one application is considered. As a result, the option of a manager to grow its investment rather than considering one RFID application as an independent application is revealed.

An assessment parametric and dynamic model which calculates the net present value based on specific inputs and data was created based on these three case studies. Changes in specific inputs alter automatically the whole result of the net present value of the IT project. This model can be utilised for other similar RFID investment problems. In addition, this model can be utilised further to embed volatility and real options modeling as future research.

6. The value of Real Option types is amplified in specific IT project types

A cross-case comparison provides evidence according to which specific real option types are more valuable in specific IT project types. In particular, in contrast to the other two case studies, in case study II evidence revealed the option to delay the investment. In the other two case studies the delay option may be valuable, but we did not have any evidence to support this. Based on the IT/RFID deployment typology, case organisation II assessed a large scale RFID investment as it was a supply chain, strategic investment. In contrast to the other two case studies, where the assessed RFID applications were internal and for transactional purposes, RFID implementation in the second case study entailed a more risky RFID deployment as it required a high level of supply chain collaboration and business process reengineering (based on the questionnaire distributed to the workshop executives).

Because of the high uncertainty of this type of IT project, executives expressed the option to delay RFID investment at a later point of time with the expectation that this uncertainty will be decreased after a couple of years. This finding is supported by the real options theory, according to which the value of real options increases when the level of uncertainty in an assessed project is higher (Benaroch 2002). On the contrary, in the other two case studies the uncertainty of the implementation was lower. That could be a reason of the fact that we did not have any evidence for the recognition by managers of the option to delay the investment.

Another example where the impact of real options could be enhanced was revealed in the family applications. In particular, in case study I and III where the RFID deployment was categorised to be under the category of family applications, we have seen that the stage and growth opportunities were valuable in contrast to case study II, where the two applications of promotion management and dynamic pricing were standalone applications. When the IT applications are related to each other is easy to be considered as an investment which can be easily divided and broken up in stages (stage option) and initial and follow-on applications (growth option).

Studying the connection of Real Option types with specific IT project types can be beneficial for the decision makers. IT project types which are not a fertile environment for the utilisation of Real Options would be better to be assessed based on traditional evaluation metrics and methods rather than with real options analysis, methodology and respective formulas. In addition, decision makers can identify the types of IT projects which trigger the generation of specific real option types and exploit their value to justify investments and IT funding.

4.7 **Refined Research Questions**

The initial research questions of this thesis in order to investigate the influence of real options on IT investment evaluation are the following.

1. *What are the <u>determinants</u> which influence real option recognition in an information technology project?*
2. *What is the impact of <u>real options</u> on the perceived value of returns of an information technology project?*
3. *Is this impact strengthened or mitigated across <u>different types of IT projects</u>?*

However, in order to develop and form specific hypotheses and conduct the second phase of this study (the confirmatory phase), there were some issues which had to be clarified. After the conduction of the three case studies and based on the cross-case findings (Section 4.6) the research questions above were refined and became more precise and specific. The following paragraphs indicate the refined research questions.

As far as the first initial research question is concerned: ***"What are the determinants which influence real option recognition in an information technology project?"*** the following modification of the question has been made. The previous case studies provided us with evidence about the identification of several organisational or technological parameters that can be related to the overall value of an IT project and its growth option value. Although pertinent literature has proposed that these determinants influence the recognition of growth real options by managers, empirical research to test these propositions is very few. One of the aims of the confirmatory phase of this thesis (chapter 5) is to empirically examine which of these factors are the best predictors of managers' ability to recognise growth real options in an assessed IT project. The emphasis on growth option is given as previous studies reveal that` growth option is the one which is the most recognizable and highly valued options by managers. A specific study (Tiwana et al. 2006) indicated that growth option was the most significant predictor of the managers' decision to continue a troubled IT investment. For this reason the research questions were modified as the following:

- *What is the impact of the technology strategy on the recognition of a growth option?*
- *What is the impact of the organisational learning and innovative capabilities on the recognition of a growth option?*
- *What is the impact of the technology bandwagon on the recognition of a growth option?*
- *What is the impact of the technology adaptation on the recognition of a growth option?*

Regarding the second research question: ***"What is the impact of real options on the perceived value of returns of an information technology project?",*** the issue which has been clarified after the case studies conduction was about the types of real options which are going to be investigated further. During the investment evaluation of the three case studies, several options for the managers were revealed. These types of real options were: the growth option, the option to delay investments and the option to stage investments. The scale option was also evident but it was excluded from the confirmatory phase in order to minimise the complexity of the examined sub-models and the ultimate interpretation of the results. In addition, these three types of real options were the ones mostly studied from the very few previous studies on the behavorial implications of IT Real Options literature. Moreover, comparison of previous studies results revealed specific discrepancies for these types of options. For example, in specific studies the option to delay was considered as not significant whereas in other studies was considered as significant and positively related to the perceived value of the assessed IT project. These differences in the results made the choice of these options more meaningful to be tested and further investigated. Thus, the opportunity to compare results of this thesis with the ones from the previous studies was highly valuable.

As a result, the following refined research questions were developed. The empirical confirmatory phase of the study (chapter 6) which follows has the aim to examine whether managers understand the significance of these kind of options for the adoption and evaluation decisions of an assessed IT project.

- *What is the impact of the recognition of <u>growth options</u> on the perceived value of returns of an information technology innovative project?*
- *What is the impact of the recognition of <u>stage options</u> on the perceived value of returns of an information technology innovative project?*
- *What is the impact the recognition of <u>deferral options</u> on the perceived value of returns of an information technology innovative project?*

Finally regarding the third initial research question: **"*Is this impact strengthened or mitigated across <u>different types of IT projects</u>?"*,** the case studies helped us to indicate what types of IT project is worthwhile to investigate. In particular, an important finding derived from the three case studies is that the implementation and adoption of RFID projects can get different forms. Case studies revealed the dimensions of the RFID deployment which differentiates RFID implementation and generates several types of IT/RFID project types. Thus, the case studies revealed that there is a necessity to follow an IT typology when assessing the value of an IT project. Case studies gave us evidence that the different types of IT projects are related to different type of value. This different typology resulted in a differentiation for managers regarding their perceptions on the value of the assessed IT projects. As a result, additional aim of the second empirical research (chapter 6) is to investigate whether the significance of the real options (defined above) regarding their impact on the perceived IT project value of returns varies among the different IT project types. Although literature underlines the significance of this aim, empirical research is rare. The research questions are refined below:

- *Does the scope of an IT project (whether it is a family or standalone application) moderate the effect that real options have on the perceived value of returns of this project?*
- *Does the purpose of an IT project (whether it is strategic, informational or transactional application) moderate the effect that real options have on the perceived value of returns of this project?*
- *Does the span of an IT project (whether it is an internal or supply-chain application) moderate the effect that real options have on the perceived value of returns of this project?*

5 FACTORS AFFECTING IT REAL OPTIONS RECOGNITION

5.1 Introduction

This chapter investigates the first research question which was identified in Chapter 3 (Research Methodology): *"What are the determinants which influence real option recognition in an information technology project?"* and the second research question: *"What is the impact of real options on the perceived value of returns of an information technology project?"*. This chapter is going to focus on the impact of growth options and the variables which trigger its recognition by managers.

One of the top Information technology management themes is improving the measurement of information technology impact on business performance (Bélissent 2009). However, due to the debt crisis in a number of countries, spending on information technology is expected to be declined by 3.6% in local currencies (Bartels 2012). As a result, nowadays IT justification and investment evaluation process becomes a more solid and significant issue that concerns a variety of firms with limited budgets. Despite its significance, assessing and measuring the contribution of IT can be difficult (Joshi & Pant 2008). The significance and the difficulty of appraising innovative information technologies are inextricably related to the ultimate adoption of these technologies (Thong 1999). In order for firms to justify a technology adoption, it is important to understand the factors that lead to such a decision.

As it was discussed in Chapter 2 (Literature Review-Section 2.2.2) , although research on the firm adoption of technology innovations (C. Zhang & J. Dhaliwal 2009; Chwelos et al. 2001; Oliveira & Martins 2011; Grandon & Pearson 2004; Kuan & Patrick Y.K. Chau 2001; Pan & Jang 2008; Tsai et al. 2012; Ke et al. 2009) offers significant contributions to such understanding (Frambach & Schillewaert 2002), it ignores managerial flexibility and real options as determinants of technology innovation adoption.

As it was discussed in Chapter 2- Section 2.3, Real Options theory and analysis has been applied to the IS literature (Benaroch & Kauffman 1999; Dos Santos 1991; Nalin Kulatilaka et al. 1999; Panayi & Lenos Trigeorgis 1998) as an alternative dynamic evaluation approach in order to take into consideration managerial flexibility regarding IT investments under uncertainty (Sanyal & Sett 2011) with the exploitation of specific types of options (e.g. growth options, option to delay investments) which are sources of value. Although literature (Tiwana et al. 2006; Denison 2009; Lankton & Luft 2008) signifies the importance of understanding qualitative and intuitive judgment for real options, it highlights that there has been little research on examining *how the use of real options in capital budgeting affects the behavior and decisions of managers* (Denison 2009). Apart from few behavioral studies in the IT Real Options literature (Tiwana et al. 2006; Goswami et al. 2010; Lankton & Luft 2008; Saya et al. 2010) which have supported empirically that recognition of different kind of options can be a significant factor which affects perceived value and ultimately adoption of an innovative technology, further empirical research has been scarce.

Furthermore, the Literature review in Chapter 2 on studies for IT Real Options has shown that the pertinent research apart from examining the recognition of real options as a factor which influences the value and adoption of an IT project, proposes tangible or intangible variables which stimulate the creation and recognition of these options. However, the majority of these studies either develop conceptual models with propositions (Fichman 2004; Scarso 1996; Y. J. Kim & Sanders 2002; McGrath & MacMillan 2000) or test the impact of these variables utilising quantitative mathematical modeling (Angelou & Economides 2009a; X. Li & Johnson 2002). Empirical studies (Lankton & Luft 2008; Goswami et al. 2008; Goswami et al. 2010; Saya et al. 2010) which investigate the significance of these variables on real option recognition based on managers' perceptions are very few.

To fulfill the above underlined research gaps derived from the IT innovation adoption and IT Real Options fields this study has a twofold aim: (1) to empirically investigate (based on managerial views) the significance of the recognition of real options and more specifically growth options regarding their impact on the value and adoption of an IT project and (2) to empirically examine a number of factors which are proposed by the literature that affect growth option recognition and value.

To accomplish this aim, a survey is conducted with data gathered from 109 organisations across Europe. Due to its features, RFID technology is chosen as a suitable context to apply the research model. Pertinent literature (Curtin et al. 2007) has underlined the importance of evaluating RFID under the real options lens. Apart from few studies (Goswami et al. 2008; Goswami et al. 2010) empirical research which tests the behavorial implications of Real Options on RFID technology investment evaluation is rare.

Through structural equation modeling, results reveal that the recognition of growth option has a significant impact on the perceived value of the assessed IT project and ultimately its adoption. In addition, this work identifies the sources which trigger the recognition of growth options during an IT evaluation and adoption process. In particular, it is empirically supported from this study that organisational learning and innovative capabilities, as well as specific technology features (i.e. the level of strategic importance, radicalness and sustainability of the technology outcome) constitute the most significant sources of growth option value of the assessed technology. As a conclusion, this work shows the significance of the managerial recognition of real options and in particular growth options as an important variable which explains the mechanism through which specific organisational and technological attributes influence managerial decision making for the adoption of an IT project.

The remainder of this chapter is arranged as follows. In the next section (Section 5.2) specific hypotheses are developed based on relevant studies on IT innovation adoption and IT Real Options. The following section (Section 5.3) refers to the context and the measures of the study. Next, the results are presented (Section 5.4). Finally, we conclude with the summary of the findings (Section 5.5)

5.2 Hypotheses development and theory support

5.2.1 IT adoption and Real Option value

As it has been discussed in the Literature Review (Chapter 2, Section 2.2.2), there is a broad field in the literature which focuses on the examination of determinants which affect a firm's decision to adopt an innovative information technology application. These determinants are related to the technological, the organisational and the environmental context based on Tornatzky and Fleischer (Tornatzky & Fleischer 1990) framework. Based on the authors these are the three main elements which entail variables that influence firm IT innovation decision and adoption. In particular, determinants from the first area which refer to the assessed technology have been examined such as: the perceived direct or indirect benefits derived from the technology implementation (Kuan & Patrick Y.K. Chau 2001), interoperability and interconnectivity of the technology itself (Patrick Y K Chau & Tam 1997), technology competence (Zhu & Kraemer 2005), relative advantage, complexity and compatibility of the assessed innovation (Rogers 1995; Thong 1999; Ramamurthy et al. 2008). As far as the second context is concerned, several organisational parameters have been empirically tested for their impact on IT adoption such as: organisational size (G. Lee & Xia 2006; Zhu & Kraemer 2005; Thong 1999; Pan & Jang 2008), technological knowledge (Kuan & Patrick Y.K. Chau 2001; S. Kim & Garrison 2010), organisational financial resources and commitment [6],[38], IT deployment capability (C. Zhang & J. Dhaliwal 2009), top management/organisational support (Tsai et al. 2010; Grandon & Pearson 2004; Y.-M. Wang et al. 2010; S.-I. Chang et al. 2008). Regarding the third context, factors from a firm's environment are examined for their impact on IT adoption, such as: external pressure from competition and partners (Iacovou et al. 1995; Frambach & Schillewaert 2002; Y.-M. Wang et al. 2010), dependency on trading partners (Chwelos et al. 2001; S.-I. Chang et al. 2008), network externalities (Frambach & Schillewaert 2002), regulations (Zhu & Kraemer 2005; Pan & Jang 2008), institutional pressures (Goswami et al. 2008; D. Henderson et al. 2012; Tsai et al. 2012).

However, the above studies neglect the impact of flexibility as a key factor which can effect managerial decisions for the adoption of innovative IT projects with uncertainty. Flexibility, with the aim to mitigate uncertainty, gives management the option to revise decisions while a project is undertaken such as: shut down, abandon, expand or change the assessed technology (Nalin Kulatilaka 1995). Real Options analysis has been proposed in the IS literature from the financial field as a method which investigates the impact of these options on IT adoption and investment evaluation. Real Option analysis has been utilized in the IS field either through mathematical modeling or behavioral studies in order to evaluate and assess innovative information technologies. Apart from a few studies (Fichman 2004; Goswami et al. 2008; Goswami et al. 2010; Tiwana et al. 2006; Lankton & Luft 2008) which have empirically supported and shown that recognition of different kinds of options can be a significant factor which affects the perceived value and ultimately adoption of an innovative IT project, further empirical research has been rare.

In this study, hypothesis 1 is related to the impact that the recognition of growth option is expected to have on the perceived payoffs of an innovative IT project. Several studies have shown that growth option adds value for a firm. Dos Santos (Dos Santos 1991) justified an initial investment in an integrated services digital network (ISDN) technology because it can lead to future second-stage investments. Taudes (Taudes 1998; Taudes et al. 2000) showed how the value of an initial investment in a software platform can be increased if managers take into account optional future investments. Panayi and Trigeorgis (Panayi & Lenos Trigeorgis 1998) concluded that the value of an initial investment in a Telecommunications IT infrastructure can be increased if the value of its expansion opportunity (growth option) is taken into consideration (Panayi & Lenos Trigeorgis 1998).

In addition, few empirical studies on the behavioral implications of real options (Tiwana et al. 2006; Hult et al. 2010) have shown that the presence of growth options in assessed IT projects positively influence managers views regarding the value of these projects. One of the main conclusions of the above studies is the fact that decision makers recognise and value real options and more specifically growth options. They have shown that taking into consideration the growth option of an investment can reveal an additional value of this investment. Otherwise the IT justification can underestimate the value of an appraised IT project. Thus, we hypothesise that when such growth options are recognised by managers the perceived value assigned to the assessed technology will be increased. For this study, perceived value of the assessed IT project is the sum of the perceived net present value of this project based on cost-benefit analysis plus its option value. This is based on previous studies on the behavorial implications of IT real options such as Tiwana's et al. (Tiwana et al. 2006) work. We hypothesize that this option value will be a result of the recognition of real options and in this case growth options.

Overall, as a result of the above arguments, the following hypothesis is formulated:

H1: Increases in the recognition of growth option will increase the perceived value of returns of the IT project.

In addition, according to Fichman (Fichman 2004) the perceived option value of an IT platform is proposed to increase tendency of organisations to adopt this technology. Relevant studies (Goswami et al. 2010; Goswami et al. 2008; Tiwana et al. 2006) have shown that the growth option recognition can positively influence the project value and as a result adoption or escalation of commitment.

In this work, it is assumed that the recognition of growth options of an assessed IT project will influence its perceived value which will then lead to its adoption (H2). More specifically, when managers estimate that the value of returns of the assessed technology project will increase, then the possibility of technology adoption is expected to increase too. This hypothesis is supported by previous research studies which have shown that the perceived benefits that a technology can offer has a direct impact on its adoption and use (Kuan & Patrick Y.K. Chau 2001; Grandon & Pearson 2004). In addition, according to Rogers (Rogers 1995), the adoption of innovations is related to the attributes of the innovations perceived by potential adopters. Furthermore, studies on the behavorial implications of Real Options have shown that the value of an assessed technology project which consists of real option value can increase intention to adopt this technology or willingness to continue investing (Goswami et al. 2008; Tiwana et al. 2006; Saya et al. 2010).

As a result of the above arguments, the following hypothesis is formulated:

H2: Higher levels of perceived value of returns of an IT project will positively affect the likelihood of its adoption.

5.2.2 Determinants of IT Real Option value

Based on the pertinent literature on the evaluation of IT investments through the utilisation of Real Options analysis, several determinants have been proposed as factors which influence the option value of an IT investment. Apart from the studies (Dos Santos 1991; Benaroch & Kauffman 1999) which examine the impact of purely monetary variables (e.g. the expected cash flows of the assessed investment, volatility of these cash flows), there are few studies which propose qualitative variables as determinants which influence the value of an option. Examples of these determinants are related to (a) the organisational context such as: firm learning capabilities and tacit know-how (Fichman 2004; X. Li 2009; Scarso 1996), (b) the technology context e.g. interdependencies and synergetic effects among the existing IT projects in an organisation (Scarso 1996; Y. J. Kim & Sanders 2002; Pendharkar 2010; Angelou & Economides 2008a), modularity and divisibility of a technology (Scarso 1996; Fichman 2004; Angelou & Economides 2009a) and (c) the environmental context e.g. competition pressure (McGrath & MacMillan 2000; Lankton & Luft 2008; X. Li & Johnson 2002; Angelou & Economides 2009b; Y. J. Kim & Sanders 2002), institutional regulations and influences (Goswami et al. 2008), level of IT product demand of the affected from IT products (Q. Dai et al. 2007), network effects (Angelou & Economides 2009b).

However, according to the literature, before assessing the value of an option, one of the first steps for the real options analysis is the identification of the different types of options (Özogul et al. 2009; Benaroch 2001; Copeland & Antikarov 2001). Based on McGrath et al. (McGrath et al. 2004), the presence of options can result in option value which can be enhanced or diminished by several properties. Under this perspective, the above mentioned studies can be categorised into two main streams. The first stream of research (Scarso 1996; Angelou & Economides 2008a; Goswami et al. 2008; Saya et al. 2010; Angelou & Economides 2009a) is focused on the investigation of factors which influence the recognition of real options i.e. characteristics of the organisation, its environment or technological attributes which can trigger and stimulate the generation and the presence of real options in an assessed IT innovative project. For example, according to the literature an ICT platform has to be more generic and modular in order to have higher flexibility and as a result create growth option opportunities (Angelou & Economides 2009a). In addition, based on another work (Scarso 1996) in this stream, synergetic effects among the existing technologies in a firm IT portfolio can be a source of a growth option creation. The second stream of research (Fichman 2004; McGrath 1997; Y. J. Kim & Sanders 2002; X. Li 2009) focuses on the factors which boost or weaken option value and its impact on the overall value or adoption of an assessed IT project. For example, Lankton & Luft (Lankton & Luft 2008) have shown in their study that as technical uncertainty increases, individuals judge deferral options as more valuable and growth options as less valuable. The same authors empirically prove that competition increases growth option value, while it diminishes the value of postponing investment (deferral option). In addition, Goswami's study (Goswami et al. 2010) has shown that the type of business strategy that an organisation follows moderates the impact of real options on the adoption of a technology.

In this study we adopt the first stream of research as we are focused on exploring the factors which stimulate the recognition of real options. This emphasis is given because the identification of options is a prerequisite of the option value. We investigate the significance of organisational, technological or environmental characteristics in encouraging the presence of options in assessed IT projects. It should be underlined however that in this study, we utilise factors which are investigated not only in the first but also in the second stream of research discussed above. More specifically, we believe that some of the factors which are proposed in the literature to have an impact on option value can first create the background to stimulate the creation of options and then give value to them in a later stage. As a result, we treat "recognition of real options" as a mediator among the determinants of real option recognition and option value.

Some of these studies focus on specific IT option value determinants, while others focus on a list of factors. One of the few studies which propose a set of factors from a multi context perspective as antecedents of option value is Fichman's (Fichman 2004) study. The author developed a model with option value determinants relevant to investments in innovative IT platforms. These determinants refer to organisational or technological features from the IT innovation adoption literature which are proposed to have an impact on option value and ultimately on IT adoption. The model focuses on the value of growth option and factors which have an economic construal from a real options perspective. Determinants proposed by Fichman's and other authors' work are exploited in this study.

One of the first factors which are investigated in this study is the "technology strategy" which is proposed by Fichman (Fichman 2004) as a factor that influences the option value of an IT platform. In this study, this factor will be measured based on three dimensions: (a) the "strategic importance" of products/processes affected by the technology, (b) the expected "sustainability of the competitive advantage" and (c) the "radicalness" of the technology (Fichman 2004).

"**Strategic importance"** of the technology investment refers to the managers' and decision makers' perceptions of the potential strategic benefits derived from the investment in a particular technology (Voudouris et al. 2012). Based on the literature (Fichman 2004) "strategic benefits are derived from an innovation when the products or processes potentially improved by this innovation are central to the competitive position or value proposition of the firm", through many ways such as: minimising cost, offering new product planning, product service differentiation, process innovations, new product development, competitive pricing (Oh & Pinsonneault 2007; Porter 2001; King et al. 1989). It is proposed in the literature (Scarso 1996) that the competitive position that a strategic technology application offers to an organisation is a source of growth options. Benaroch (2001) highlights that strategic technology platform investments can trigger the creation of growth options and future business opportunities. Goswami et al., (2010) highlights that growth options become especially valuable when the technology holds a promise to offer a strategic and competitive advantage to the adopter. Scarso (1996) proposes that one source of technology growth options is the "first mover" advantage. It is expected that a company in order to keep its first mover advantage will rather exploit the option to grow its technology investments rather than delaying them. Optimal option exercise strategies will have to find a balance between the value of waiting for uncertainties to be diminished and the fear of "pre-emption" i.e. the possibility that a competitor may take hold of an advantage by acting first (Tsekrekos 2003). First mover advantages can help a firm to gain high market share and expand the time period that the leader can act as a monopolist (Tsekrekos 2003). It is expected that when a technology application is inextricably related to the strategy of a firm, it represents something permanent, thus it gives the motivation for an organisation to grow its investment into future innovative applications and at the same time block rival's entry into the market. As a result of the above arguments, it is likely that an increase in the level of the expected strategic importance of the IT enabled organisational products or processes, will increase the recognition of growth options.

The second variable as one of the dimensions of the technology strategy, i.e. the "**sustainability"** of the competitive advantage, is proposed that will positively affect the option value (McGrath 1997; Fichman 2004). It refers to the development and exploitation of a value-creating strategy by a firm which is difficult for other competing companies to imitate (Barney 1991). When a competitor cannot imitate the technology which is already offered by another company, then the sustainability of the competitive advantage that the first mover company gained is increased (McGrath 1997). According to the literature, sustainability increases the option value (McGrath 1997; McGrath & MacMillan 2000). When a firm sustains its competitive advantage it is likely that it will continue investing further and grow its initial investment to keep and maintain its position. As a result, under these circumstances managers are expected to be able to recognise and exploit opportunities for growth. Thus, it is expected that when sustainability increases the recognition of growth option will increase too.

The third variable of the "technology strategy" factor which is investigated in this study as a source of option recognition is **"Radicalness".** It emerges from fundamental technologies (Moosmayer & Koehn 2011) which transform (i.e. "radical innovations") rather than refining current firm products or processes (M. Subramaniam & Youndt 2005; R. Henderson 1993). Fichman (Fichman 2004) proposes that radicalness increases the option value. Radical innovations force an organisation's capabilities to draw on new technical skills and to employ new-problem solving approaches (R. Henderson & Clark 1990). They also include the creation of large amounts of new knowledge (Moosmayer & Koehn 2011). According to Scarso (1996), the know-how can be a possible resource of technology growth options. As a result, we hypothesize that radical innovations will increase the recognition of an option for an investment to grow.

As a result of the above arguments, the following hypothesis is reported:

H3: The technology strategy positively influences the recognition of growth option.

Apart from the level of strategic and sustainable impact of a technology, literature hypothesizes that firm capabilities will be a second factor which can be a source of growth option value. In this study, firm capabilities consist of three dimensions: (a) "learning related endowments" (b) "contributions to exploitable absorptive capacity" and "innovative capabilities" (Fichman 2004).

"Learning related endowments", according to Fichman (Fichman 2004), measures the extent to which an organisation possesses knowledge, skills, routines, incentives and other resources (e.g. technologically up-to-date staff) which contribute to effective organisational learning related to the innovative technology. The "organisational learning capability" (OLC) measurement instrument which was developed by scholars (Chiva et al. 2007) measures this variable based on the level of an organisation's risk taking, experimentation, dialogue, interaction with the external environment and participative decision making. Based on the pertinent literature (Cohen & Levinthal 1990; Zahra & George 2002; Fichman 2004; Scarso 1996), learning processes and capabilities and tacit know-how are possible resources of technology growth options as they increase the skill of an organisation to recognise these kind of options.

Apart from the capabilities of a firm to learn from a technology adoption, there is the "**absorptive capacity"** i.e. the ability of an organisation to acquire, assimilate and exploit this information and learning (Cohen & Levinthal 1990). According to Fichman (2004), "contributions to exploitable absorptive capacity" measure the extent to which "*knowledge to be gained during deployment contributes to absorptive capacity in domains with long-lasting strategic relevance".* This ability is expected to stimulate the generation of a growth option. According to Scarso (Scarso 1996), the cumulativeness of technical improvements are possible resources of technology growth options. Thus, current IT projects and the respective gained knowledge provide a window for forthcoming technology applications. Moreover, absorptive capacity is expected to trigger the recognition of these forthcoming applications. "Increases in exploitable absorptive capacity, increase managerial flexibility to pursue currently unforeseen follow-on investments (Fichman 2004)".

The third dimension which is hypothesized that increases the recognition of growth options is the "**Innovative capabilities"** of a firm. It is the extent to which an organisation possesses resources (human, technical, organisational) which contribute to effective deployment of the innovation (Fichman 2004). Innovative activities are linked to the previous attribute: absorptive capacity. Based on the theory absorptive capacity is used as a predictor of innovative activities as it creates new knowledge for innovation. It is anticipated that innovations can stimulate the generation of growth options. *"Where the innovative assets may be the essential basis for subsequent innovations, they have the potential to generate opportunities in the future"* (Scarso 1996). Further, firms that acquire innovative capabilities have a greater ability to recognise and exploit a series of follow-on projects (Fichman 2004). As a result, it is likely that when the innovative capabilities of an organisation increase, firm ability to identify and exploit a growth option is increased too.

As a result of the above arguments, the following hypothesis is formulated:

H4: Organisational learning and innovative capabilities will be positively associated with the recognition of growth options.

Apart from technology and firm features, variables from the environment are considered in this study as sources of option recognition and ultimately value. A third factor which is investigated in this work is the "Technology bandwagon" which constitutes of (a) the "recognition of positive network externalities" and (b) the "network dominance of the technology" (Fichman 2004). **"Network externalities"** exist when the value of a technology increases if adopters within the adoption network increase too (Katz & Shapiro 1985; Katz & Shapiro 1986; Strader et al. 2007; Asvanund et al. 2004). Under the positive network effects, a firm's investment project has higher value if another company also invests (Angelou & Economides 2008a). This adoption network can be considered as an institution which entails other organisations which are technology adopters. It is believed that this institution can influence another firm's decision regarding the option to grow a technology investment. Goswami et al. (Goswami et al. 2008) have found through an empirical study that institutional influences i.e. pressures on organisation based on the actions of other members of the *institution, such as trend setting organizations, competitors, and trade and industry association positively affects the recognition of growth options.* As a result, it is expected that network externalities would positively influence a manager to recognize the opportunity to grow a technology investment and invest further with the aim to benefit from this growth.

The second dimension: **"Network dominance of the technology class"** refers to the dominant position that an innovation technology class receives among other competing technology classes (Fichman 2004). For example, RFID is likely to achieve a dominant position over other automatic identification technologies such as barcode technology and smart card technology. It is hypothesized that when a specific technology like RFID dominates over other technologies, managers may be influenced to take advantage of these expected developments and be willing to escalate their commitment and adopt additional RFID applications. When managers believe that a technology will dominate over others, it is expected that the variety of the candidate technology applications will increase too. The high number of technology applications will give firms a greater incentive to invest in a supporting IT infrastructure because this infrastructure can result in the development of new software functionalities (Q. Dai et al. 2007). Thus, it is expected that the acknowledgement of the network dominance of the technology will increase the recognition of a growth option and future investments.

As a result of the above arguments, the following hypothesis is formed.

H5: Technology bandwagon positively influences the recognition of growth option.

The fourth and final factor which is investigated in this study regarding its effect on the option recognition and value is a technology feature: the "technology adaptation" which refers to the business-technology alignment and includes (a) "the interpretive flexibility" and (b) the "divisibility" of the technology (Fichman 2004). **"Interpretive flexibility"** is the extent to which a technology permits multiple interpretations about how it should be implemented and used by adopters (Orlikowski 1996; Fichman 2004). There is flexibility in how people design, interpret and use technology (Kakola 1995). When a technology can be implemented and interpreted in different several ways and feasible configurations, it is expected that there is flexibility for the technology to alter or update its initial use. In a further step, this flexibility can result in other future investments. Modularity of the technology is a determinant and source of a growth option (Scarso 1996). Angelou and Economides (Angelou & Economides 2008a) refer to the term "systems flexibility-modularity" to indicate that the creation of growth option usually involves making an ICT platform more modular and generic in order to obtain higher flexibility. As a result, it is likely that the interpretive flexibility of an innovative IT project increases the recognition of a growth option.

The second variable: the **"divisibility"** of the technology specifies that a project can be divided into a series of short, intensive cycles of implementation each of which delivers a measurable business benefit (Fichman & Moses 1999). An incremental, stage-wise strategy is supported by trial investments that can be later lead to full-scale investments (Bowman & Hurry 1993). It is likely that the implementation of a technology project which can be divided into smaller stages can stimulate growth options which can be exploited only when an initial implementation stage proves to be successful. As a result, it is hypothesized that the higher the level of technology divisibility, the higher the recognition of a growth option. Given the above arguments, the following hypothesis is formulated. The above figure shows the overall hypotheses.

H6: Technology adaptation positively influences the recognition of growth option.

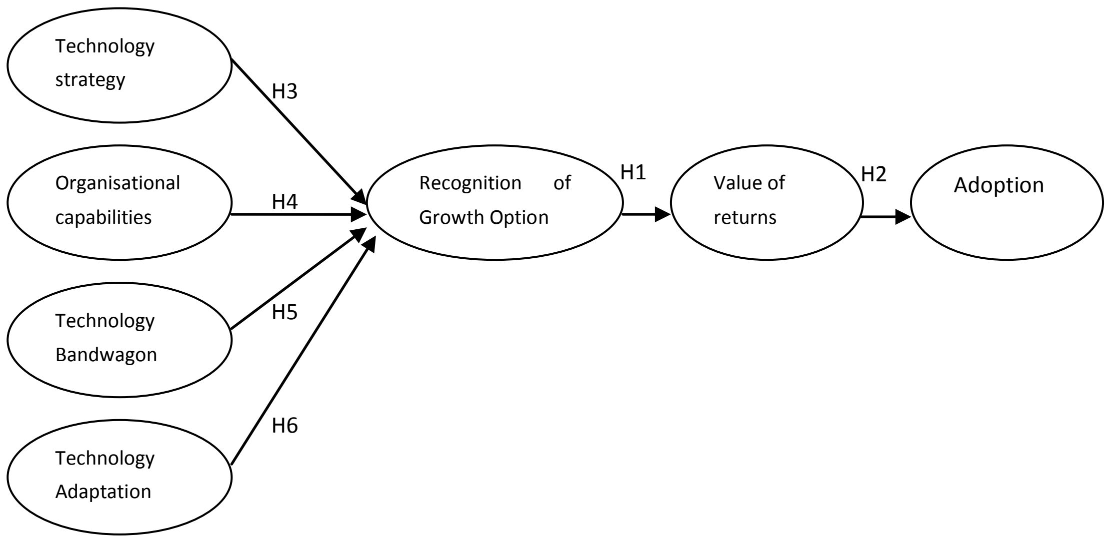


Figure 5.1 The Research model

<u>Justification of the Growth Option as the main focus of this research model</u>

This paragraph tackles the question: "Why is the Growth Option chosen to be studied instead of other types of options?". The other types of options are actually considered and examined in Chapter 6, as a separate research model (which consists of the second part of the Hyper model displayed in Chapter 3). However, for this chapter the emphasis is given on studying the determinants of growth option recognition for the following reasons.

First of all, based on the previous studies (Tiwana et al. 2006), growth option is the most highly recognisable and clear to be understood by business executives in contrast to the other types of options. In order to be able to study growth option determinants, recognition of the option is considered as a prerequisite. Second, Fichman's model which this study (chapter 5) is mainly based on, focuses on the growth option. Although the author refers to the option value in general he underlines that the proposed determinants are considered for growth option. *"Other kinds of real options are applicable to IT investments.…However, this paper will focus on the growth options associated with early investments in IT platform"* (Fichman 2004). In addition, Fichman's propositions are supported by other scholars who refer to the variables that affect growth option recognition and its value. For example, Scarso (1996) refers to the fact that modularity of the technology investment can be a source for the generation of growth option. In addition, another study (Angelou & Economides 2009a) comes to reinforce this proposition as it shows that creating a growth option usually involves making the ICT platform more generic and modular in order to obtain higher flexibility. This modularity covers the variable: "interpretive flexibility" proposed by Fichman. In addition first-mover advantages according to Scarso (1996) can result in a growth option. First-mover advantages is closely relevant to the respective variable proposed by Fichman: "strategic importance of the technology" which is measured in this doctoral study.

A third reason for the focus of this model on the growth option is the results from the case studies and the exploratory research described in the previous Chapter 4. The business executives in the three case studies have recognised the opportunity that RFID offers to grow and offer future investments. In addition, the Net Present Value analysis revealed in the three case studies that when the option for an investment to grow and offer future applications is taken into consideration the overall value of the IT project is getting higher.

We wanted to focus on a specific type of option to be more precise and specific. However, future studies can take into consideration other types of options and additional determinants which trigger the generation of these options.

5.3 **Research Method**

5.3.1 **Data collection and sample**

To test the above hypotheses an empirical study was conducted. Representatives from 121 firms participated in the survey coming from 14 different European countries, including United Kingdom, Czech Republic, France, Germany, Sweden, Ireland, Italy and Greece. A web-based questionnaire was used, which was distributed via e-mail to several recipients from 14 country representatives. From the 121 overall responses, 12 answers were discarded due to partial replies, resulting in 109 overall usable questionnaires. APPENDIX 2 includes the data collection instrument.

For this study, participants were asked to evaluate information technology projects and in particular projects based on RFID technology in the supply chain. The participants are members of a European Network on RFID which is called "RFID in Europe". The members of the network are more than 300. The web survey was sent to these members. The members of the network were asked to send the survey link to additional contacts/companies of their own network that are familiar with RFID Technology.

At the beginning of the questionnaire the respondents were asked to identify a specific RFID project (from a given list of RFID applications) which has either been implemented in their organization or is currently under consideration and use it as a reference when answering the rest of the questions. Out of the 109 respondents, 63.3 per cent (N=69) identified an RFID project they had already implemented in the organization. From those who had not yet implemented the selected RFID project, 62.5 per cent stated that they were currently considering its implementation and leaned towards investing in it, while 42.1 per cent of them considered implementing this project in less than a year's time. Thus, the great majority of respondents when answering the rest of the questionnaire had in mind an actual and not a hypothetical RFID project.

Regarding the level of **diversity of the company respondents**, 73.6 per cent were managers (27.4 per cent CEOs, 21.7 per cent senior managers and 24.5 per cent middle managers), while 26.5 per cent were employees or external partners. Half of the participating firms were small and medium enterprises (SMEs) (54.6 per cent), while the rest (45.4 per cent) were large companies with more than 250 employees and an annual turnover over 50 million Euros. The participating companies represented several industries including the following with the highest percents: IT (17.9%), logistics (12,3%), retail (11,3%), production (9.4%) and services(8.5%). The justification of the respondents' diversity (different industries and departments) is analysed in the next paragraphs.

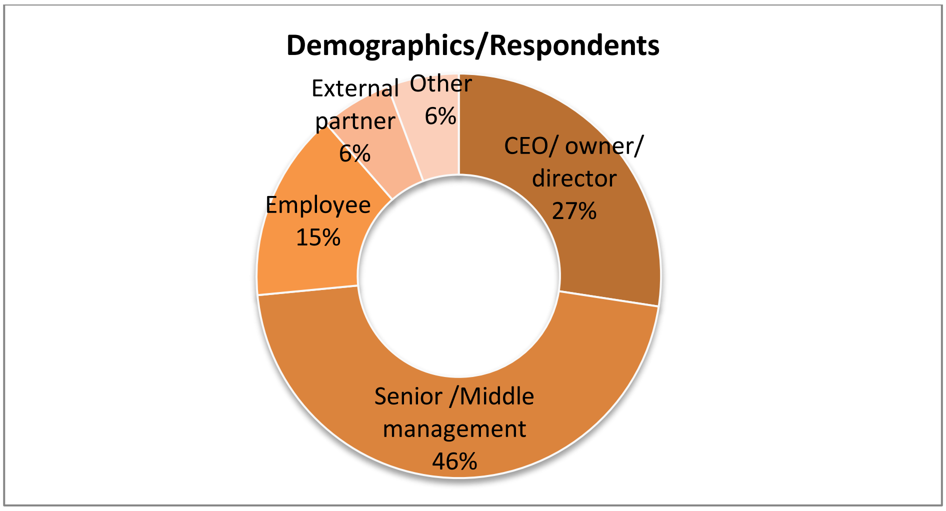


Figure 5.2 Position of the respondents

Due to the variety of RFID applications, the project leaders and decision makers of such implementations are often coming from many different departments and operations within a firm, such as logistics, sales, personnel management etc., and are not only MIS managers. This diversity is also depicted in the respondents of the survey who represent several departments of a company and not only the IT department. In particular, 49 per cent of the respondents work in the IT or the logistics department, which are the departments with the highest relevance to RFID implementations, while 31.7 per cent of the respondents work in other departments (e.g. marketing, sales etc.).

To assess the **respondents' involvement in RFID implementations,** the survey included questions to examine their familiarity with RFID technology. 80.7 per cent of the respondents stated that they are highly familiar with the technology, while 16.5 per cent stated that they are experts. In addition, the fact that the participants have either been members of the European "RFID in Europe" network or have been contacted by members of that network, increases awareness for the technology and communicate RFID best practices. For this reason, the respondents are expected to be the key personnel in their company involved in the respective RFID project they assess.

5.3.2 **RFID Context**

RFID technology is utilized in this study as it is considered one of the most suitable contexts to test our hypotheses. Since, the majority of relevant research (e.g. Fichman model) concerns the evaluation of innovative IT platforms, RFID technology which is an innovative and infrastructure (platform) technology is considered as a highly related context where the examined factors can be applied to and examined. A second reason for this choice, is that very few empirical studies (Goswami et al. 2008; Goswami et al. 2010) have been conducted to evaluate RFID technology based on Real Options analysis. Although there have been conducted a lot of studies (C.-Y. Lin 2009; Thiesse et al. 2011; S. Leimeister et al. 2009; S.-I. Chang et al. 2008; Vijayaraman et al. 2008; Roh et al. 2009; S. Kim & Garrison 2010; Tsai et al. 2010; Tsai et al. 2012; I. Brown & Russell 2007) which examine the determinants of RFID adoption and the antecedents of RFID investment evaluation, studies on the examination of real options as a motivation of RFID adoption are rare. However, recognition of options in the case of RFID can have a significant impact on its perceived value and willingness of adoption (Goswami et al. 2008; Goswami et al. 2010). Thus, the application of real options in the case of RFID can give interesting insights. Curtin et al. (Curtin et al. 2007) argue that interesting opportunities for research on RFID emerge and that “researchers could test the notion that infrastructure technologies may not be the primary drivers of business value themselves but rather create real options for additional follow-on investments”.

One of the very few studies which examines empirically RFID adoption under the option lens is Goswami et al. (Goswami et al. 2008; Goswami et al. 2010). Our study is differentiated with Goswami's study as following. Goswami's study explores a set of institutional factors which affect the recognition of real options and ultimately RFID adoption, while this study examines the impact of a different set of technology and organisational parameters. In addition, Goswami's study is focused on non-RFID adopters. On the contrary, this study takes into consideration not only adopters but also companies which have already adopted and implemented RFID technology. Comparison of these two groups gives interesting results. Another difference between Goswami's study and this one is that the focus of this study is the examination of determinants of growth option value, while Goswami's study examines more than one type of options. In addition, our study collects data derived from a European network and several countries rather than focusing on one country as Goswami's study.

5.3.3 Measures and Measurement Analysis

The following table depicts the variables and their measurements. For a detailed reference to the measurements and the respective scales proposed by pertinent literature please see the second part (b) of APPENDIX 2. All the measurements for the option value determinants are based on Fichman's definitions and other sources from the IT innovation adoption and IT Real Options literature. Due to questionnaire size limitations and based on Diamantopoulos et al. (Diamantopoulos et al. 2012) guidelines for the circumstances under which this decision is justified, many of the variables were measured based on a single-item scale rather than a multi-item scale.

Table 5.1 Measures and measurement analysis

Variables	Measures	Source
Technology strategy (TS)		
TS1.Radicalness	This RFID project produces fundamental changes in the activities of my organization	(Fichman 2004; R. Henderson 1993; R. Henderson & Clark 1990; Moosmayer & Koehn 2011)
TS2.Strategic importance of affected products/processes	This RFID project has got a strategic importance for my organisation.	(Oh & Pinsonneault 2007; Porter 2001; King et al. 1989; Fichman 2004)
TS3.Sustainability of advantage	The improvements that this RFID project offers to my organisation will defend against rapid duplication by competitors.	(Fichman 2004; McGrath 1997; McGrath & MacMillan 2000; Barney 1991)
Organisational capabilities (OC)		
OC1.Learning-related endowments	My organization is able to exploit its capabilities (e.g. technologically up-to-date staff, diversity and high degree of organizational skills) in order to learn and gain knowledge through the implementation of this RFID project	(Chiva et al. 2007; Fichman 2004)
OC2.Contributions to exploitable absorptive capacity	Through the deployment of this RFID project my organisation will expand its knowledge and skills and acquire the ability to utilize them in other domains	(Cohen & Levinthal 1990; Fichman 2004)
OC3.Innovative capabilities	My organisation possesses resources (human, technical, organizational) which can contribute to the effective deployment of this RFID project	(M. Subramaniam & Youndt 2005; R. Henderson 1993; Fichman 2004)
Technology Bandwagon (TB)		
TB1.Recognition of network externalities	The value of RFID technology will increase as more companies adopt it	(Katz & Shapiro 1985; Katz & Shapiro 1986; Strader et al. 2007; Asvanund et al. 2004)
TB2.Network dominance	RFID technology is likely to achieve a dominant position and offer substantial performance over other competing automatic identification technologies (such as barcode technology, smart card technology etc.)	(Fichman 2004)
Technology Adaptation (TA)		
TA1.Interpretive flexibility	This RFID project can be implemented in different ways and feasible configurations	(Fichman 2004; Kakola 1995; Orlikowski 1996)
TA2.Divisibility	The implementation of this RFID project can be completed in stages. Each stage of the implementation can result in a positive payoff, even if no further implementation stages are pursued	(Fichman & Moses 1999)
Growth Option (GO)	This RFID project is a necessary	(Tiwana et al. 2006; Tiwana et al.

	foundation for my organisation to develop interrelated follow-on projects in the future.	2007; Hult et al. 2010; Panayi & Lenos Trigeorgis 1998)
Value of Returns (VR)	The expected value of the potential returns/ payoffs for my organization as a result of this project deployment is:	(Fichman 2004; Hult et al. 2010; Tiwana et al. 2006)
Actual Adoption-dichotomous measure treated with logistic regression	Have you already invested in this RFID project?	(Thong 1999)

5.3.4 **Common Method bias**

Specific steps have been conducted to remedy common method bias based on (a) the design of the study's procedures and (b) statistical controls based on the respective literature (Podsakoff et al. 2003). Regarding the design of the study, anonymity of the respondents to answer the questionnaire was established. Anonymity make respondents less likely to edit their responses to be more socially pleasing and consistent with the researcher's desirable way of answering (Podsakoff et al. 2003). A second tactic followed for this study is the fact that the scale items were previously tested in the pilot survey in Greece and any ambiguous terms or wording were modified in order to be clear, simple, specific and concise (Tourangeau et al. 2000). Other tactics based on the literature (Podsakoff et al. 2003; Tourangeau et al. 2000) which were followed by this study and decreased the possibility of common method bias is the fact that the questions were decomposed into more focused questions and the complicated syntax was avoided.

In addition, apart from the above tactics which concern the design of the research, statistical tests were conducted. In particular, we conducted Harman's single-factor test (Podsakoff et al. 2003). Based on this technique, we loaded all the variables in the study (which were utilised for further analysis) into an exploratory factor analysis and examined unrotated factor solution. As a result, we concluded that one single factor cannot account for the variance of all the constructs of this study. No single factor emerged from the factor analysis. This test supports the fact that common method bias is not a problem in this study. In the table above the test of the Eigenvalues with more than one values signifies that there is no one single factor. We have to note that we have not excluded from the analysis the binary variable for the adoption, as Principal Component Analysis (PCA) can incorporate dichotomous variables. In addition, the increase of the variance explained if this variable is excluded from the analysis is negligible.

Table 5.2 Harman's test results

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.657	35.824	35.824	4.657	35.824	35.824
2	1.300	9.999	45.823	1.300	9.999	45.823
3	1.225	9.420	55.243	1.225	9.420	55.243
4	.977	7.519	62.762			
5	.861	6.624	69.386			
6	.765	5.885	75.271			
7	.737	5.666	80.937			
8	.622	4.786	85.723			
9	.547	4.204	89.927			
10	.515	3.965	93.892			
11	.351	2.702	96.593			
12	.262	2.016	98.610			
13	.181	1.390	100.000			

Extraction Method: Principal Component Analysis.

5.4 Results

5.4.1 Descriptive Statistics

The following table includes the desrciptives (mean, median, Standard Deviation skewness and kurtosis) of the variables exploited in the model.

Table 5.3 Descriptive Statistics for the variables of the study

	Mean	Median	Variance	SD	Skewness	z test for skewness	Kurtosis	z test for kurtosis
Technology Strategy								
Radicalness	4.39	5.00	2.574	1.60	-0.299	-1.274	-0.694	-1.479
Strategic importance of affected products and processes	4.64	5.00	3.215	1.79	-0.446	-1.901	-0.846	-1.803
Sustainability of comp.advantage	3.60	4.00	3.350	1.83	0.114	0.486	-1.138	-2.425
Organisational Capabilities								
Learning related endowments	5.04	5.00	2.640	1.63	-0.989	-4.215	0.448	0.955
Contributions to exploitable absorptive capacity	5.14	5.50	2.457	1.57	-1.035	-4.411	0.469	0.999
Innovative capabilities	4.92	5.00	2.528	1.59	-0.758	-3.231	-0.009	-0.019
Technology Bandwagon								
Recognition of network externalities	5.69	6.00	2.330	1.53	-1.267	-5.400	0.947	2.018
Network dominance	5.01	5.00	1.632	1.28	-0.46	-1.961	0.364	0.776
Technology Adaptation								
Interpretive flexiblity	4.71	5.00	2.585	1.61	-0.542	-2.310	-0.659	-1.404
Divisibility	4.61	5.00	3.156	1.78	-0.451	-1.922	-0.855	-1.822
Growth option	4.39	5.00	3.363	1.83	-0.278	-1.185	-1.013	-2.159
Value of returns	4.97	5.00	2.231	1.49	-0.513	-2.187	-0.08	-0.170

Skewness is the extent to which a variable's distribution is symmetrical. If the distribution stretches toward the right or the left tail of the distribution then the data are skewed. Kurtosis provides information about the 'peakedness' of the distribution. When both skewness and kurtosis are close to zero, this means that we have a normal distribution. However, because of the fact that this is not very common to happen, the issue which has to be clarified is the level of skewness or kurtosis.

Based on the skewness results, we can conclude that the values of the majority of the variables are gathered into the right (negative skewness), with the exception of the variable: "sustainability of competitive advantage" where the data are gathered into the left (positive skewness).

For the majority of the variables, the skewness and kurtosis values of the indicators are within the -1 and +1 acceptable range (Hair et al. 2013, p.61). However, the data for four variables deviate from normality. However, the values of skewness and kurtosis for these four variables are close to 1 which makes the deviation low and not substantial. In order to validate the above results and assess the normality of the variables, the following statistic tests (rules of thumb) proposed by Hair et al. 2009 are calculated.

$$z\ skewness = \frac{Skewness}{\sqrt{\frac{6}{n}}}$$

$$z\ kurtosis = \frac{kurtosis}{\sqrt{\frac{24}{n}}}$$

Where, n is the sample size. If either calculated Z value exceeds the specified critical value (±2.58 for 0.01 significance level and the ±1.96 value for 0.05 error level) then the distribution is non normal. In our case, for all the variables the z kurtosis tests and for the majority of the variables the z skewness tests do not exceed the above value (±2.58). However, for four variables (i.e. learning related endowments, contributions to exploitable capacity, innovative capabilities and recognition of network externalities) the z tests for the skewness have exceeded the cut-off point, thus the data are deviated from normality.

The deviation from normality (for these variables) is not an issue, as PLS-SEM generally makes no assumptions about the data distributions and it is basically a nonparametric statistical method (Hair et al. 2013). However, it is important to assess the level of normality to take into consideration the impact of non-normality on the significance of the examined parameters. According to the literature (Henseler et al. 2009; Hair et al. 2013), extremely non normal data can inflate the standard errors which may result in decreasing the possibility that the t value (and as a result the p value) of a parameter will be significant (significance of the independent variables on the dependent). In the following section, where an analysis of the structural model is made regarding the significance of the predicting variables on the dependent variable, we should take into consideration the non-normality of these four variables. This issue may explain and justify any possible insignificant results.

5.4.2 Measurement model evaluation

For the analysis, the measurement (outer) and the structural (inner) model are tested through the Smart Pls version 2.0 software. To test the construct validity of our measures, we employed Confirmatory Factor analysis using this software. We have chosen confirmatory factor analysis, as it leads to a stricter and more objective interpretation of validity than the exploratory factor analysis does (Spanos & Lioukas 2001). The variables (within each one factor) are treated as reflective measurements of the respective factors, as it was shown that they have a high level of correlation which is not an attribute of the formative measurements. In addition, they could not be considered as formative, because these variables did not form the exclusive list of the attributes of the factor that they measure.

Reliability: As a first step for the internal structure of the measurement model, the authors examined the reliability of all the items of each one factor. Reliability tests the degree of agreement among a set of measures of a single construct (Bagozzi & Yi 2011). As it is shown table 2, all “composite reliability” estimates are quite satisfactory and above the cut-off level of 0.70 (Fornell & Larcker 1981; Spanos & Lioukas 2001; Joe F. Hair et al. 2012). This provides a proof that each factor has internal consistency, as the measurement items for each one factor are consistent to each other. In PLS, composite reliability relies on actual loadings to compute the factor scores and is a better indicator of internal consistency than Cronbach alpha (Ranganathan et al. 2004). The growth option recognition and the value of returns are measured with one item scale, therefore, the AVE and CR for these variables equal to 1.

Table 5.4 Average Variance Extracted and Composite Reliability

	AVE	Composite Reliability
Adaptation	0.5916	0.7408
Technology Bandwagon	0.7264	0.8392
Organisational Capabilities	0.7617	0.9056
Technology Strategy	0.5642	0.7936

In addition, we tested the "indicator reliability", i.e. the reliability of the individual items of each one factor (Joe F. Hair et al. 2012). A factor loading represents the correlation between an original variable and its factor, which according to Hair et al. (Joseph F. Hair et al. 2009), it should be higher than 0.55 for samples with N=100. In this study, all the factor loadings of each one item within each one factor is above 0.6 (R. P. Bagozzi & Y. Yi 1988), as it is shown in the following table. Thus, all the variables utilized in this study load significantly on their respective factor. In the following table the factor loadings of each indicator variable on their respective factors are in bold.

Table 5.5 Factor loadings (in bold) and cross loadings

	Technology Adaptation	Technology Bandwagon effect	Organisational Capabilities	Growth option recognition	Technology Strategy	Value of returns
Contributions to exploitable absorptive capacity	0.4185	0.3882	**0.8901**	0.5737	0.5581	0.5467
Rec. of Growth option	0.4195	0.2462	0.5539	**1.0000**	0.6122	0.4484
Innovative capabilities	0.3181	0.2813	**0.8536**	0.4101	0.4272	0.4159
Interpretive flexibility	**0.6751**	0.1709	0.2543	0.2632	0.3686	0.2490
Learning related endowments	0.3324	0.2421	**0.8743**	0.4372	0.3978	0.4359
Network dominance	0.0726	**0.7340**	0.2923	0.1140	0.2287	0.2971
Radicalness	0.3197	0.2220	0.3562	0.4641	**0.7425**	0.4257
Divisibility	**0.8528**	0.1823	0.3723	0.3719	0.3361	0.4310
Strategic importance of affected products and processes	0.3771	0.4416	0.4652	0.5532	**0.8424**	0.5355
Recognition of network externalities	0.2588	**0.9561**	0.3285	0.2642	0.4411	0.3146
Sustainability of comp.advantage	0.3154	0.2676	0.3964	0.3247	**0.6569**	0.2661
Value of returns	0.4563	0.3479	0.5429	0.4484	0.5666	**1.0000**

Convergent validity: In order to examine if the measurements of each one factor converge and share a high proportion of variance in common, the Average Variance

Extracted (AVE) is calculated. As it is shown in Table 5.4 it is found that AVE for each one factor is greater than 0.5 which is the threshold point (R. P. Bagozzi & Y. Yi 1988) above which convergent validity becomes evident. Results show that one of the highest AVEs is that of the organizational learning, indicating that this factor explains the 76% of the variation in the items with the rest percent being error variance.

Discriminant validity: After examining the relatedness among the 13 indicators within their 4 respective factors, the discriminant validity of the measurement model is tested. This measure examines the extent to which a construct is truly distinct from other constructs (Joseph F. Hair et al. 2009). The authors tested discriminant validity with two measures. According to the first test, the loadings of each one measurement item on its corresponding item should be higher than their loading on other constructs (Joe F. Hair et al. 2012). For this study, as it is shown in the table below which depicts the cross loadings of the items, each indicator loads the highest on the factor it is intended to measure. For example, the item which measures the innovative capabilities of an organisation has a factor loading of 0,8536 on the factor "organizational capabilities" that it represents, which is the highest loading compared to its loadings on the other constructs of the model.

To examine the discriminant validity of the measurement model, the authors conducted another test. According to this test (the Fornell-Larcker criterion) the square root of the Average Variance Extracted (AVE) of each one construct should be higher than its correlation score with all other constructs (Fornell & Larcker 1981). In the table below it is shown that the square root of the AVE of each one construct (shown in the grey cells, diagonally) is greater than its correlations with the other constructs (on left and below the grey zones). This result indicates that more variance is shared between the construct and its measurement items than with another construct which includes a different set of items.

Table 5.6 Latent variable correlations and square roots of average extracted (AVE)

	Adaptation	Bandwagon effect	Organisational Capabilities	Growth Option	Technology Strategy	Value of returns
Techn.Adaptation	0.769	0.0000	0.0000	0.0000	0.0000	0.0000
Techn.Bandwagon	0.2279	0.852	0.0000	0.0000	0.0000	0.0000
Organisational Capabilities	0.4150	0.3572	0.872	0.0000	0.0000	0.0000
Rec. of Growth	0.4195	0.2462	0.5539	1.0000	0.0000	0.0000

Option						
Technology Strategy	0.4487	0.4241	0.5385	0.6122	0.751	0.0000
Value of returns	0.4563	0.3479	0.5429	0.4484	0.5666	1.0000

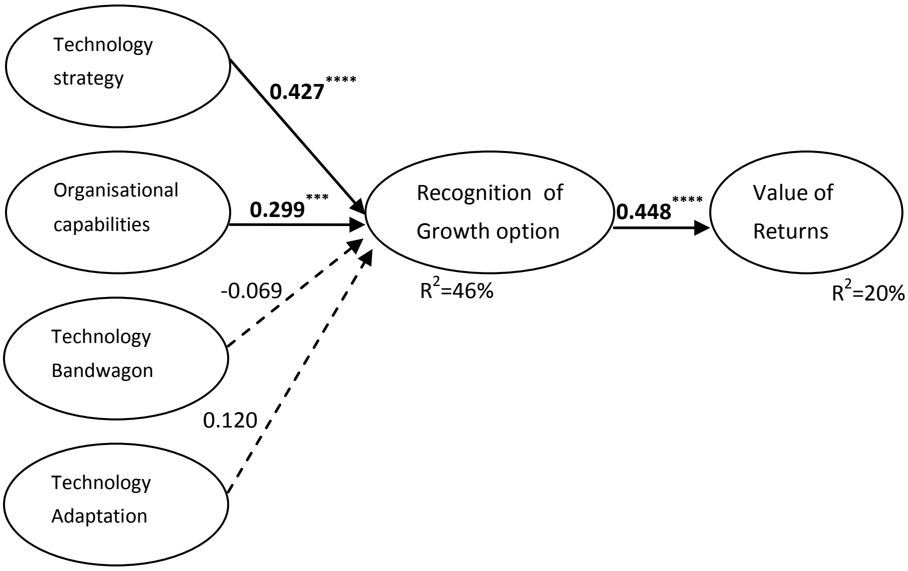
5.4.3 Testing of hypotheses

5.4.3.1 *Structural model evaluation*

To test the formulated hypotheses and the significance of the independent variables, Partial Least Squares (PLS) algorithm is conducted in the Smart PLS software programme. The **explanatory power of the model** is examined by testing the R^2. As it is shown in the figure below the R^2 of the structural inner model is 0.46. This means that the 46% of the variance in the dependent variable (recognition of growth option of the assessed RFID project) is explained by the independent variables. Thus, growth option recognition is well explained by the option determinants. In addition 20% of the variance in value of returns is explained by the independent variable: growth option recognition.

Table 5.7 Results of Path Analysis

Path	Path coefficient	T value	P value	Effect
Technology strategy→ Rec. of Growth option	0.427****	4.186	0.000	Very strong
Organisational capabilities→ Rec. of Growth option	0.299***	3.865	0.001	Very Strong
Techn.Adaptation → Rec. of Growth option	0.120	1.168	ns	Weak
Techn.Bandwagon → Rec. of Growth option	-0.069	0.922	ns	Weak
Rec. of Growth Option →Value of returns	0.448****	4.936	0.000	Very strong



P values: Probability (two-tailed test), 15 degrees of freedom, **= p<=0.05, ***=p<=0.01, ****p<=0.001

Figure 5.3 Regression Results

Predictive power of the model is tested by examining the magnitude of the standardized parameter estimates and the respective level of significance. The estimation of the path coefficients and their respective T value came as a result of the PLS algorithm and the bootstrapping analysis. Based on the parameter settings, the number of the bootstrap samples was set to be 5,000. According to the literature on PLS (Joe F. Hair et al. 2012) the number of the bootstrap samples should be higher than the number of the valid observations. Hypothesis 1 is fully supported, as the growth option recognition has a strong effect on the perceived value of returns (β=0.448, t=4.936). In addition, the hypothesis 3 and 4 are supported by this study, as the technology strategy and organizational capabilities have a strong significant impact on the growth option recognition (β=0.427,t=4.186 for technology strategy and β=0.299, t= 3.865 for organisational capabilities). However, hypothesis 5 and 6 cannot be supported as the impact of the technology adaptation and the impact of network effects on the recognition of growth options are insignificant.

Collinearity statistics

Due to the fact that PLS-SEM modeling is based on multiple regressions, collinearity (i.e. correlations) among the predicting variables should be avoided. Collinearity can affect the overall predicting ability of a model and the significance of the impact of the predictors. Because of the fact that the effect of two predicting variables on growth option value (i.e. technology bandwagon and adaption) is not significant, we would like to see whether this effect is a result of high correlations among the independent variables.

There are two basic statistical tests to examine the level of collinearity (Hair et al. 2013). Tolerance (TOL) tests and the Variance inflation factor (VIF). Tolerance levels represent the amount of variance of a variable not explained by the other predicting variables. We regress each one predicting variable on the remaining ones in order to calculate the R^2 which is the proportion of variance of X_1 which is associated with the other predictors. The tolerance level equals to $1-R^2$. A tolerance level of 0.20 or lower indicates collinearity problems. A related measure of collinearity is the VIF which is defined as the reciprocal of the tolerance (i.e. $VIF_{X1}=1/TOL_{x1}$). The term VIF is based on the square root of the VIF which is the level to which the standard error has been increased due to the presence of collinearity. A VIF value of 5 and higher indicates collinearity problems.

For this study, we ran regression analysis with the latent variables scores (based on the output of the smart pls) in the SPSS software. The software automatically calculates the TOL and VIF levels. The results below show that the VIF is less than 5 for all the indicator variables and the tolerance measures are far above 0,20. Thus, we can conclude that there is no collinearity issues for the independent variables.

Table 5.8 Collinearity Statistics

Coefficients[a]

Model		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		Beta			Tolerance	VIF
1	(Constant)		.000	1.000		
	Adaptation	.120	1.444	.152	.756	1.322
	Bandwagon effect	-.069	-.853	.396	.797	1.255
	Organisational capabilities	.299	3.358	.001	.655	1.528
	Techn. strategy	.427	4.579	.000	.598	1.673

a. Dependent Variable: Growth option

Control variables

The regression model is conducted with four control variables: (1) firm size, (2) country (3) industry sector and (4) IT application. In the demographics section of the questionnaire these variables are measured. Size is measured based on a multiple choice question regarding the number of the company's employees ((a) <10, (b) 10-50, (c) 51-250 and (d) >250 employees). Finally a multiple choice question asked the respondents regarding their country. Sector is measured based on a multiple-choice question based on the different industry categories (e.g. Primary industry, retail, health sector, logistics etc.). The IT application is measured based on a 7 point multiple choice question with different types of RFID applications (e.g. inbound/outbound logistics, inventory audit, asset tracking, anti-theft control, personnel management etc.). See APPENDIX 2 for the full questions.

The smart PLS algorithm ran and results showed that the effect of these variables on the growth option recognition variable is not statistically significant. The standardised coefficients, t and p values are: -0.069 (t=0.939, p value=0.36), 0.054 (t=0.833,p value=0.41), -0.060 (t=0.793,p value=0.44) and -0.069 (t=0.854, p value=0.94) respectively which shows that the effect of these variables is minor ($p > 0.05$ and $p>0.10$). These factors do not add value into the overall model regarding its ability to account for the variance of the dependent variable. For this reason they are not added in the main model and analysis.

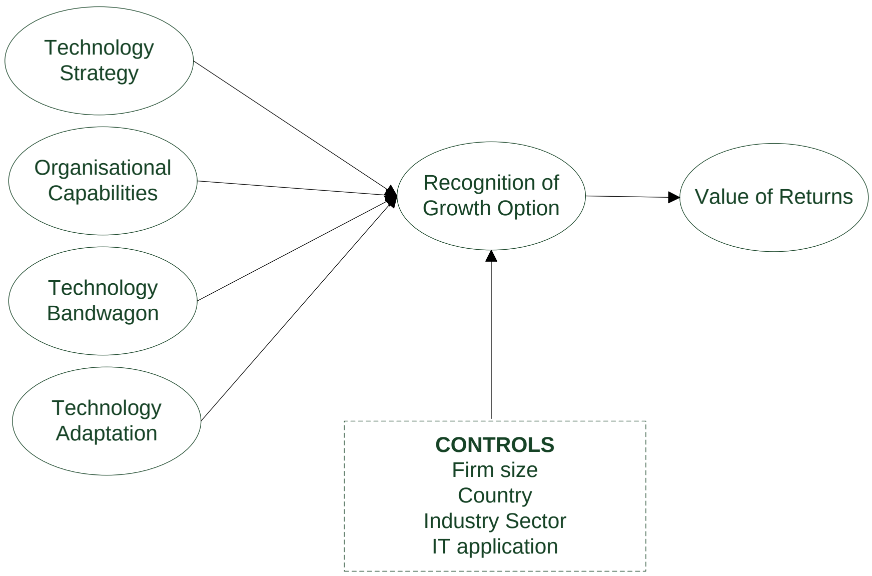


Figure 5.4 Control variables in the research model

5.4.3.2 *Logistic Regression*

To test hypotheses 2, the authors conducted on the SPSS software a binary logistic regression model to evaluate the relative importance of the variable: "value of returns" in predicting the likelihood that a company will have already adopted the assessed IT project. The dependent variable (Investment status) is a binary (categorical) one with the following two values: Yes, I have invested in this RFID project=1 and No, I have not invested in this RFID project=0. This analysis will allow us to assess how well our predictor variable explains our categorical dependent variable (Pallant 2005). For the analysis we included the same **control variables:** country, firm size, Industry sector and IT application.

(a) Overall evaluation and "goodness- of- fit" of the model: The *Omnibus Test of Model Coefficients* shows the "goodness of fit" of the model and how well it works. The significance of the value as it is shown in the respective table is high (p value= 0.032). This means that the model with the predictor variable is better than SPSS's speculation which made the assumption that everyone would have invested in the assessed RFID project. Based on the *Hosmer and Lemeshow Test,* the model is meaningful as its Sig. is 0.170, which is higher than the 0.05 point above which the model is supported (Pallant 2005). The p-value here indicates that the proposed model is not significantly different from a perfect one which can classify correctly all the respondents into their respective groups (RFID adopter and non-adopter firms) (Patrick Y K Chau & Tam 1997). In the *Model Summary*, the value of the *Cox and Snell R square and the Nagelkerke R Square values* give us the information about the usefulness of the model. In particular, between 11% and 16% of the variance of the dependent variable (adoption) is explained by the predictor variables.

(b) Significance of the individual predictors: The *Variables in the Equation* shows the contribution of the predictor variable. Results show that the "Value of returns" contributes significantly to the predictive ability of the model (β=0.347 and p value=0.032) and increases the likelihood that a decision maker is an adopter of the RFID technology. In addition, its *Exponentiated logistic coefficient* Exp(B) is 1.415. According to the literature (Hair et al. 2009), when this outcome is more than 1, this means that it has positive relationship with the dependent variable (investment status). Based on this value, a one-unit increase in the perceived value of returns will increase the "odds ratio of probabilities" by 42%. If we assume that the odds are 1.0 (i.e. 50% for a company to be an adopter and 50% for not). Because of the fact that the probability=odds/(1+odds), if the perceived value of returns will increase 1 unit (from 6 to 7), then this means that the probability of company to be an adopter will increase from 50% to 59% (probability= 1.42/1+1.42=0.586~0.59). This means that the likelihood will be increased to a percent of 18%. This means that as the perceived value of returns increases by one unit, the likelihood that a manager will be categorised as being an adopter of the assessed RFID project is increased by 18%. On the contrary, the control variables do not have a significant impact on the likelihood of adoption.

(c) Predictive accuracy of the model: Based on the *Classification Table,* the sensitivity and the specificity of the model are showed. The results shown in the table below, indicate an overall predictive accuracy of 67,3% based on the logistic regression model. As there are 69 adopters and 40 non-adopters in this study, guessing by random choice would result in $(69/109)^2 + (40/109)^2 = 53.5\%$ accuracy, which is less than in the case in our model. Thus, we can conclude that the logistic regression model has a higher discriminating power than the random choice model. In particular, our model was able to correctly classify and identify 86.2% of the managers who have invested in the assessed IT project. In addition, 33,3% of the managers who have not invested in the RFID project correctly predicted not to have invested in this project.

Table 5.9 Logistic regression results of predicting adoption of the assessed IT project

Overall model fit

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	4.895	1	.027
	Block	4.895	1	.027
	Model	12.189	5	**.032**

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	119.382[a]	.114	.156

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	11.597	8	.170

Predictive accuracy of the model

Classification Table[a]

Observed			Predicted		
			Investment status log		
			NO	YES	Percentage Correct
Step 1	Investment status log	NO	12	24	33.3
		YES	9	56	86.2
	Overall Percentage				**67.3**

a. The cut value is .500

Statistical significance of the predictor variables

Variables in the Equation

Control variables and the value of returns		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	95% C.I.for EXP(B) Upper
Step 1[a]	Country	.042	.043	.970	1	.325	1.043	.959	1.135
	Demographics industry sector	-.010	.043	.056	1	.813	.990	.910	1.077
	Demographics No employees	-.297	.194	2.336	1	.126	.743	.508	1.087
	Application area of the project	.120	.103	1.348	1	.246	1.127	.921	1.380
	Value of returns	**.347****	.162	4.610	1	**.032**	1.415	1.031	1.943
	Constant	-.977	1.153	.718	1	.397	.376		

a. Variable(s) entered on step 1: Country. Demographics industry sector. Demographics No employees. Application area of the project. Value of returns.

P value: *=p<=0.10, **= p<=0.05, ***=p<=0.01, ****p<=0.001

The following table includes the results on the overall hypotheses of this study.

Table 5.10 Overall Hypotheses results

Hypothesis	Result
H1	Supported
H2	Supported
H3	Supported
H4	Supported
H5	Not Supported
H6	Not supported for the full sample (Supported for adopters, not supported for non-adopters)

5.4.3.3 *Test of mediating effects*

As previously discussed, the authors had the aim to investigate the role of growth option recognition as a mediator between the proposed by the literature determinants of option recognition and the ultimate value of returns of the assessed IT project. To test these mediating effects, the authors adopted the three-step method for mediation suggested by Baron and Kenny (1986).

According to the literature (Baron & Kenny 1986) three steps must hold to establish mediation. The first two steps are based on simple regressions, whereas the last step is based on multiple regression. First, the dependent variable is regressed to the independent variable. According to the authors, the independent variable must directly affect the dependent variable. Based on table 5.11 below, technology strategy, organisational capabilities, bandwagon and adaptation variable have a direct significant effect (each one separately) on the dependent variable: value of returns. According to the second step, the mediator variable is regressed to the independent variable. The independent variable must affect the mediator. Based on the results in Table 5.11 all the independent variables have a significant effect on the mediator effect which is the recognition of the growth option. According to third step the dependent variable is regressed to both the mediator and the independent variable. Based on the authors' requirements, the mediator should affect the outcome variable, when the independent variable is added into the model. Indeed, Table 5.11 shows that in all the separate models the recognition of growth options has an effect on the value of returns of the assessed IT project. In particular, this effect is significant for all the variables (apart from the effect of the growth option recognition when the independent variable is the technology strategy). According to the authors if these three steps are met, then we have at least a partial mediation.

The authors followed the above steps initially proposed by Baron and Kenny(1986) and explained further based on one of the two authors: Kenny's (David A. Kenny 2012) work. Based on Kenny's quotation: "the above steps are stated in terms of zero and non zero coefficients and not in terms of statistical significance as they were in Baron and Kenny (1986)". In this case, we have statistical significance for all the regressions (apart from the effect of the mediator on the dependent variable when the independent variable is the technology strategy which can be found in the third regression model). Taking into consideration, the non-zero requirement instead of the statistical significance, we can see that all the coefficients in the table are not zero. As a conclusion, the recognition of growth options mediates the relationship of these four independent factors on the perceived value of returns (even in the case of technology strategy).

We can validate this by looking at the decrease of the effect of the independent variables on the dependent variable (value of returns), when both the independent and the mediator variable are embedded in the multiple regression model (for each one separate independent variable). This shows that when the mediator is entered into the equation, the impact of the independent variable diminishes. Since the effect of the independent variable on the dependent variable in the multiple regression models (last step) are not zero we can conclude that we have a partial and not a full mediation.

To test the significance of the mediation, the Sobel test (Sobel 1982) has been conducted. The Sobel test provides an approximate significance test for the indirect effect of the independent variable on the dependent variable via the mediator (Baron & D. a Kenny 1986). The z tests with the respective p values are calculated and depicted in the following table. The path coefficients and the respective standard errors are calculated through bootstrapping analysis. The respective inputs are embedded in the Sobel formula. Results show that the mediation is significant for the three out of four independent variables (organisational capabilities, bandwagon and adaptation effect).

In addition, a validation of the mediation results is undertaken, through the calculation of the mediated/indirect effect. According to the literature (Judd & D A Kenny 1981) the indirect effect equals to the difference between the two regression coefficients, when the dependent variable is regressed to the independent before and after the addition of the mediator (c-c'). Based on Sobel (Sobel 1982) the indirect effect equals to the number which is computed when multiplying two regression coefficients (a x b: the effect of the independent variable on the mediator and the effect of the mediator on the dependent variable). In this case, as it is shown in the following table, the above two requirements are fulfilled, as a x b=c-c'.

Table 5.11 Results of mediating effects

Coefficient of regressions								Sobel test (significance of mediation)		Validation
IV	M	DV	IV→DV 1st regression model	IV→M 2nd regression model	IV+M→DV 3rd regression model					
					IN→DV	M→DV	Mediation	Z test	P value	Mediated effect
			c	a	c'	b				axb=c-c'
Techn.Str.	Rec.of Gr.Option	Val.of Ret.	0.572	0.6122	0.4760	0.1554	Partial	1.344	0.17	0.096
Org.Capab.	Rec.of Gr.Option	Val.of Ret.	0.541	0.554	0.4225	0.215	Partial	**1.93****	0.05	0.119
Band.	Rec.of Gr.Option	Val.of Ret.	0.353	0.2462	0.2672	0.3894	Partial	**2.14****	0.03	0.086
Adapt.	Rec.of Gr.Option	Val.of Ret.	0.461	0.420	0.3312	0.3092	Partial	**2.44****	0.014	0.130

IV: Independent variable, DV: Dependent variable, M: Mediator variable, Techn.Str.: Technology strategy, Org.Capab.: Organisational capabilities, Band.:Bandwagon effect, Adapt. : Technology adaptation, Rec.of Gr.Option: Recognition of Growth Option.

P values: Probability (two-tailed test), *p<=0.10,**p<=0.05, ***p<=0.01,****p<=0.001

5.5 **Summary of Findings**

Although literature on IT innovation adoption examines several factors regarding their impact on IT firm adoption, the majority of the pertinent studies ignore managerial flexibility and the respective real options inherent in an IT innovation as variables which can affect IT adoption. However, literature on IT evaluation through Real Options theory has acknowledged the significance of real options regarding their impact on the perceived value and adoption of an assessed IT project with uncertainty. Nevertheless, empirical research which examines how real options affect managerial decision making is very limited. In addition, while relevant studies propose several determinants which create this kind of flexibility and real options for an IT innovation, studies which test empirically these propositions are very few. With the aim to fulfill this gap, this study conducts an empirical European survey with the following objectives:

- Empirically investigate the impact of the recognition of growth options on the perceived IT project value and adoption
- Examine the significance of the factors which trigger the recognition of growth options
- Test the role of growth options as a mediating factor among IT innovation adoption parameters and perceived IT project value
- Develop and empirically test a model for the above objectives and apply it to a real context (RFID technology)

Summarizing the findings of the study, results showed that:

- When evaluating an IT project, the ability of an organisation to recognise growth options (embedded in this project) has a significant positive impact on the assessed value of returns of the appraised technology and ultimately its adoption.
- Growth option recognition of an IT project is a result of specific organisational (i.e. organisational learning and innovative capabilities) and technological parameters (i.e. technology strategy characteristics) which have to be considered during evaluation and adoption decision as significant determinants and sources of growth option value.
- Real Options and in particular growth options is a variable which facilitates understanding of the mechanism under which specific technology and organisational parameters (from the IT innovation field) influence managers decisions regarding their assessment of an IT project

The significance and the reflections on these findings (i.e. strengths and limitations of the results, theory and previous studies support, conflicting to the theory results) are going to be discussed in the last Chapter of the thesis: Chapter 7.

6 THE MODERATING EFFECT OF THE IT PROJECT TYPE ON REAL OPTION VALUE

6.1 Introduction

Selecting and effectively pursuing the right information technology (IT) investments can be a key factor in sustaining corporate viability and prosperity (Bacon 1992). Due to financial limitations, companies deploy several evaluation techniques to justify IT investments. As a result of the recognized drawbacks of the traditional evaluation methodologies (e.g. Net Present Value approach), Real Options analysis has been suggested as a promising justification approach which takes into consideration the flexibility of such investments as a way to confront several risks and uncertainties through the exploitation of specific types of options.

As it was analysed in the Chapter of the Literature Review (Chapter 2) , most studies in the Information Systems (IS) field that have applied Real Options analysis to IT investment evaluation follow the normative approach, where a Real Options model is applied to measure the value of an IT project (e.g. Dos Santos 1991; Benaroch & Kauffman 1999; Taudes 1998; Tiwana et al. 2007; Bardhan et al. 2004). A limited number of studies, though, have followed the behavioral approach, where the effect of Real Options on managers' perceptions is examined (Tiwana et al. 2006; Tiwana et al. 2007; Lankton & Luft 2008; Fichman 2004; McGrath 1997; Goswami et al. 2010). This study contributes to this latter branch of research.

Moreover, the great majority of studies applying Real Options in the IT field treat IT projects as a homogeneous group rather than looking at individual features or types of IT projects. However, *different types of IT projects might carry different option value* (Wu & Ong 2008; Tiwana et al. 2006; Li & Johnson 2002). For example, prior research (Q. Dai et al. 2007; Fichman 2004; Taudes et al. 2000) suggests that platform IT investments (e.g. ERP, wireless networking, infrastructure investments) are very good candidates for growth opportunities. Li & Johnson (2002) have shown in their normative study that “shared IT projects” (i.e. open standard technologies, e.g. wireless access), in contrast to “proprietary” ones, indicate a higher level of competition, thus the value of the option to wait is diminished. Wu & Ong (2008) in their study underline that small-scale applications (e.g. daily accounting and office automation systems) offer few options in contrast to other larger-scale investments.

Although the pertinent literature has acknowledged the importance of extending research on the above issues, there have been very few attempts to empirically compare different types of IT projects and examine the different types of options and the respective value they generate. In addition, limited effort has been devoted to identifying the features or the attributes of IT projects related to the creation of an option.

To fulfill this gap this study aims to examine whether there is a difference regarding the impact of real options on the perceived IT project value among different types of IT projects. Three types of options are considered (growth, stage and deferral) and IT projects are differentiated based on their scope, purpose and span, as will be specified in the following section. The specific types of Real Options and the types of IT projects are based on the findings of the Case Studies Chapter (Chapter 4). Cross-case findings revealed that he examined RFID deployments embedded these three types of options. In addition, cross- case findings had shown that the specific RFID deployments in the three examined companies had been different based on these specific dimensions (scope, purpose and span).

As a result, the specific study in this chapter has the aim to investigate the second and third research question of the thesis as they were stated in the Chapter of Research Methodology (Chapter 3) and refined in the Case Studies Chapter (Chapter 4):

Research Question 2: *What is the impact of real options on the perceived value of returns of an information technology project?*

which was refined into the following questions:

- *What is the impact of the recognition of growth options on the perceived value of returns of an information technology innovative project?*
- *What is the impact of the recognition of stage options on the perceived value of returns of an information technology innovative project?*
- *What is the impact the recognition of deferral options on the perceived value of returns of an information technology innovative project?*

Research Question 3: *Is this impact strengthened or mitigated across different types of IT projects?* which was refined into the following questions:

- *Does the* <u>*scope of an IT project*</u> *(whether it is a family or standalone application) moderate the effect that real options have on the perceived value of returns of this project?*
- *Does the* <u>*purpose of an IT project*</u> *(whether it is strategic, informational or transactional application) moderate the effect that real options have on the perceived value of returns of this project?*
- *Does the* <u>*span of an IT project*</u> *(whether it is an internal or supply-chain application) moderate the effect that real options have on the perceived value of returns of this project?*

Results from a questionnaire-based survey, with data collected from European companies, show that the three examined real options influence managers' perceptions regarding the IT project value returns. In addition, results indicate that the effect of real options on the perceived value of an assessed IT project differs significantly across different types of IT projects. Results further reveal that large scale IT projects which share synergies, IT applications with long-term aims and IT solutions which are deployed on a wide scale, such as supply chain IT projects, are suitable candidates for the application of Real Options analysis.

The remainder of this Chapter is organized as follows. The following section presents the respective theory of Real Options and IT classification leading to the development of the research hypotheses and research model (Section 6.2). Next, the research method (Section 6.3) and results (Section 6.4 & Section 6.5) are presented. Chapter 6 closes with the Summary of findings (Section 6.6).

6.2 Hypotheses formulation and the Research Model

6.2.1 Real Options IT evaluation

New information technologies emerge as candidate investments for several companies. Since some of these technologies do not occur as necessities for organizations, they become subject to investment evaluation processes in order to be justified. In recognition of the limitations of the traditional evaluation methodologies (such as the Net Present Value approach), Real Options analysis has been suggested as an alternative approach which takes into consideration the flexibility of such investments as a way to confront several risks and uncertainties. Flexibility can be defined as the "ability to respond or conform to a changing or new situation in a variety of ways" (Kumar 1999), whereas "uncertainty is an investment's risk or volatility in cash flows that results from the inability to predict behaviors related to economy, market, technology or organization" (Lankton & Luft 2008:217). Through Real Options analysis, decision makers can reduce the risk by changing their investment decisions as new information in terms of prices, costs and other market conditions becomes available (Kim & Sanders 2002).

This flexibility can be signified through several options that occur for an investment decision. The Real Options approach tends to incorporate the value of this kind of options because it assumes that investment projects can be stopped, put on hold, redirected or postponed (MacMillan et al. 2006). For example, should the results of a first-stage investment occur to be unfavorable, a manager can abandon or reduce the scope of the following second-stage projects (Dos Santos 1991). On the contrary, traditional evaluation approaches, such as the Net Present Value (NPV), neglect the value of these options and do not take into consideration management's flexibility regarding investment decisions, as they assume that once a project is approved all the cash flows will automatically take place (MacMillan et al. 2006). Traditional approaches treat investments as now-or-never decisions. If such options are available but are not considered during the investment assessment, then the investment will be undervalued (Dos Santos 1991).

The pertinent literature (e.g. Benaroch et al. 2007; Kumar 1999; Pendharkar 2010) either exploits option formulas from the financial field or develops new models to estimate the value of these options in IT investments. A limited number of studies have formed a second stream of research in this field, assessing the value of these options based on managers' perceptions. According to Lankton & Luft (2008), intuitive judgment of investment decisions that take into account the real options is very important, because it can substitute the more costly alternative of the normative Real Options analysis (utilization of option pricing formulas) to evaluate IT investments. In addition, Lankton and Luft (2008) argue that it is vital to understand when and how managers' views on real options are different from real options principles and theory. In cases where such differences occur, intuitive judgment considering real options cannot replace the normative Real Options analysis, as the results could lead to misleading decisions. Moreover, when these discrepancies take place, training on Real Options analysis becomes very important (Lankton & Luft 2008).

Focusing on this second stream of research and the behavioral implications of Real Options, recent empirical studies have shown that Real Options have a significant effect on the perceived value of an assessed IT project. Tiwana's et al. study (2006) has shown that managers acknowledge the value of options which influence their investment decisions. Their results underline that the presence of Real Options can lead to a higher tendency to continue a troubled IT project. A further study (Tiwana et al. 2007) has concluded that managers ascribe value to Real Options when they consider the assessed IT projects as opportunities with low quantifiable benefits. Lankton's and Luft's study (2008) has shown that managerial investment behavior regarding IT projects is influenced by Real Options and under specific levels of uncertainty and competition managers value differently several types of options. Further studies (Goswami et al. 2008; Goswami et al. 2010) have shown that the recognition of several options by managers affects significantly their intention to adopt an IT project. Other studies (Denison 2009; Hult et al. 2010; Miller & Shapira 2004; Busby & Pitts 1997) suggest that Real Options have a significant effect on the value of an assessed project in general, other than an IT project. These studies suggest that the value of an assessed project will be influenced by the presence of these options. In this study we specifically consider "the value of returns" of an IT project as the expected value of the potential returns/ payoffs (Fichman 2004) occurring as a result of an IT project deployment. Thus, based on the pertinent literature, we formulate the following hypothesis:

***H1**: Real Options influence the perceived value of returns of an IT project*

Prior research (Lenos Trigeorgis 1993; Benaroch 2001) has classified Real Options into two major categories: i) Growth and ii) Operating. As far as the growth option is concerned, an early IT investment is seen as a prerequisite or a link in a chain of interrelated projects opening up future growth opportunities (Trigeorgis 1993:204). The cost of the initial investment is viewed as the premium that a company is willing to pay to buy the option to invest in other related investments in the future. On the other hand, "Operating options" give management the opportunity to adapt traits (timing, scale) of an investment to unforeseen conditions (Benaroch 2001). An example of an operating option is the option to delay an investment (deferral option). A firm can postpone an investment up to "t" time (e.g. years) and wait until further information reduces market uncertainty (Benaroch 2001; Brach 2003). Another operating option is the option to abandon a project. A manager has the opportunity to dispose an unprofitable project and redeploy remaining project resources (Brach 2003; Fichman et al. 2005). In addition, according to the stage option, a firm can break up an investment into incremental, conditional steps (Brach

2003). Only if previous stages have a favorable outcome, does a firm go further to the next stage. Otherwise the firm stops investing in the project. Other researchers (Whang 1992; Clemons & Weber 1990) have evaluated IT projects by taking into consideration other kinds of operating options such as the option of a company to "outsource" the development of the evaluated project or "lease" the resources for this development. In this way, the company can transfer the associated risk or avoid committing internal resources (Yeo & Qiu 2003). Another type of option which has been considered in the IS field (Herath & Herath 2008) is the "learning option". Investing in a project can be used to create an opportunity for a company to learn. For example, a firm can initiate a pilot IT project and based on the outcome of this first stage it can learn about the environmental variables (e.g. customer demand, investment cost) and react respectively (e.g. abandon or continue the investment in this project). Other types of operating options such as abandon or change the scale (expand or contract) of an IT investment have also been examined (Wu et al. 2008; Kumar 2002; Benaroch 2001; Benaroch 2002). Based on the pertinent literature, all the above options entail value, thus they should be taken into consideration during an IT investment evaluation. Exercising operating options, thus assessing IT projects as a process of continuous monitoring of the business and technical environment rather than as a now-or-never decision, can offer benefits and save costs for a company (Scarso 1996; Wu et al. 2008).

In this study we will focus on the behavioral implications of the following three types of options: growth, stage and deferral. These three types were chosen for two main reasons: First, the specific types are widely recognized and very well researched in the pertinent literature on IT investment evaluation through Real Options analysis, thus we have the opportunity to test theory and previous results. Second, these three types of options are revealed during the case study analysis of the three examined organisations which aimed at deploying RFID (Chapter 4).

Regarding the growth option, there are several studies which have shown that this option encompasses value for a firm. Dos Santos (1991) justified an initial investment in ISDN technology because it can lead to future second-stage investments. Taudes (1998; Taudes et al. 2000) justified the introduction of a software platform because it could open the door to other follow-on projects, such as e-commerce and electronic data interchange (EDI). Panayi and Trigeorgis (1998) assessed a Telecommunications IT infrastructure in Cyprus and concluded that options valuation can justify such strategic investments even if NPV suggests otherwise (Panayi & Trigeorgis 1998:675). In addition, studies on the behavioral implications of real options (Tiwana et al. 2006; Hult et al. 2010) have shown that growth options positively influence managers' views regarding the value of an assessed project. One of the main conclusions of the above studies is the fact that taking into consideration the growth option of an investment can reveal an additional value of this investment. Otherwise the IT justification can underestimate the value of an appraised IT project.

As far as the stage option is concerned, previous studies (Angelou & Economides 2005; Clemons & Gu 2003; Herath & Herath 2008; Hilhorst et al. 2008) have shown that dividing an investment into several stages can create value. This value derives from “providing an opportunity to alter or terminate a project before each new stage of funding, based on updated information about cost and benefits of this project” (Hilhorst et al. 2008). Previous studies (Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010) regarding managers’ views on the stage option have proposed that the option to stage an investment will have a positive impact on the project value.

For the deferral option, several studies (McGrath 1997; Benaroch & Kauffman 1999; Benaroch & Kauffman 2000; Campbell 2002) have assessed the value of the option to delay an IT investment and have shown that “waiting before investing” could yield to additional benefits. Such benefits could give the opportunity to a manager to acquire more information on the technology that is evaluated. While waiting, the uncertainty for this technology or its price might be decreased. When uncertainty is high, the deferral option can be very valuable (Fichman et al. 2005). Previous studies (Hult et al. 2010) on the impact of the deferral option on the perceived value of projects have shown that an option to wait is positively related to the project value under conditions of high uncertainty.

Based on the above, the following hypotheses for these three option types are formulated:

H1a: The growth option is positively related to the perceived value of returns of an IT project.

H1b: The stage option is positively related to the perceived value of returns of an IT project.

H1c: The deferral option is positively related to the perceived value of returns of an IT project.

6.2.2 **IT project typology**

Apart from testing the impact of Real Options on the perceived value of an IT project, the main aim of this study is to compare this relationship among different types of IT projects. The following paragraphs develop the respective hypotheses to examine this. The dimensions which differentiate the types of IT projects were based on the Literature on the IS Classification and the Case Studies analysis (Chapter 4). Cross-case findings revealed specific dimensions of an IT project that differentiate RFID implementations. Based on these dimensions specific hypotheses are formulated, as discussed below.

6.2.2.1 *The scope of an IT project (standalone or family application)*

Most of the empirical research on IT evaluation appraises individual IT applications, ignoring the existence of an extensive variety of IT applications and their opportunity to cooperate through the presence of “interdependency”. This effect results when specific sets of projects share a specific feature in common (Iniestra & Gutierrez 2009).

General Systems Theory (Von Bertalanffy 1969; Yourdon 1989) and the literature regarding the evaluation and the selection of IT and other kinds of projects (Iniestra & Gutierrez 2009; Lee & Kim 2000; Santhanam & Kyparisis 1996; Verma & Sinha 2002; Liesio et al. 2008) encompass the notion of interdependence between systems referring to the interaction that exists among them, as they rarely can work in isolation. According to the literature, the main types of interdependencies or synergies are the “resource or cost” ones, when IT or other kind of projects share the same resources and cost, the “benefit or value interdependencies”, when the total organizational benefits can be increased if related projects are implemented together, and the “technical” or “follow-on synergies”, when the development of a project requires the development of a related one. In other words, interdependent projects are interrelated projects which share common characteristics.

The exploitation of these synergies among IT projects is beneficial for an organization. By evaluating and selecting interdependent projects, valuable resources can be shared. Total resource expenditures (Santhanam & Kyparisis 1996) can be reduced and more benefits can be gained than those that would be derived if the IS projects were evaluated and implemented separately (Lee & Kim 2000). As a result, the investment evaluation of interdependent IT projects can be more adequately justified than if these projects are assessed in isolation. According to

Panayi & Trigeorgis (1998) *"investment projects can be considered as a 'bundle' of interrelated investment opportunities, the earlier of which are prerequisites for others to follow".*

The notion of interdependence in IT projects can yield to the creation of real options. For example, when an initial project shares the same resources with another, it can result in a follow-on project, thus in a growth option. One type of interdependent information technology projects which share resources are the IT platforms. According to Fichman (2004), an IT platform is a general-purpose technology that enables a family of applications and related business opportunities. Prior research (Q. Dai et al. 2007; Fichman 2004; Taudes et al. 2000) suggests that platform IT investments (e.g. ERP, wireless networking, infrastructure investments) are very good candidates for growth opportunities. Bardhan et al. (2004) underlines that "an IT infrastructure which by itself might not create value, might enable another project and completion of both may yield significant value". Thus, the synergetic effects among IT projects are one kind of technological resources for the generation of a growth option (Scarso 1996). In addition, Kim and Sanders (2002) propose that growth options appear when there are high interaction effects among IT investments. Thus, we hypothesize that, in family applications, growth options become more evident than in standalone applications. Therefore, we expect that the effect of growth options on the perceived value of returns will be higher in family than in standalone IT projects.

In addition, synergies among family IT projects can yield to a stage option. A firm can decompose one family application into smaller stages and IT applications and fund them incrementally. Previous research on Real Options for IT investments (Angelou & Economides 2008a; Pendharkar 2010) acknowledges the importance of synergies among several IT projects and relates them with the option to stage an IT investment. Investments in family applications are expected to be higher in cost in contrast to standalone applications. Therefore, it is expected that the option to stage a family application in order to minimize possible future costs is more valuable than in standalone applications. Thus, we expect that in family applications the option to stage an investment will have a higher impact on the value of the project than in standalone applications, where the option to stage is likely to be insignificant. Finally we have support for these expectations based on the findings of the case studies (Chapter 4-Section 4.6). In the case organisations which assessed RFID family applications, stage and growth options were recognised by the organisational members in contrast to the case where the organisation considered the examined RFID applications as standalone projects.

As far as the deferral option is concerned, it is expected that this option will have a more significant effect on the perceived value of a family IT project than in standalone IT applications. Based on the literature, large-scale projects in the supply chain have many uncertainties (Wickramatillake et al. 2007). Family IT applications which serve a variety of business processes can be considered as large-scale projects which result in high uncertainty. Based on the Real Options theory, when uncertainty increases the option value will follow the same route. It is expected that managers will find an IT project more valuable when they have the opportunity to postpone its investment to alleviate any current uncertainties. This value is likely to be strengthened in family IT applications than in standalone ones.

We use the term ‘scope’ to differentiate between standalone IT projects - which serve mainly one business activity - and family IT projects - which entail interdependent business processes and applications - and we formulate the following hypotheses:

H2: *The scope of an IT project (whether it is a family or standalone application) moderates the effect that real options have on the perceived value of returns of this project.*
H2a: For standalone applications the effect of real options on the value of returns will be lessened.
H2b: For family applications the effect of real options on the value of returns will be strengthened.

6.2.2.2 *The purpose of an IT project (strategic, informational or transactional)*

The literature (Turner & H. C. J. Lucas 1985; Weill 1992) proposes that according to the management objective and the purpose of an IT asset, IT investments can be classified into transactional, strategic and informational. Transactional IT investments are associated with the automation of firm repetitive transactions and processes in order to reduce cost (Weill 1992; Aral & Weill 2007). Informational IT investments provide information for management, decision support, planning, control and analysis, whereas strategic IT projects aim to create a competitive advantage for a firm and influence the growth aspects of firm performance, such as market share or sales growth and product innovation (Weill 1992; Aral & Weill 2007).

We hypothesize that the influence of real options on the IT project value will significantly vary among the above types of IT investments.

Strategic investments are expected to be related to the creation of real options. Pertinent literature (Clemons 1991; Bowman & Hurry 2010) suggests that strategic investments may not be important presently but should be considered as investments which create future opportunities and strategic options. Moreover, strategic projects, in contrast to transactional IT projects, entail a high level of uncertainty, as there are “unfamiliar risks and difficulties that executives confront” in relation to strategic IT investments (Eric K Clemons & Weber 1990). In this kind of projects, where environmental events unfold rapidly and create risks, flexible firm responses become very important (Clemons 1991). This flexibility can be applied with the exploitation of options in order to alleviate any kind of risks. On the other hand, due to the fact that transactional projects are related to routine IT processes and activities, they do not embed high uncertainty. The future of transactional IT investments, in respect to their technical, financial or organizational risks is not as uncertain as it is for strategic IT investments. As a result, when the future is certain there is no need to create options as a firm knows what to do later (McGrath et al. 2004). Thus, we expect that in strategic IT projects the value of real options will be significant and will have a greater impact on the perceived value of an IT project than in transactional IT projects. Specifically for the option to delay and its significance in strategic IT projects in contrast to transactional IT projects, we had evidence from cross-case study findings too (Chapter 4 -Section 4.6).

Drawing on the IS classification literature (Weill 1992; Aral & Weill 2007), except for the strategic and transactional IT projects, there is a third category of IT projects, the informational ones. Informational IT projects provide an organization with the information, technology and communications infrastructure to support activities such as management control, planning and analysis (Weill 1992). An informational project does not usually focus on the creation of current cash flows but on longer-term benefits. Thus, we anticipate that the impact of options on the value of an informational IT project will have the same significance as in strategic IT projects, in contrast to the transactional IT projects. Based on the above arguments, we formulate the hypotheses below:

H3: *The purpose of an IT project (whether it is transactional, informational or strategic) moderates the effect that real options have on the perceived value of returns of this project.*

H3a: For transactional IT projects the effect of real options on the value of returns will be lessened.
H3b: For informational IT projects the effect of real options on the value of returns will be strengthened.
H3c: For strategic IT projects the effect of real options on the value of returns will be strengthened.

6.2.2.3 *The span of an IT project (internal or supply chain application)*

Supply chain projects differ from those developed inside a firm as they include the "interconnection of organizations (e.g. material suppliers, producers, distributors and customers) which relate to each other through upstream and downstream linkages between the different processes that produce value in the form of products and services (Williamson et al. 2004; Humphreys et al. 2001; Slack et al. 2001)". For this study we utilize the term 'span' (Mejza & Wisner 2001) to differentiate between IT projects which are developed inside a firm (internal projects) and projects which are implemented in collaboration with a firm's supply chain partners (supply chain projects). More specifically, the 'span' of a firm's supply chain management refers to the level of integration of a firm with other organizations (e.g. suppliers, customers) (Mejza & Wisner 2001). An example of a supply chain IT project is the development of an information system to enable collaborative ordering between a buyer and its suppliers (Pramatari et al., 2009). In this case, the success of the project depends not only on internal firm efforts and investment but also on the involvement of its supply chain partners.

Previous work (Hult et al. 2010) suggests that the effect of real options on the value of a project differs between a supply chain and firm-level one. For example, while for internal projects the deferral option is not significant regarding its effect on the perceived value of a project, the study concluded that an option to defer is statistically significant and positively related to the perceived value of a supply chain project under conditions of high uncertainty (Hult et al. 2010). Drawing on this study, we hypothesize that the impact of real options varies between supply chain IT projects and internal IT projects and we suggest that options will be perceived as more significant in supply chain IT projects.

Supply chain projects entail high risks and uncertainties (Humphreys et al. 2001; Bensaou & Venkatraman 1996). Thus, the necessity of mitigating risks through flexible actions, such as the exploitation of real options, is vital for a firm. In supply chain projects several organizations are involved in contrast to individual firm projects. The aspect of collaboration among organizations creates a lot of uncertainties. Bensaou & Venkatraman (1996) suggest that the following three sources of uncertainties exist regarding inter-organizational coordination: (a) environmental uncertainty regarding the market conditions for this collaboration, (b) partnership uncertainty about firms' behavior, and (c) task uncertainty regarding the characteristics of the task accomplished by the collaborators jointly. Regarding IT-enabled supply chain projects, Pramatari et al. (2009) have further supported that a variety of technical, organizational and multi-party coordination challenges are encountered. These challenges create a lot of uncertainties regarding the successful implementation of supply chain initiatives. Thus, it is expected that these uncertainties will be a driver for the exploitation of the options, in contrast to internal IT projects, where uncertainties are expected to be lessened, so as the necessity for the options. Through the application of options, firms can alleviate this kind of risks. For example, two firms which collaborate can invest in an information system supporting only one supply chain process (e.g. order fulfillment) and then, if the initial stage is fruitful, invest further in systems supporting the rest of the supply chain processes (growth and stage option). On the other hand, a firm can postpone its involvement in a supply chain IT project until it earns further information on its supply chain partners' intention (option to defer). A previous study (Hult et al. 2010) gives support for the importance that managers ascribe to the option to delay an investment when this is a supply chain decision. According to this study and the supporting literature (Dixit & Pindyck 1994; Green 2004) uncertainty is more exogenous in supply chain environments than in firm decisions. Uncertainty is viewed as a factor that could decrease performance. For this reason, the option to delay an investment (in order to avoid any further losses) is likely to be more important for managers within a supply chain context than within the firm boundaries. For the option to delay and its value in internal projects compared to supply chain projects, we got evidence from Chapter 4 on the Case Studies analysis. In particular, in case study II a supply chain RFID project was assessed, whereas in the other two case studies, the examined RFID project was an internal one as it did not require for its execution the collaboration among the supply chain partners. In Case II managers expressed their willingness to delay investment in this supply chain RFID project in order to resolve uncertainty, whereas in the other two cases the option to delay the investment was not revealed. Under this perspective, we formulate the hypotheses below:

H4: *The span of an IT project (whether it is an internal or supply chain one) moderates the effect that real options have on the perceived value of returns of this project.*

H4a: For internal IT projects the effect of real options on the value of returns will be lessened.

H4b: For supply chain IT projects the effect of real options on the value of returns will be strengthened.

The figure below depicts the research model and the hypotheses developed in this study.

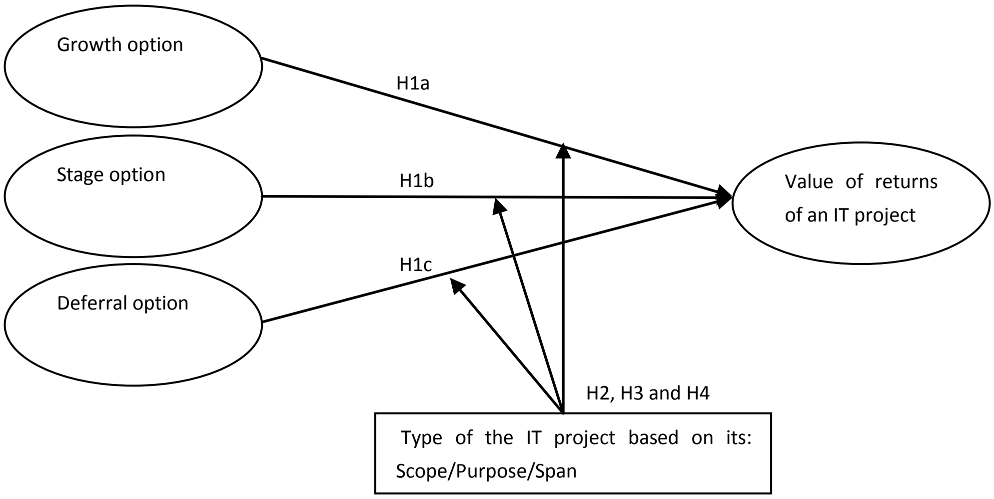


Figure 6.1 The proposed research model

6.3 **Research Method**

6.3.1 **Data collection process and study sample**

In order to test the developed hypotheses a European web-survey was distributed through email to representative companies in Europe which are familiar to the RFID technology. The survey was sent to the members of the "RFID in Europe" Network which includes more than 300 organisations which are involved in the specific technology. In order to increase response rate, the members were asked to distribute further the survey to any other organisation is interested in RFID and it is not a member of the particular network. We have received 121 answers from which 109 were able to be utilised. For this study the sample was the same with that for the study discussed in the previous chapter (Section 5.3.1). Thus we will briefly refer to the basic samples characteristics. In particular, from the 109 respondents the highest percent (73.6%) were managers (CEOS/ senior or middle management). 80.7% of the total participated organisations were highly familiar with RFID technology.

At the beginning of the questionnaire the respondents were asked to identify an RFID project which has either been implemented in their organization or is currently under consideration and use it as a reference when answering the rest of the questions. Out of the 109 respondents, 63.3 per cent (N=69) identified an RFID project they had already implemented in the organization. From those who had not yet implemented the selected RFID project, 62.5 per cent stated that they were currently considering its implementation and leaned towards investing in it, while 42.1 per cent of them considered implementing this project in less than a year's time. Thus, the great majority of respondents had in mind an actual and not a hypothetical RFID project.

More specifically, the participants were given a list of the following RFID applications to select from: (a) inbound/outbound logistics, (b) inventory audit/count, (c) asset tracking, (d) anti-theft control/security, (e) personnel management and (f) traceability. The respondents were asked to state whether they had already implemented (with a pilot or a roll-out deployment) or considered to implement each one of these specific RFID applications in the list. After this, the survey participants were asked to choose one of these RFID applications and have it in mind when answering the rest of the questionnaire. APPENDIX 2 includes the questionnaire.

6.3.2 **RFID typology**

RFID technology is utilized in this study as it is considered one of the most suitable contexts to test our hypotheses regarding the moderating effect of the different IT project types. RFID technology, due to its modularity and flexibility, can yield to several different types of investment projects according to different business needs. Thus, RFID implementations can take several different forms of investment projects. As it was shown in cross-case findings of Chapter 4 (Section 4.64.6) an RFID project can be utilized as an infrastructural project which supports several business applications or a stand-alone project which supports mainly one basic business process. In addition, RFID technology, depending on the way it is implemented, can be utilized for strategic, transactional or informational purposes. Moreover, there are RFID projects which necessitate the collaboration of several supply chain partners but also others that are developed internally in a firm, without the need for collaboration. One example of an internal RFID project is the utilization of the technology for access control. For instance, an employee's RFID tagged card is identified by a reading device which allows the access of the employee to a building. This application can be utilized solely by one company and requires investment by one business entity internally. On the other hand, an example of a supply chain RFID project is collaborative promotions management (Bardaki et al. 2012). In this case, supply chain partners need to collaborate, as the product supplier is the one to attach RFID tags on the products and the retailer is the one to exploit RFID technology in the store to offer enhanced promotion service to the consumers.

Moreover, the pertinent literature on RFID technology has acknowledged the importance of evaluating this technology through the real options lens. Curtin et al. (2007) argue that interesting opportunities for research on RFID emerge and that "researchers could test the notion that infrastructure technologies may not be the primary drivers of business value themselves but rather create real options for additional follow-on investments". For the above reasons, we employed the RFID context as an appropriate setting for the specific study.

6.3.3 Measures and measurement analysis

The three types of real options (growth, stage and defer) were measured with a 7-point Likert scale with agree-disagree statements. The dependent variable (value of returns) was measured on a 7-point scale with the endpoints: low and high. The items for the questions were based on previous studies on real options and IT, as presented in Table 6.1. Due to questionnaire size limitations and based on Diamantopoulos et al. (2012) guidelines for the circumstances under which this decision is justified, the option variables were measured based on a single-item scale rather than a multi-item scale. For a detailed reference to the measures and the respective scales proposed by the literature please see APPENDIX 2(b).

To measure the moderating effect of the IT project typology, the respondents were asked to select which of the following sentences best describe the RFID project they had in mind. The questions were three multiple choice questions. The first asked the respondents to select whether this project supports a family or a standalone application. The second question asked them to select whether the project they had chosen is an internal or a supply chain project and the last question asked them to select the purpose of the chosen RFID project (whether it is a strategic, informational or transactional project). For each answer an explanation/ definition of each specific type of IT project was given to the respondents. The questions related to the types of the projects are also depicted in the table below. There are also included in APPENDIX 2.

Table 6.1 Measures in the Study

Variables	Measures	Source
Growth option (GO)	This project is a necessary foundation for my organization to develop interrelated follow-on projects in the future.	(Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010; Panayi & Lenos Trigeorgis 1998)
Stage option (SO)	The implementation of this project can be completed in stages. Each stage of the implementation can result in a positive payoff, even if no further implementation stages are pursued.	(Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010)
Deferral option (DO)	Many uncertainties regarding this project implementation could be resolved if the investment in this project was postponed/ delayed.	(Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010)
Value of returns (VR)	The expected value of the potential returns/ payoffs for my organization as a result of this project deployment is:	(Fichman, 2004)
Standalone or family application	This project supports a family of applications and business processes based on the same platform (tags, readers etc.) This project supports a stand-alone application for a specific process.	(Angelou & Economides 2008b; Kim & Sanders 2002; Pendharkar 2010)
Transactional, strategic or informational application	The primary purpose of this project is: Strategic i.e. to provide a competitive advantage Transactional i.e. to capture and process data related to routine organizational transactions Informational i.e. to provide information for planning and decision-making	(Weill 1992; Aral & Weill 2007)
Internal or supply chain project	This project is implemented internally by the organization without the need to collaborate with other supply chain partners This project is s a supply chain project and requires collaboration with the organization's supply chain partners.	(Williamson et al. 2004; Humphreys et al. 2001; Slack et al. 2001).

6.3.4 **Common Method bias**

Specific steps have been conducted to remedy common method bias based on (a) the design of the study's procedures and (b) statistical controls based on the respective literature (Podsakoff et al. 2003). Regarding the design of the study, anonymity of the respondents to answer the questionnaire was established. Anonymity make respondents less likely to edit their responses to be more socially pleasing and consistent with the researcher's desirable way of answering (Podsakoff et al. 2003). A second tactic followed for this study is the fact that the scale items were previously tested in the pilot survey in Greece and any ambiguous terms or wording were modified in order to be clear, simple, specific and concise (Tourangeau et al. 2000). Other tactics based on the literature (Podsakoff et al. 2003; Tourangeau et al. 2000) which were followed by this study and decreased the possibility of common method bias is the fact that the questions were decomposed into more focused questions and the complicated syntax was avoided.

In addition, apart from the above tactics which concern the design of the research, statistical tests were conducted. In particular, we conducted Harman's single-factor test (P. M. Podsakoff et al. 2003). Based on this technique, we loaded all the variables in the study (which were utilised for further analysis) into an exploratory factor analysis and examined unrotated factor solution. As a result, we concluded that one single factor cannot account for the variance of all the constructs of this study. No single factor emerged from the factor analysis. This test supports the fact that common method bias is not a problem in this study.

6.3.5 **Data analysis**

To analyse the data, the SPSS version 19 was utilised to conduct multiple regressions. To test hypotheses H2, H3 and H4 we analyzed the effect of real options on the perceived IT value in the different types of IT projects using 7 different sub-models. For this purpose, we have specified 7 multiple regression models in which the perceived IT project value of returns is regressed to the three types of options. This method gave us the opportunity to examine the predictive power of real options on the perceived IT project value across 7 sub-groups (7 IT project types) and test if there is a significant difference. The following figures depict the respective models. The first two models test whether there is a significant difference of the effect of real options on the value of returns between standalone and family applications. The following two models examine whether this impact is significantly different among transactional, strategic or informational projects, whereas the last two models test the differences between internal and supply chain IT projects. For each multiple regression model we tested the descriptive statistics, the R^2, its significance through ANOVA and the standardized coefficients (beta) for each of the independent variables (the three types of options).

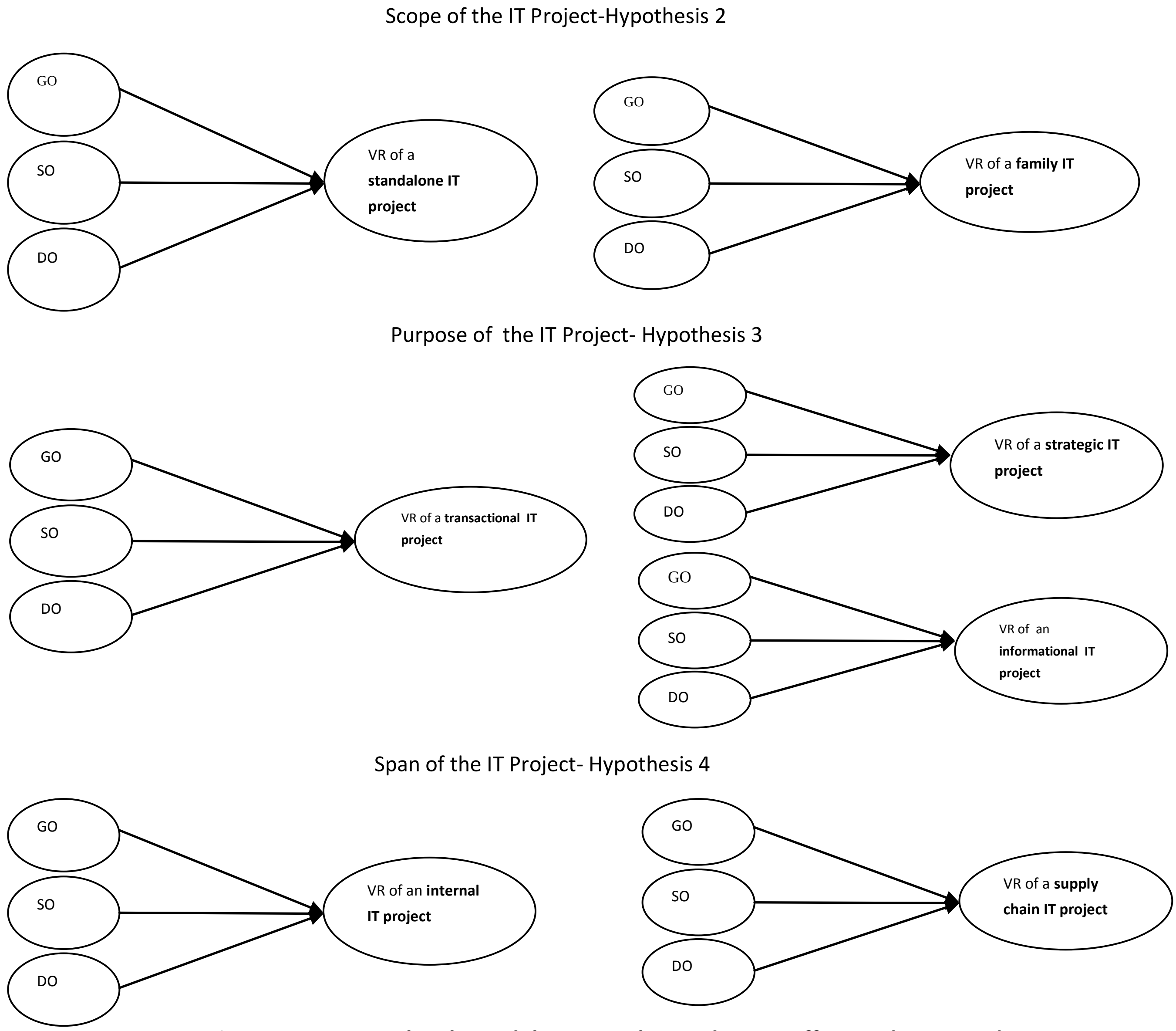


Figure 6.2 Research sub-models to test the moderator effect and H 2,3 and 4

(GO: Growth Option, SO: Stage Option, DO: Deferral option, VR: Value of Returns)

6.4 Results

6.4.1 Descriptive Statistics

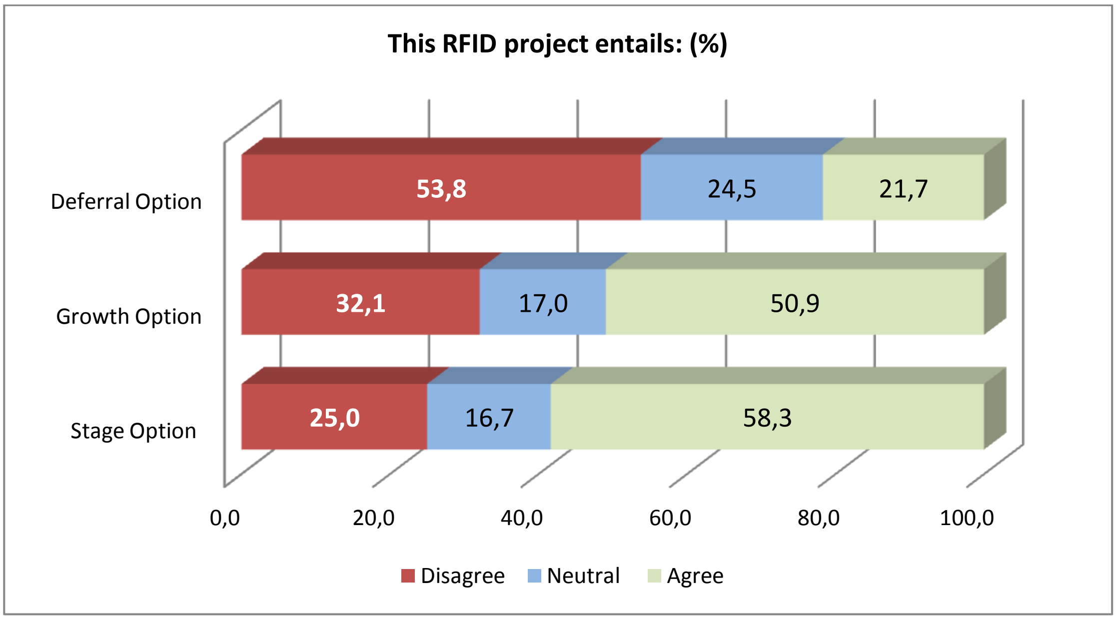


Figure 6.3 Perceived Real Options

The figure and the table show that the participants in the survey recognise in a high level that the assessed RFID project entails growth or stage options. The percentages of participants who agree that the RFID project will offer growth and stage options are 50.9% (mean: 4.38) and 58.3% (mean: 4.61) respectively. This result comes to reinforce previous research (Tiwana et al. 2006) which supports the fact that growth strategic options is the most important predictor of the willingness to continue investing in an IT project. An interesting result is the fact that the majority of the managers (53.8%) disagree that their assessed RFID project entails an option to delay its investment (defer option), while only the 21.7% of the respondents agrees and gives value to the deferral option (mean:3.32). This can be explained by the fact that managers may perceive a high competition regarding the implementation of the assessed RFID projects. Thus, deferring an investment would minimise the chance of a company to be the first mover in the implementation of the technology. An analytical explanation for the impact of the deferral options on the value of returns based on the data of this study and the pertinent literature will take place in the discussion of findings (Chapter 7).

Table 6.2 Descriptive statistics for the study's variables for the full sample

	Mean	Median	Variance	Std. Deviation	Skewness	z stat.test for skewness	Kurtosis	z stat.test for kurtosis
Growth option	4.39	5.00	3.363	1.83	-.278	-1.18	-1.013	-2.15
Stage option	4.61	5.00	3.156	1.78	-.451	-1.927	-.855	-1.823
Delay option	3.32	3.00	2.525	1.59	.342	1.46	-.750	-1.599
Value of returns	4.97	5.00	2.231	1.49	-.513	-2.19	-.080	-0.170

Based on the skewness results, we can conclude that the values of the delay option are gathered into the left (positive skewness), whereas for the rest of the variables their values are gathered into the right (negative skewness). That result depicts that the majority of the respondents have recognised the value of growth and stage option in contrast to the limited recognised value of the delay option. The skewness and kurtosis values of the indicators are within the -1 and +1 acceptable range (Hair et al. 2013, p.61). Only the growth option variable is equal to -1 which indicates that the distribution of the data is too flat. However, the value is close to -1. In order to validate the above results and assess the normality of the variables, the following statistic tests (rules of thumb) proposed by Hair et al. 2009 are calculated.

$$z\ skewness = \frac{Skewness}{\sqrt{\frac{6}{n}}}$$

$$z\ kurtosis = \frac{kurtosis}{\sqrt{\frac{24}{n}}}$$

Where, n is the sample size. If either calculated Z value exceeds the specified critical value (±2.58 for 0.01 significance level and the ±1.96 value for 0.05 error level) then the distribution is non normal. In our case, the z values do not exceed the above value (±2.58), thus they are normally distributed.

The following figure shows a pre-scanning of the relationship among the three types of real option and the value of returns, based on separate regressions.

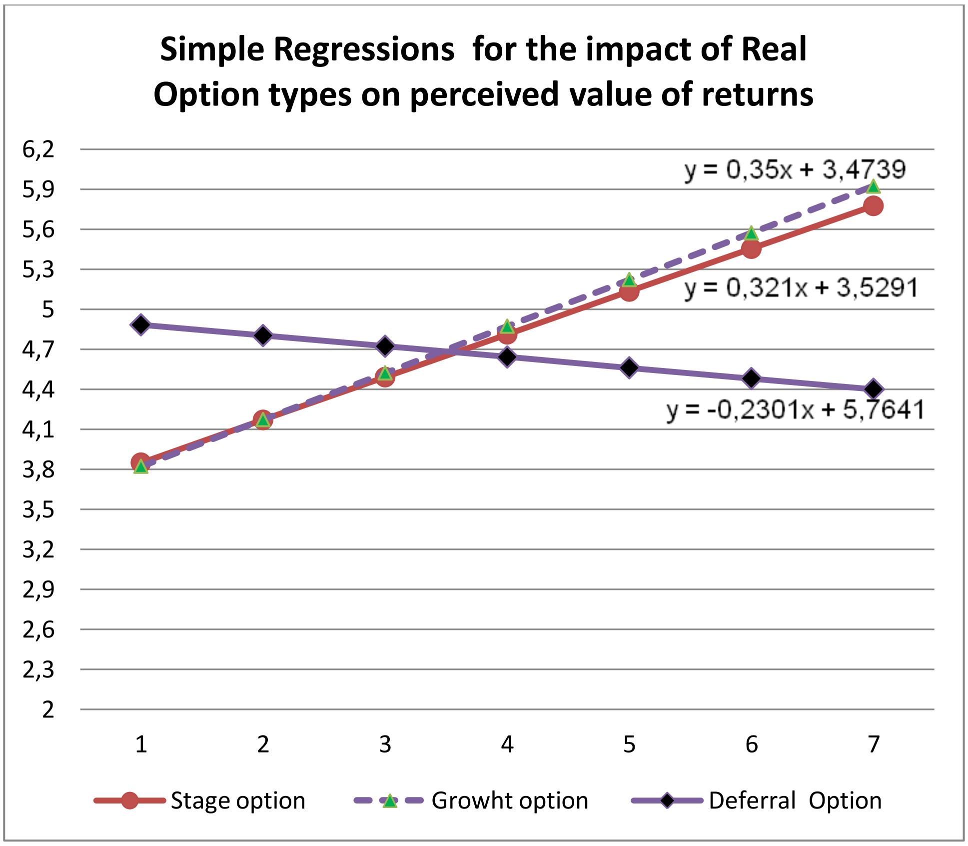


Figure 6.4 Simple Regressions of the impact of each one separate Real Option type on the perceived value of returns

In addition, the following two figures and the descriptive tests show a pre-scanning of the results based on the hypotheses. For example the following table depicts that there are differences regarding the value that managers ascribe to the options between family and standalone applications. In particular, managers perceive growth and stage options as higher in family applications than in standalone ones. At the same time, the respondents recognise that standalone applications entail higher deferral options than family applications (Figures 6.2 and 6.3). Under the same perspective, the respondents perceive growth and stage options as higher in strategic technology projects than in transactional. In addition, they recognise that deferral option is higher in transactional projects than in projects with a strategic aim (Figures 6.4 and 6.5). Finally, figures 6.6 and 6.7 illustrate that there are not significant differences between supply chain and internal applications regarding managers' perceptions for real options. An analytical justification of these results and a comparison with the respective literature will follow in the next sections (7.2.3-7.2.4) of the results and the discussion of the hypotheses.

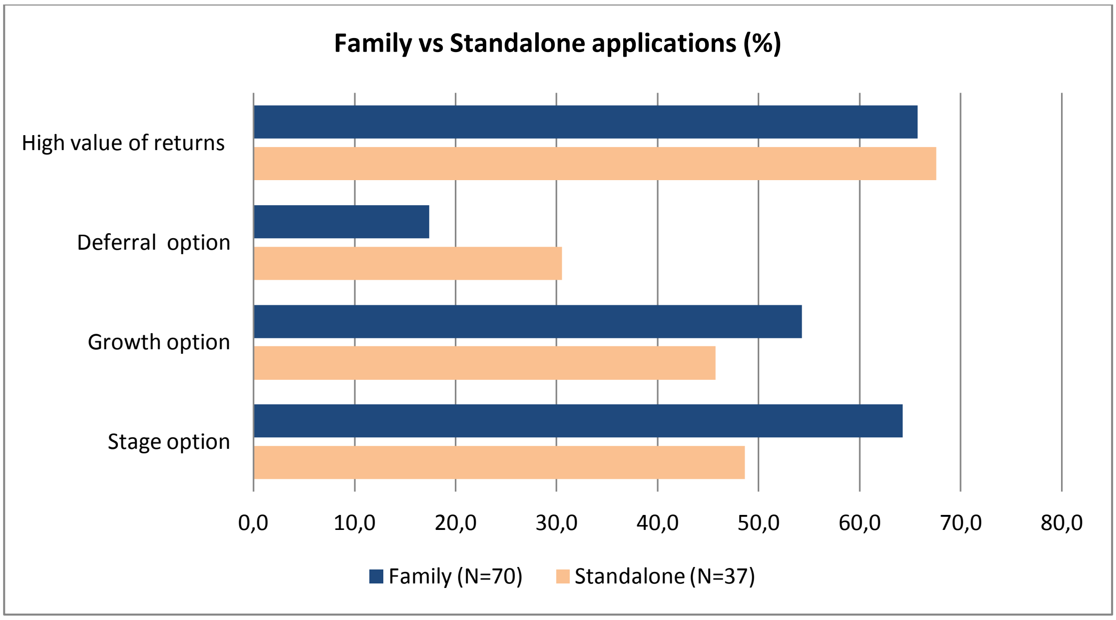


Figure 6.5 The perceived Real Options as High in Family Vs Standalone IT projects

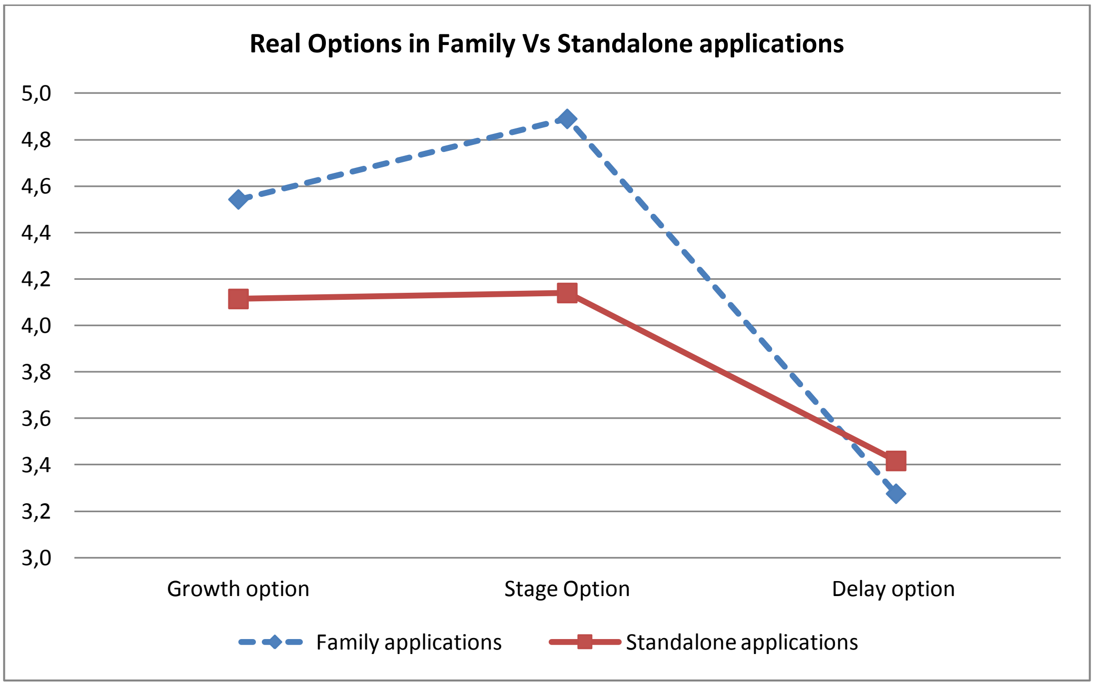


Figure 6.6 Real Option means in family and standalone applications

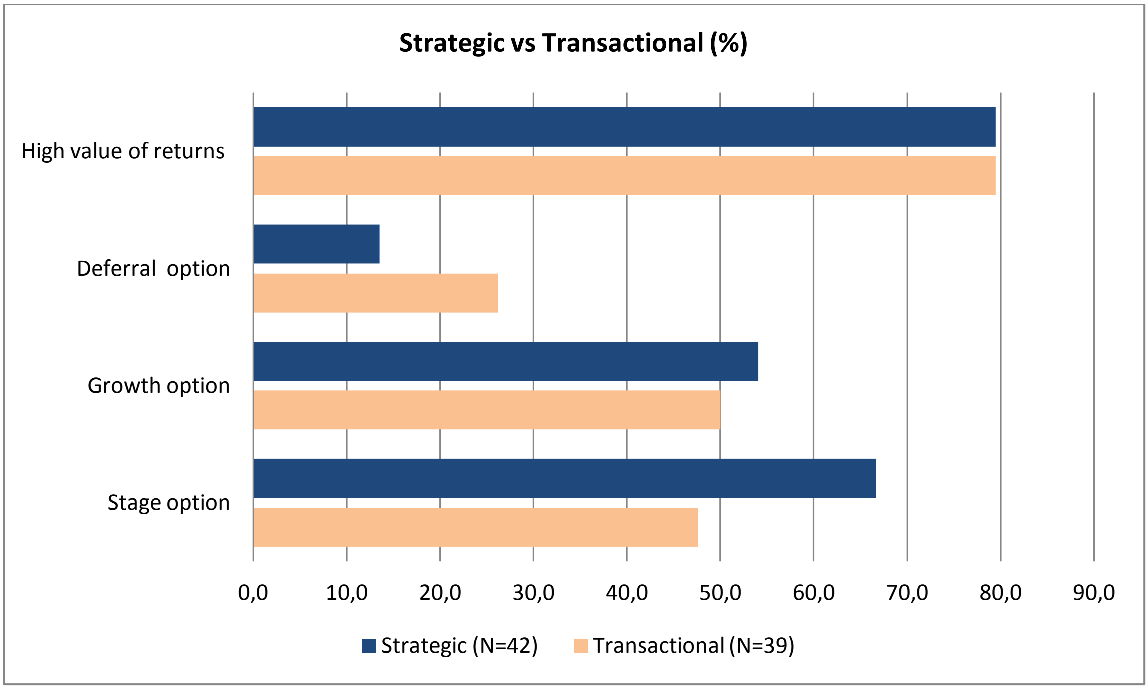


Figure 6.7 The perceived Real Options as High in strategic Vs Transactional technology projects

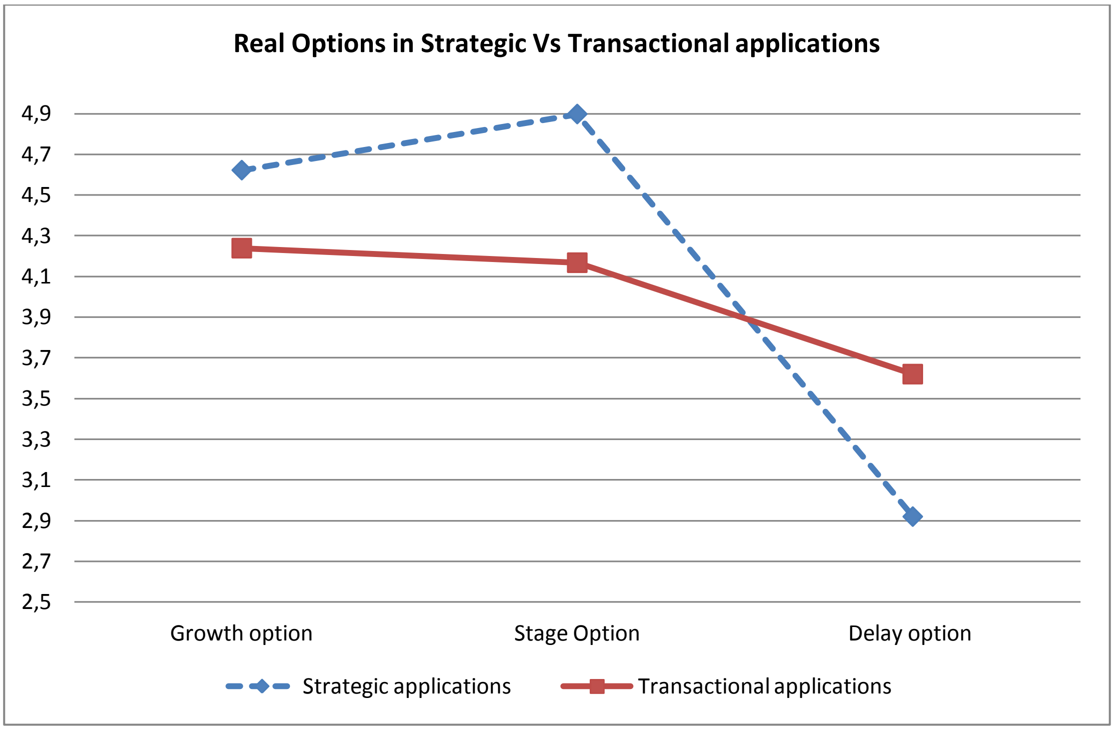


Figure 6.8 Real Option means in strategic and transactional applications

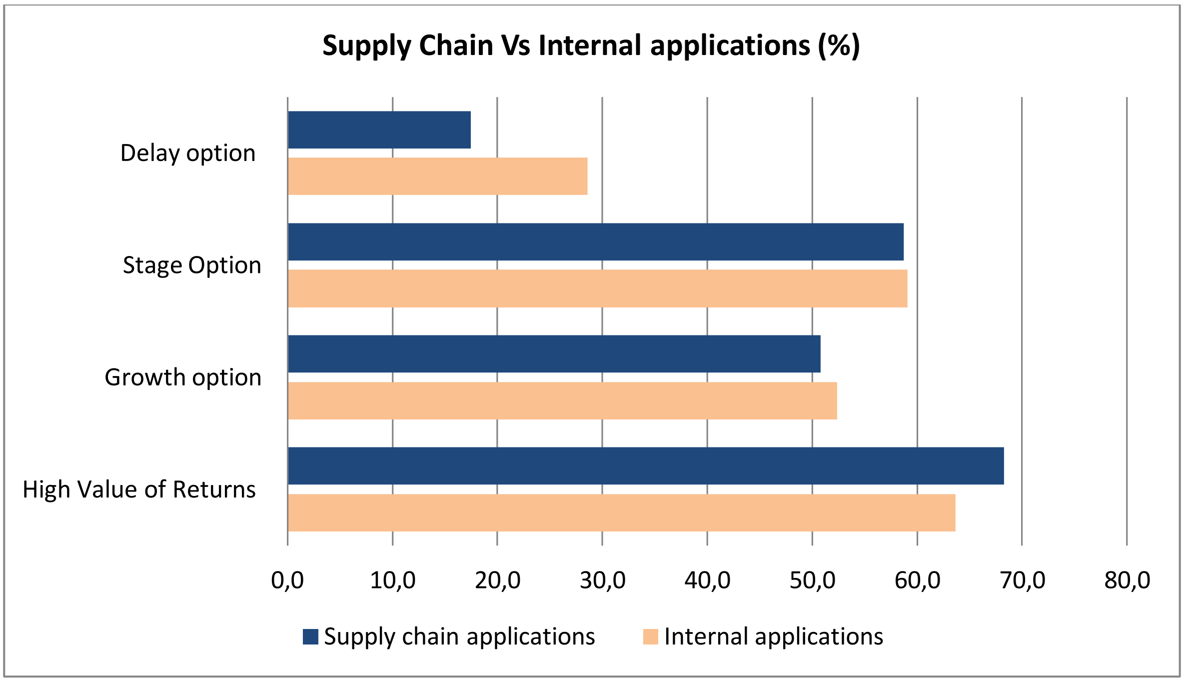


Figure 6.9 The Real Options perceived as high in the Supply Chain Vs Internal applications

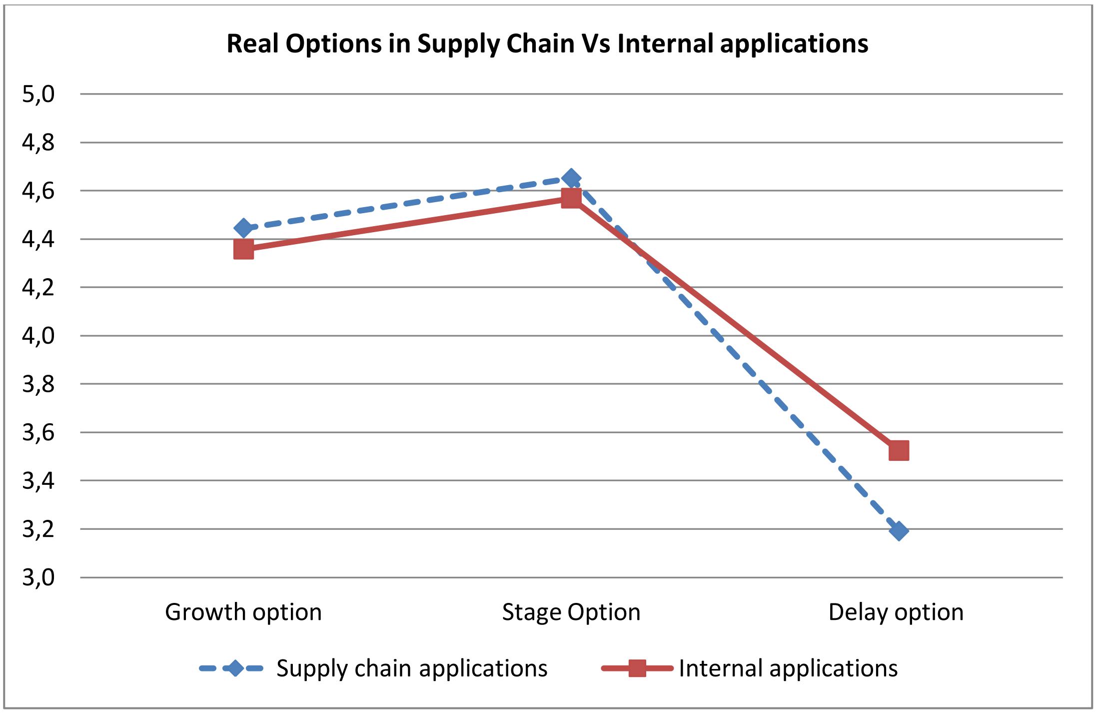
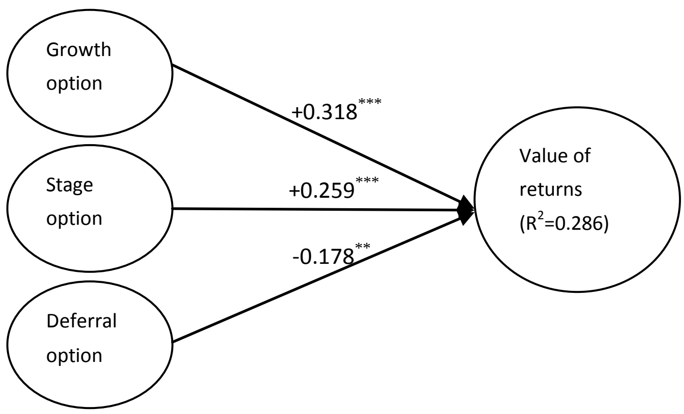


Figure 6.10 Real Option means in Supply Chain Vs Internal applications

6.4.2 Hypothesis 1- The impact of options on the perceived value of an IT project

Running the respective multiple regressions, results indicate that the three types of real options significantly influence the perceived value of returns of the IT projects. The model explains 28.6 percent of the variance in value of returns of the assessed IT projects. The model reaches statistical significance (Sig.=0.000). Thus, hypothesis H1 is confirmed. Evaluating the contribution of each one of the option types, the standardized coefficients and the respective significance are utilized.

The growth option is strongly positively related to the IT project value. As a result, hypothesis H1a is accepted. In particular, the growth option makes the strongest positive contribution to explaining the IT project value (b= 0.318, p= 0.001). In addition, results indicate that the perceived value of returns of an IT project is increased significantly with the presence of the option to implement this project in stages (stage option) (Hypothesis H1b accepted). The stage option has a significant unique contribution to the prediction of the dependent variable (b=0.259, p=0.005). A surprising result, which cannot support hypothesis H1c, is the fact that, although the option to delay (deferral option) has a significant effect on the perceived value of returns, its effect is negative (b= -0.178, p=0.039).



**= p<0.05, ***=p<0.01

Figure 6.11 Standardized multiple regression results of the RO on the value of returns (H1)- Full sample

The counterintuitive result of a variable may be an outcome of the multicollinearity among the independent variables (Thiesse et al. 2011). In our case, the delay option has a negative effect on the perceived value of returns. For this reason we wanted to test whether this counterintuitive effect is a result of high correlations among the three types of options. We have conducted the collinearity statistics tests (Variance Inflation Factor-VIF and tolerance). Results show that VIF statistics are far below the cut-off point of 5, whereas tolerance results are far above the cut off level of 0,20 (Joseph F. Hair et al. 2013). As a result, the negative impact of the delay option is not an attributed to multicollinearity issues.

Table 6.3 Standard Regression coefficients, Collinearity statistics and model significance

Coefficients[a]

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1 (Constant)	3.389	.512		6.618	.000		
Growth option	.259	.074	.318	3.482	.001	.849	1.178
Stage option	.218	.076	.259	2.861	.005	.862	1.161
Delay option	-.167	.080	-.178	-2.093	.039	.975	1.025

a. Dependent Variable: Value of returns

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66.437	3	22.146	13.510	**.000[a]**
	Residual	165.557	101	1.639		
	Total	231.995	104			

a. Predictors: (Constant), Delay option, Stage option, Growth option

b. Dependent Variable: Value of returns

Note: The assumptions for the multiple regression are tested and they are not violated. In particular multicollinearity does not exist in our model, as the independent variables (real options types) are not correlated based on the Tolerance and VIF levels which are inside the acceptable range, as it is shown above. In addition, *linearity* is fulfilled as the residuals have a straight-line relationship with the predicted dependent *variable scores based on the Normal P-P Plot of Regression Standardized Residual extracted by the SPSS output (Pallant 2005).*

In addition, we wanted to test whether the counterintuitive result of the delay option might be attributed to the lack of control for competition in the regression. For this reason, we have run the regression model and evaluated its ability after controlling for the level of competition in the industry as it is assessed by the respondents. To address this issue, we utilised hierarchical multiple regression, where we entered our variables (competition variable) and the real option types in steps in a predetermined order.

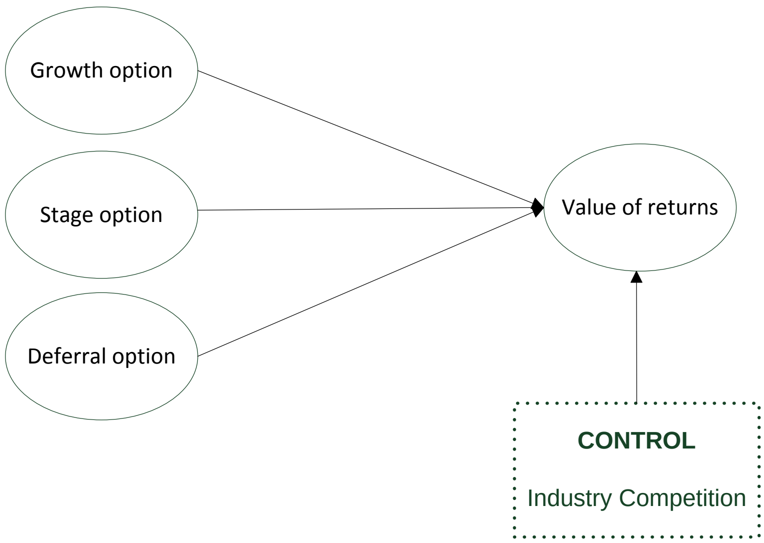


Figure 6.12 The research model with the control of competition

The results of the hierarchical regression are depicted below. In the first step of the regression we entered the variable "competition". This variable is measured with a seven point Likert scale under the item: "The competition in my organisation's industry is high". In the second step of the regression the real option types as independent variables are entered into the regression. Regression results below show that the level of competition has not got a significant effect on the perceived value of returns (β=0.042, p= 0,622). On the other hand, real option types still have a significant effect. Results show also that when we control for the competition variable, the option to delay still has got a counterintuitive significant impact on the perceived value of returns (β=0.178, p=0.040).

To validate the results, we wanted to test whether the level of competition moderates the relationship between the delay option and the value of returns. For this reason, we have run the regression model for two groups (one with high competition levels and the other with low ones). To do that, we have transformed the continuous variable "competition" into two categories (low/high). For the first category of data, where competition in the industry is perceived as low, the impact of the option to postpone investments (option to delay) on the perceived value of returns is positive. On the contrary, when the regression model is run for the second group of data (when the competition in the industry is perceived as high), the impact of the delay option on the value of returns is negative. However, in both groups the is not significant. The above result can be explained by the fact that the companies which perceive a higher degree of competition in their industry have the 'fear of 'pre-emption' (i.e. the possibility that a competitor may gain an advantage by investing first in a project before the other companies) (Tsekrekos 2003), thus the value of delaying an investment diminishes. On the contrary, participants who deal with low levels of competition, they do not encounter such a fear, thus they can more easily postpone their investments.

However, the counterintuitive result of the full sample may be explained by other additional variables which may affect the impact of the delay option. For example, respondents may perceive that delaying an investment would create a loss of some investment gains (Angelou & Economides 2008a). Another explanation would be that deferring investments would not give the opportunity to respondents to gain a direct experience with this technology (Fichman et al. 2005). The detailed explanation and discussion of this result takes place in chapter 7 (section 7.2.2).

Table 6.4 Hierarchical Regression results controlling for competition

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.041[a]	.002	-.008	1.49952	.002	.174	1	103	.677
2	.537[b]	.288	.260	1.28512	.286	13.412	3	100	.000

a. Predictors: (Constant). Industry competition. b. Predictors: (Constant). Industry competition. Delay option. Stage option. Growth option. c. Dependent Variable: Value of returns

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.392	1	.392	.174	.677[a]
	Residual	231.602	103	2.249		
	Total	231.995	104			
2	Regression	66.842	4	16.710	10.118	.000[b]
	Residual	165.153	100	1.652		
	Total	231.995	104			

a. Predictors: (Constant). Industry competition. b. Predictors: (Constant). Industry competition. Delay option. Stage option. Growth option. c. Dependent Variable: Value of returns

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	4.794	.452		10.613	.000					
	Industry competition	.036	.087	.041	.418	.677	.041	.041	.041	1.000	1.000
2	(Constant)	3.209	.630		5.090	.000					
	Industry competition	.037	.074	.042	.495	.622	.041	.049	.042	.999	1.001
	Growth option	.259	.075	.318	3.478	.001	.441	.328	.293	.849	1.178
	Stage option	.217	.076	.258	2.840	.005	.393	.273	.240	.861	1.161
	Delay option	-.167	.080	-.178	-2.085	.040	-.250	-.204	-.176	.975	1.025

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.041[a]	.002	-.008	1.49952	.002	.174	1	103	.677
2	.537[b]	.288	.260	1.28512	.286	13.412	3	100	.000

a. Dependent Variable: Value of returns

6.4.3 Hypothesis 2- Real Options and the moderating effect of the IT project scope (standalone or family application)

Through hypothesis H2, the moderating effect of the scope of the IT project (whether it is a standalone or family application) is tested by statistically comparing the standardized coefficients of the options on the project value and their significance between the two groups. The effect of the stage option on the value of a family IT project is strong and significant (β=0.234 and p=0.045), whereas this impact is not significant in standalone applications. The option to delay has a stronger impact (β= -0.242 and p=0.029) on the perceived value of returns of the IT project in family applications than in standalone projects where the effect is insignificant. Thus, the results indicate that the scope of the IT project moderates the effect of real options on the IT project value. For the stage and the deferral option, hypotheses H2, H2a and H2b are accepted.

However, hypothesis H2a in respect to the growth option cannot be confirmed, as managers associate significantly the option to grow an IT project with its value not only in family applications but also in standalone applications. In both groups the option to grow has a significant effect on the perceived IT project value of returns (β=0.417, p=0.012 and β=0.265, p=0.024 standalone and family applications respectively), meaning that the scope of the IT project does not moderate the impact of the growth option on the perceived value of the project.

6.4.4 Hypothesis 3- Real Options and the moderating effect of the IT project purpose (transactional, strategic and informational)

Results on Hypothesis H3 indicate that the effect of real options on the perceived value of an assessed IT project varies significantly depending on the purpose of the IT project (transactional, strategic and informational). Thus, hypothesis H3 is accepted. Hypotheses H3a and H3c which state that the impact of options on the project value is strengthened in the strategic and lessened in the transactional projects are confirmed for the two types of options (growth and stage). In strategic IT projects the effect of the growth and stage option on the IT project value of returns is significant (β= 0.292, p=0.048 for the growth option and β=0.456 , p=0.003 for the stage option respectively). On the other hand, the perceived value of transactional IT projects is not significantly influenced by the presence of growth and stage options. In this case, the impact of options on their value is insignificant.

Hypothesis H3b, which states that the impact of options on the value of the assessed project is strengthened in informational IT projects in contrast to transactional IT projects, is supported for the growth option. In particular, the impact of the growth option is significant in informational IT projects (β=0.397, p= 0.045). However, a surprising result is the fact that the option of a manager to stage an IT investment does not significantly affect the perceived value of an informational IT project as it happens with the strategic IT investments. Thus, hypothesis H3b for the stage option and its significance in the informational IT projects cannot be confirmed.

Regarding the deferral option, hypothesis 3a which concerns the transactional IT projects is accepted. As it was assumed, due to the low cost, risk and small scale of a transactional IT project, the option to defer its deployment and postpone its investment in a future time in order to alleviate any current uncertainties is not significant. However, an unanticipated finding is that there is no significant relationship between the presence of a deferral option and the value of a strategic or an informational IT project. The perceived value of a strategic or an informational IT project is not influenced by the opportunity managers may have to postpone an investment.

Comparing the significance of the overall three sub-models for the three types of IT projects, it is concluded that a higher percentage of the project value variance is explained by the presence of options in the strategic and the informational IT projects (R^2=0.45 and R^2=0.31 respectively), in contrast to the lower level of variance of the project value which is explained by the options in the transactional IT projects (R^2=0.20).

6.4.5 **Hypothesis 4- Real Options and the moderating effect of the IT project span (internal or supply chain)**

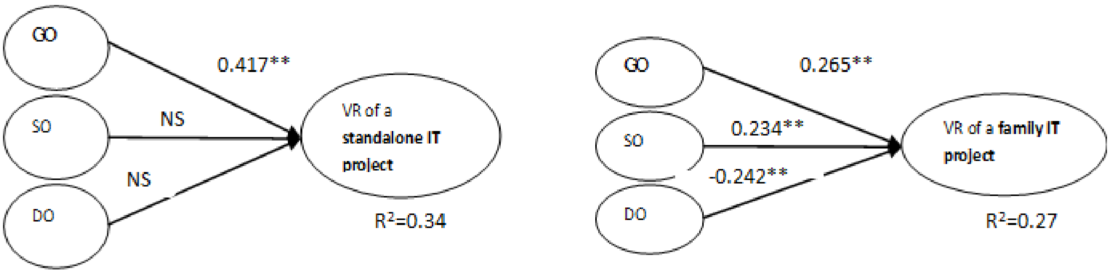
Hypothesis H4 tested the effect of real options on the perceived value of returns depending on whether the IT project is developed internally in a firm or in collaboration with its supply chain partners. The analysis reveals that the three options have a strong and significant impact on the IT project value only when the assessed project is a supply chain one. Thus hypotheses H4, H4a and H4b are fully accepted. In particular, the effect of the option to grow on the perceived project value is strengthened when the IT investment is a supply chain project (β=0.355, p=0.005), whereas in internal projects this effect is insignificant. In addition, the option to stage an IT investment has a strong and significant impact on the project value when the project is a supply chain one (β=0.284, p=0.020), whereas when it is developed internally this impact is insignificant. Moreover, when an IT project is developed internally in a firm the option to delay this investment is insignificant, compared to the supply chain projects, where the option to delay has a strong impact on the perceived project value (β=-0.237, p=0.024). In addition, in the model examining the supply chain projects, the variance of the project value is highly predicted and explained by the presence of options, resulting in an R^2 =0.42 and in a model significance of p=0.000. On the contrary, in the model examining the internal IT projects, the impact of options on the project value is insignificant (R^2= 0.089, p=0.319). Overall, the results of the moderating effect of the IT project scope, purpose and span are depicted below.

Table 6.5 Standardized multiple regression results of the RO on the IT project value of returns (H2,H3 and H4)

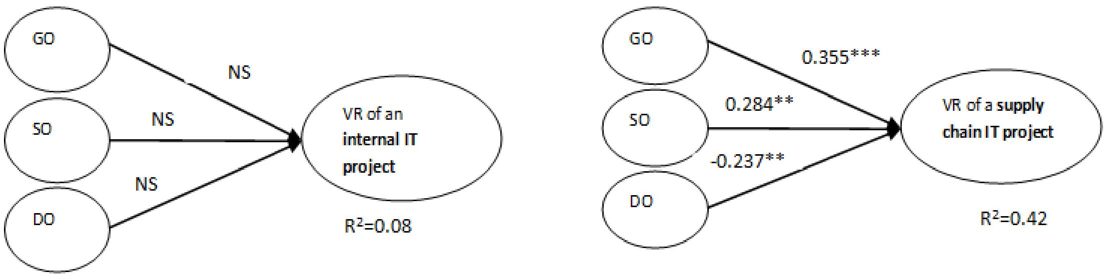
	IT projects						
	Scope of the IT project (H2)		Purpose of the IT project (H3)			Span of the IT project (H4)	
Type of option	Stand alone application (N=37)	Family application (N=70)	Transactional (N=42)	Informational (N=26)	Strategic (N=39)	Internal (N=44)	Supply chain (N=63)
Growth	0.417** (0.012)	0.265**(0.024)	NS	0.397**(0.045)	0.292**(0.048)	NS	0.355***(0.005)
Stage	NS	0.234**(0.045)	NS	NS	0.456***(0.003)	NS	0.284**(0.020)
Deferral	NS	-0.242**(0.029)	NS	NS	NS	NS	-0.237**(0.024)
Model-R^2 (p value)	*0.34(0.004)*	*0.27(0.000)*	*0.20(0.033)*	*0.31(0.039)*	*0.45(0.000)*	*0.08(0.319)*	*0.42(0.000)*

**= p<0.05, ***=p<0.01, NS: non-significant

IT Project Scope- Hypothesis 2



IT Project Purpose- Hypothesis 3



IT Project Span- Hypothesis 4

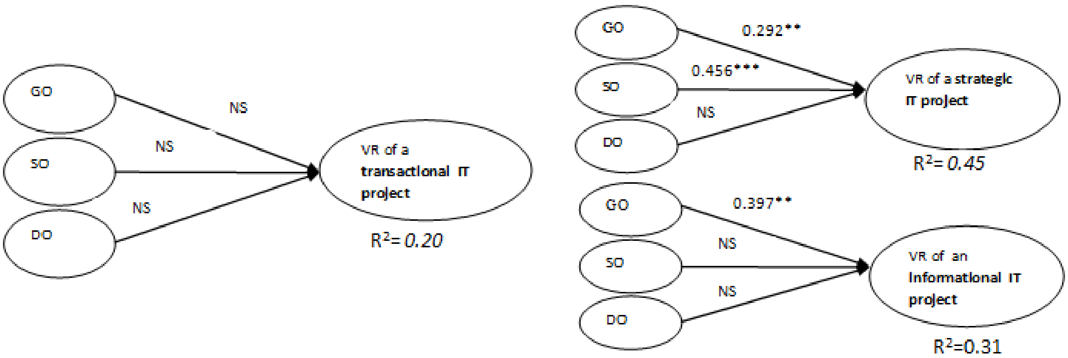


Figure 6.13 Standardised multiple regression results of the real options on the value of returns of an IT project (hypotheses 2,3 and 4)

**= p<0.05, ***=p<0.01, NS: non-significant

Overall, the above results from the hypotheses testing are depicted below.

Table 6.6 Hypotheses results

Respective Hypothesis	Hypotheses	Hypothesis Testing Results	Finding
H1, H1a, H1b, H1c	*H1: Real Options influence the perceived value of returns of an IT project.* *H1a: The growth option is positively related to the perceived value of returns of an IT project.* *H1b: The stage option is positively related to the perceived value of returns of an IT project.* *H1c: The deferral option is positively related to the perceived value of returns of an IT project.*	H1, H1a, H1b all supported. H1c not confirmed	The three types of options have a significant effect on the perceived IT project value of returns. Growth and stage option have a positive effect, whereas the option to defer has a negative effect.
H2	*The scope of an IT project (whether it is a family or standalone application) moderates the effect that real options have on the perceived value of returns of this project.*	Supported	The scope of the IT project moderates the impact of the options on the perceived IT project value of returns (VR).
H2a	*For standalone applications the effect of real options on the value of returns will be lessened.*	Supported for stage and deferral option, not supported for growth option	For standalone IT applications the growth option has a significant effect on the VR. The effect of the other two options is insignificant.
H2b	*For family applications the effect of real options on the value of returns will be strengthened.*	Supported	For family IT applications the growth, stage and deferral options have a significant effect on the VR.
H3	*The purpose of an IT project (whether it is transactional, informational or strategic) moderates the effect that real options have on the perceived value of returns of this project.*	Supported	The purpose of the IT project moderates the impact of the options on the perceived IT project value of returns (VR).
H3a	*For transactional IT projects the effect of real options on the value of returns will be lessened.*	Supported	For transactional IT applications the three types of options have no significant effect on VR.
H3b	*For informational IT projects the effect of real options on the value of returns will be strengthened.*	Supported for growth, not supported for stage and deferral option	For informational IT applications the growth option has a significant effect on the VR, whereas the stage and deferral options have an insignificant effect.
H3c	*For strategic IT projects the effect of real options on the value of returns will be strengthened.*	Supported for growth and stage option, not supported for deferral option	For strategic IT applications the growth and stage options have a significant effect on the VR, whereas the effect of the deferral option is insignificant.
H4	*The span of an IT project (whether it is internal or supply chain) moderates the effect that real options have on the perceived value of returns of this project.*	Supported	The span of the IT project moderates the impact of the options on the perceived IT project value of returns (VR).
H4a	*For internal IT projects the effect of real options on the value of returns will be lessened.*	Supported	For internal IT applications the three types of options have no significant effect on VR.
H4b	*For supply chain IT projects the effect of real options on the value of returns will be strengthened.*	Supported	For supply chain IT applications the growth, stage and deferral options have a significant effect on the VR.

6.5 Further Statistical Analysis

6.5.1 Multi-Group analysis

The previous results confirm that the IT project type moderates the power of the real option recognition regarding its effect on managerial decision making. However, to test the significance of the moderating power of the IT project types on the relation between the option recognition and the assessed value of returns an analysis is undertaken below. For this aim, Multi-Group Analysis is conducted and the path coefficients for each sub-sample are compared through a t-test. A comparison of regression parameters across the different types of IT projects might support an interaction between real options and IT project type. We have followed the Multi-group analysis (MGA) methodology and the steps for the moderating effect proposed by Chin (2000). The specific methodology is proposed when the moderator is a categorical variable as it is in our study (i.e. IT project type).

We have ran the multiple regressions (both in SPSS and Smart PLS for validation) for each one IT project type group and have utilised the standardised path coefficients and the respective standard errors for each sub-group. Next, we embedded the above values into the t-test statistical formula to test the significance of the difference of the path coefficients. A t-test validated with a modified t-test and in particular Smith-Satterthwaite test are calculated based on Chin (2000). The formulas for the t-tests are depicted below. The formulas (1) and (2) are based on previous works on multigroup analysis (Jörg Henseler 2011). Utilising both formulas[4], the results are approximately the same and depicted in the table below.

$$t = \frac{\theta^{(1)} - \theta^{(2)}}{\sqrt{\frac{(n^{(1)}-1)^2}{n^{(1)}+n^{(2)}-2} \cdot se^2_{\theta^{(1)}} + \frac{(n^{(2)}-1)^2}{n^{(1)}+n^{(2)}-2} \cdot se^2_{\theta^{(2)}}} \cdot \sqrt{\frac{1}{n^{(1)}} + \frac{1}{n^{(2)}}}} \qquad (1)$$

$$t = \frac{\theta^{(1)} - \theta^{(2)}}{\sqrt{\frac{n^{(1)}-1}{n^{(1)}} \cdot se^2_{\theta^{(1)}} + \frac{n^{(2)}-1}{n^{(2)}} \cdot se^2_{\theta^{(2)}}}} \qquad (2)$$

Where:

- *ϑ:the path coefficients for group 1 and group 2,*
- *n:the sample size for each one group 1 and 2 and*
- *se: standard error for each one path coefficient*

[4] Formula (1) follows a t-distribution with $n^{(1)} + n^{(2)} - 2$ degrees of freedom, whereas formula (2) is utilised when the two variances $n^{(1)} \cdot se^2_{\theta(1)}$ and $n^{(2)} \cdot se^2_{\theta(2)}$ are assumed different.

Additional tests other than the above parametric test (i.e. permutation test and Henseler's (2011) non -parametric test) are not estimated as according to previous studies in terms of significant differences, the latter approaches closely resemble the parametric test's results (Sarstedt & Ringle 2011).

As it is depicted in the table below, the moderating effect of the IT project types is highly significant in the case of stage option recognition between strategic and transactional IT projects and between informational and transactional IT projects. In addition, the difference of the importance of growth option recognition is significant between supply and internal IT project. From the above, the highest significant difference of the path coefficient across the IT project types is in the case of the stage option impact between strategic and transactional IT projects.

Table 6.7 Multi Group Analysis Results

Options	Supply chain	Internal	t-statistic	Significance
GROWTH	,355***	,157	**1,289**	P<0.10 in one tailed test
STAGE	,284**	,200	0,538	ns
DEFER	-,237**	-,105	0,82	ns
	Family	Standalone	t-statistic	
GROWTH	,265**	,417**	0,997	ns
STAGE	,234**	,268	0,209	ns
DEFER	-,242**	-,102	0,842	ns
	Strategic	Transactional	t-statistic	
GROWTH	,292**	,322	0,176	ns
STAGE	,456***	,008	**2,669**	P<0.001
DEFER	-,148	-,257	0,622	ns
	Informational	Transactional	t-statistic	
GROWTH	,397**	,322	0,363	ns
STAGE	,297	,008	**1,335**	p<0.10 in one tailed test
DEFER	-,010	-,257	1,16	ns

As a result, the difference of the real options impact across different types of IT projects is strong in specific cases. For the rest of the cases, there is evidence that IT project type moderates the impact of real options. However, the data is not adequate to support the significance of this moderating effect. According to (Bagozzi & Yi 2011), in the cases where no significant interaction effect is found then we cannot rule out the possibility that this was due to a failure to take into consideration enough information. On the contrary, when significant differences are found across groups, one might conclude that there is some merit for claiming an interaction effect (Bagozzi & Yi 2011). Hence, this leaves the room for future research to conduct similar studies or experiments to clarify this issue and offer further evidence.

6.5.2 Two-Way ANOVA

To test whether the influence of Real Options on the perceived value of returns depends on the type of an IT project, a two-way ANOVA is conducted in the SPSS software. For the analysis we have 1 continuous variable (value of returns), 1 categorical independent variable (the type of the IT project) and 1 continuous independent variable (Growth /Stage/Deferral Option). Because of the fact that the analysis of variance requires that the independent variables are categorical and not continuous we have recoded the variables of Real Options into categorical ones, with low, medium and high levels.

The following analysis is one indicative case of the ANOVA analyses that have been conducted. It tests whether the influence of Growth Option recognition on the perceived value of returns depends on whether the IT project is implemented internally in the organisation or as a supply chain project with the collaboration of the organisation's partners. The Levene's test (0.140 > 0.05) suggests that the homogeneity of variances assumption is not violated. In addition, based on the table with the tests of Between-Subjects Effects, the interaction of the type of the IT project (internal Vs Supply Chain) with the Growth Option level (Low/Medium/High) is significant (p=0,09< 0,10). This means that there is a significant difference on the effect of Growth Option recognition on value of returns between internal and supply chain projects. In other words, the "span" of an IT project moderates significantly the relationship between Growth Options and Value of Returns. The Post-Hoc comparisons using the Tukey Honestly Significant Difference Test, indicates that the mean score of value of returns for the group of respondents who don't recognise growth options (Low Score with Mean:4.15 and SD:1.52) is significantly different from the other two groups [medium (mean: 5.16 and SD:0.92) and high recognition of growth options (mean:5.50, SD: 1.34)].

Table 6.8 Two-way ANOVA results

Descriptive Statistics

Dependent Variable: Value of returns

Growth option categorical	Scope of RFID project	Mean	Std. Deviation	N
Low	Internal project	4,6364	1,62928	11
	Supply chain project	3,9091	1,44450	22
	Total	4,1515	1,52318	33
Medium	Internal project	5,2222	,97183	9
	Supply chain project	5,1111	,92796	9
	Total	5,1667	,92355	18
High	Internal project	5,1364	1,16682	22
	Supply chain project	5,7500	1,41421	32
	Total	5,5000	1,34234	54
Total	Internal project	5,0238	1,25888	42
	Supply chain project	5,0159	1,59123	63
	Total	5,0190	1,46091	105

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Value of returns

F	df1	df2	Sig.
1,705	5	99	,140

Tests the null hypothesis that the error variance of the dependent variable is equal across groups. a. Design: Intercept + Growth option categorical + Scope of RFID project + Growth option categorical * Scope of RFID project

Tests of Between-Subjects Effects

Dependent Variable: Value of returns

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	46,563[a]	5	9,313	5,256	,000	,210
Intercept	2035,341	1	2035,341	1148,802	,000	,921
Growth option categorical	26,028	2	13,014	7,345	,001	,129
Scope of RFID project	,116	1	,116	,065	,799	,001
Growth option categorical * Scope of RFID project	8,655	2	4,327	2,442	**,092**	,047
Error	175,399	99	1,772			
Total	2867,000	105				
Corrected Total	221,962	104				

a. R Squared = ,210 (Adjusted R Squared = ,170)

Multiple Comparisons

Value of returns

Tukey HSD

(I) Growth option categorical	(J) Growth option categorical	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	**Medium**	**-1,0152***	**,39002**	**,029**	-1,9432	-,0871
	High	**-1,3485***	**,29410**	**,000**	-2,0483	-,6487
Medium	**Low**	**1,0152***	**,39002**	**,029**	,0871	1,9432
	High	-,3333	,36227	,629	-1,1953	,5287
High	**Low**	**1,3485***	**,29410**	**,000**	,6487	2,0483
	Medium	,3333	,36227	,629	-,5287	1,1953

Based on observed means. The error term is Mean Square(Error) = 1,772.

*. The mean difference is significant at the ,05 level.

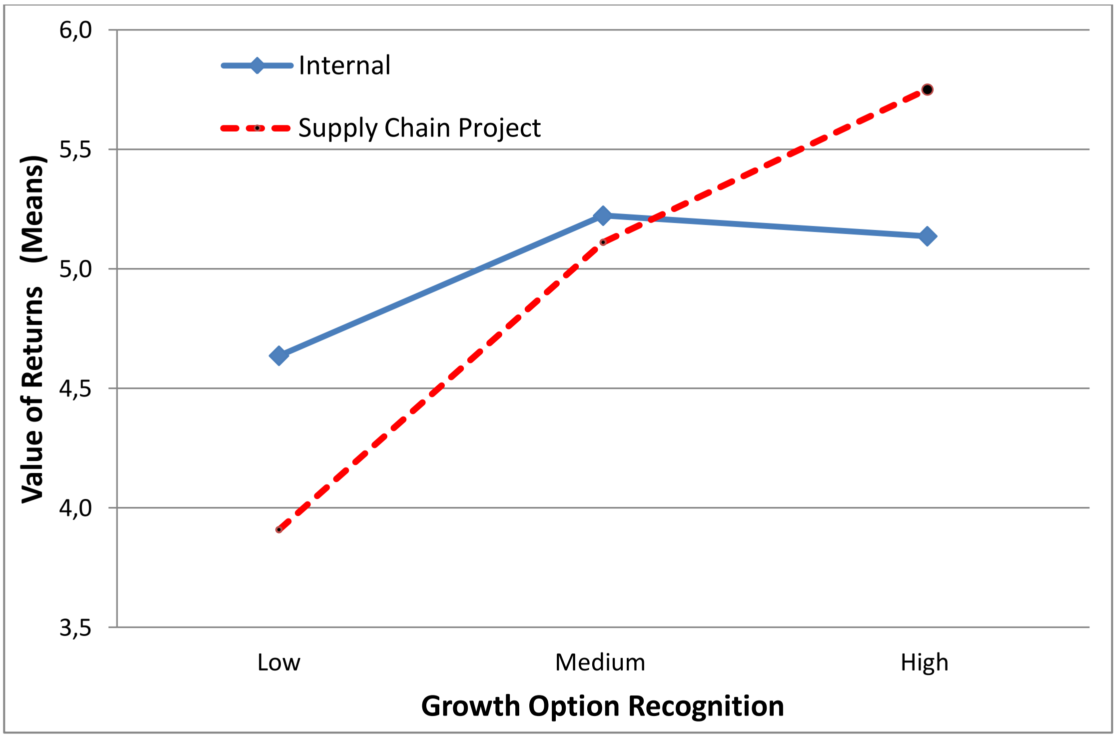


Figure 6.14 Interaction Plot (Moderating effect of IT project span)

6.6 **Summary of Findings**

While literature on information technology (IT) investment evaluation through Real Option analysis has acknowledged that different types of IT projects might encompass diverse real option value, the majority of the research treats IT projects as a homogeneous group. Little research has been conducted to empirically test and compare different project types and examine whether their option value varies. Pertinent empirical study which is focused on the types of Information Technology projects and the investigation of whether they encompass a varied real option value has not been conducted to our knowledge. This study attempts to fulfill this gap. Its aim is to:

- Examine the impact of three types of options (growth, stage and deferral) on the perceived value of returns
- Investigate whether the impact of three types of options (growth, stage and deferral) on the perceived IT project value is moderated by the type of IT project.
- Develop and empirically test a model which examines the above in a real context, that of RFID technology projects.

Using data collected from companies within the "RFID in Europe Network" results indicate that:

- Growth and stage options have a positive significant impact on the perceived value of returns of information technology projects, whereas the option to delay has significant but negative effect on the value of returns.
- The scope of an IT project (whether it is a family or standalone application) moderates the effect that real options have on the perceived value of returns derived from this project. This impact is strengthened for family IT applications and lessened for standalone applications (except for the impact of growth options which is strong in both types of projects)
- The span of an IT project (whether it is internal or supply chain IT project) moderates the effect that real options have on the perceived value of returns of this project. The effect of real options for supply chain IT projects is strengthened, whereas it is lessened for internal IT projects.

The purpose of an IT project (whether it is a strategic or transactional) moderates the impact of real options on the perceived value of returns of this project. The impact of growth and stage option is strengthened for strategic information technology projects, whereas for transactional information technology projects is lessened. However, the deferral option has insignificant impact in both types of projects.

7 DISCUSSION OF FINDINGS & CONLCUSIONS

7.1 Introduction

The aim of this Chapter is to discuss the results presented in the previous chapters (4, 5 and 6). The first section 7.2 includes the main findings of the thesis and the respective reflections based on previous research. In the next sections 7.3 & 7.4, the theoretical and the practical contribution of the thesis are presented. The Chapter ends with the limitations of the doctoral thesis and proposed directions for future research (Section 7.5).

7.2 Key Findings and Discussion -Meeting the objective and the aim of the study

This section has the aim to show how this doctoral research has met the objective and the aim of the study. This section includes the discussion of the main findings of the thesis based on the developed and refined research questions. It has the aim to show how the stated research questions were addressed and how they are related to the thesis findings. Previous studies which support or contradict the thesis' findings are also discussed.

Overall, this thesis has examined the impact of Real Options on managerial behavior regarding the investment evaluation of innovative information technology projects. The objective of the thesis was to answer:

- ***How do real options influence the value of an IT project?***
- ***How does the use of real options in IT capital budgeting affect the behavior and decisions of managers?***

In order to answer this general research objective, this thesis had the aim to investigate the following research questions:

1. *What are the <u>determinants</u> which influence the <u>real option</u> recognition in an information technology project?*
2. *What is the <u>impact of real options</u> on the <u>perceived value of returns</u> of an information technology project?*
3. *Is this impact strengthened or mitigated across <u>different types of IT projects</u>?*

In order to make research more specific the above questions were investigated under the RFID case. As it was justified across the thesis (Section 2.4, Section 5.3.2 & Section 6.3.2) this technology has the attributes which make it applicable and suitable for the aim of this thesis. In the following paragraphs, the key findings are presented and discussed based on each one of these three questions.

7.2.1 RQ 1: What are the determinants which influence the real option recognition in an information technology project?

To address this research question the thesis investigated the following sub-questions.

- ***What is the impact of the technology strategy on the recognition of a growth option?***

Results show that the technology strategy is the most significant and important source which can trigger the recognition of a growth option embedded in an IT project. Data support that when an assessed IT project is expected to generate fundamental organisational changes and a competitive and sustainable advantage, then the perceived growth option of this IT project is increased. This result comes in accordance with the theory (McGrath 1997) which supports that sustainability of a competitive advantage increases the option value. When an IT project offers strategic and sustainable benefits for a firm through radical changes, it provides the organisation with knowledge and know-how for something new (Moosmayer & Koehn 2011). Based on the literature (Scarso 1996), this gained knowledge is a trigger point for managers to recognise and exploit growth options coming from the technology. The more an organisation becomes the leader and the knowledge expert the more it wants to keep this position and invest further in follow-on related IT projects.

This is an important finding in the case of RFID technology. According to Attaran and Hardgrave et al. (Attaran 2007; Hardgrave et al. 2007) there are three types of RFID adoption: (a) RFID is viewed rather as a necessity than a business value technology, (b) RFID is adopted for "data understating" in order for the organisation to be able to increase traceability and visibility of its business assets and (c) RFID is viewed as an enabler of drastically changed or entirely new processes. The third type of RFID adoption comes in accordance with the "technology strategy" variable which is examined in this study and entails the strategic importance of RFID. As it is supported from this study, this type of RFID adoption can be a significant resource for the recognition and exploitation of growth options. Data support that considering an initial RFID investment as a strategic tool can increase the ability of an organisation to recognise and identify any possible growth opportunities, in contrast to those who do not see any strategic value of RFID technology.

- ***What is the impact of the <u>organisational learning and innovative capabilities</u> on the recognition of a growth option?***

Results of this study indicate a second significant source of growth option which is: organisation learning and innovative capabilities. This result is supported by the theory (Cohen & Levinthal 1990; Zahra & George 2002; Scarso 1996; Fichman 2004) according to which the learning skills, the know-how and the ability of an organisation to assimilate and exploit knowledge are possible sources of growth options. In addition, results of this study confirm the theory (Fichman 2004) which acknowledges firm innovative capabilities as a foundation of growth options coming from initial IT investments. Levinthal and March (Levinthal & March 1993) quotation explains and underpins this result: *"The return from any particular innovation, technology, or reform is partly a function of an organization's experience with the new idea. Even successful innovations, when introduced, are likely to perform poorly until experience has been accumulated in using them."*

This result has an essential impact in the case of RFID which can act as a platform investment which can offer growth opportunities and a series of follow-on investments. Because of the nature of RFID which is an innovative and flexible technology, organisational learning capabilities become an essential prerequisite for future investments. Managers, who are able to learn from initial investments in RFID and innovate further, will be able to identify any possible opportunities to utilise and exploit this knowledge and know-how in future RFID applications.

- ***What is the impact of the <u>technology bandwagon</u> on the recognition of a growth option?***

Based on the pertinent literature (Katz & Shapiro 1985; Katz & Shapiro 1986; Strader et al. 2007; Asvanund et al. 2004) it was expected that the effect of the technology bandwagon (which includes the positive network externalities and the expected network dominance of the technology) on the recognition of growth options would be significant. A surprising result is that this effect is negative and not significant.

This result could be explained by the fact that when the adoption network increases, the number of competitors increases too. According to Scarso (Scarso 1996), the presence of network externalities may stimulate a more or less rapid commitment. "In the case of positive network externalities (which is the case in this study), where adoption benefits increase with the number of previous adopters it may be convenient to wait (Scarso 1996)". Thus the growth option may not be the case. For RFID technology, managers may believe that it is better under positive network externalities to delay rather than expanding their adoption. According to Li & Johnson (2002), strong competition will restrict managerial flexibility if the investment opportunity is shared. In the case of positive network externalities, as the adoption network increases, RFID technology becomes a shared investment between competitors. As a result, the flexibility of an organisation to recognise and exploit growth option diminishes too.

- ***What is the impact of the <u>technology adaptation</u> on the recognition of a growth option?***

Another surprising result is that "technology adaptation" (i.e. the capability of the technology to be divided in different implementation stages and its flexibility to permit multiple interpretations by adopters) has an insignificant impact on growth option recognition. This outcome may be a result of whether or not the participants of the survey have already invested in the technology. It is anticipated that this impact will be moderated by the status of adoption. To test the difference among these two groups, the full sample has been divided into two groups and the research model is tested under structural equation modeling for Adopters and Non-adopters separately. An interesting finding is that for adopters, the technology adaptation factor is significant (β=0.185, t=2.130), whereas for non-adopters the technology adaptation factor is insignificant (β=0.080, t=0.664).

This can be explained by the fact that managers who have already invested in the technology have the experience and the know-how to understand that an incremental rather than a full-scale implementation gives the opportunity to managers to test the technology and if only the first stage is successful move to the next one. In addition, adopters can understand the importance of a technology to be flexible and offer many optional interpretations to its adopters, thus opportunities for customisation to the business needs and ultimately result in higher returns. On the contrary, managers who have not yet implemented this technology are not able to acknowledge the importance of these parameters. Organisations who have not yet implemented the technology have not got the experience to assess its adoption and appreciate any possible features which can be key for a successful outcome.

- ***Does growth option recognition <u>mediate</u> the impact of the above factors on the perceived value of returns of an IT project?***

Results show that growth option recognition partially mediates the effect of the technology strategy, organisational capabilities, technology bandwagon and technology adaptation on the value of returns. The majority of prior studies on IT innovation adoption focus on the direct impact of these factors on the perceived value of IT and its ultimate adoption. This study has shown that this impact can be explained by the recognition of real options and more specifically growth options. As a result, this study supports the fact that the recognition of growth options yielded from IT projects can generate value from specific organisational and technological capabilities. In other words, for firms which do not recognise growth options in an IT project it is difficult to derive any benefits from these organisational and technological factors that they encompass. As a conclusion, the recognition of growth options can help us to understand the mechanism under which specific organisational and technological capabilities can influence managers' perceptions regarding the value of returns of an IT innovation and ultimately its adoption.

The mediating role of growth options has been supported by previous studies too, but for different parameters. In particular Saya et al. (2010) have shown that growth options mediate the impact of several technological characteristics of cloud computing (e.g. perceived accessibility, scalability, cost effectiveness) on the intention to adopt cloud computing. Another study (Goswami et al. 2008) shows that growth option recognition mediates the impact of institutional influences on the intention to adopt RFID technology.

7.2.2 **RQ 2: What is the impact of real options on the perceived value of returns of an information technology project?**

In order to be able to investigate the specific research question, the types of real options which were going to be explored had to be identified. For this reason the case studies conducted revealed specific types of real options which were recognised and acknowledged by the three organisations. Thus, the first type of sub-questions which was explored was the following as it was stated in Section 4.2.1, under the chapter with the case studies analysis.

- ***What types of real options occur during the investment evaluation process of an IT innovative project such as RFID?***

The cross-case findings (Section 4.6) revealed that RFID investment evaluation process embedded several types of real options. In particular, growth and stage opportunities were recognised and acknowledged by the members of the organisations. Based on specific source of evidence (e.g. workshops, focus groups) initial investments in RFID were considered by the organisational members as investments in an initial infrastructure which would later lead to future investments. In addition, supply chain executives expressed their willingness to implement pilot RFID applications which reveals their attitude towards staging and breaking-up RFID investment into stages. Although, an option pricing model is not exploited in the case studies, the NPV model which was created revealed that the above types of real options alter the ultimate monetary value of the assessed RFID applications if they are considered. In particular, when the growth and the stage opportunity of the RFID applications were considered, then the NPV amount was increased due to the exploitation of the cost and benefit synergies among the initial and the follow-on related RFID applications.

In addition, the case studies revealed the opportunity to scale RFID applications into additional warehouses/stores, which altered the overall monetary value of the investment based on the NPV calculations. Finally in one of the case studies, the opportunity that an organisation has to delay RFID investments had occurred. The interviewed supply chain executives in the specific organisation expressed their reluctance to invest in RFID on at least a 3 year time horizon. They stated that this opportunity to delay investments was triggered by the current high cost of investment, the uncertainty and immaturity of the RFID technology.

As it was stated in the thesis, the focus of the research is on the three above types of real options, excluding the scale option for further empirical analysis. The scale option was also evident but it was excluded from the confirmatory phase of the thesis in order to minimise the complexity of the examined sub-models and the ultimate interpretation of the results. See section 4.7 for a more detailed justification of this exclusion.

Based on the above types of real options the second research question was refined into the following ones. The aim was to investigate how do managers evaluate these three types of real options embedded in assessed RFID projects.

- ***What is the impact of the recognition of growth options on the perceived value of returns of an information technology innovative project?***

Results (Chapters 5&6) indicate that recognition of growth options is a significant factor which affects perceived value of an assessed IT project and ultimately its adoption. In particular, results support in accordance with previous research (Dos Santos 1991; Taudes 1998; Taudes et al. 2000; Panayi & Lenos Trigeorgis 1998; Tiwana et al. 2006) that when an IT project is considered by decision makers as a necessary foundation for an organisation to develop interrelated follow-on projects in the future, its perceived value of returns increases. The growth option not only is strongly positively related to the IT project value but also it makes the strongest positive contribution to explaining the IT project value (compared to the other two examined types of options). This result complements previous studies (Tiwana et al. 2006; Hult et al. 2010) in the field. It is explained in Tiwana's study (Tiwana et al. 2006) that managers give more value to growth opportunities, because such options may entail value of more than one further assets, rather than changing the value of a single asset, as it happens with the other types of options.

The affected value of returns is examined also in this study regarding its predictive power on the status of adoption. In particular, data show that when the perceived value of returns and the embedded option value of an assessed IT project increases for a manager, the possibility that this manager will be an already adopter of the technology increases too. While pertinent literature (Goswami et al. 2008; Goswami et al. 2010; Tiwana et al. 2006) has shown that the recognition of growth options is positively associated with the intention to adopt or the escalate commitment; this study is focused on the "actual" adoption. Results show that the higher the recognition of growth options and the respective value of returns, the higher the likelihood that managers should have been already adopted the assessed technology.

- ***What is the impact of the recognition of stage options on the perceived value of returns of an information technology innovative project?***

In addition, results indicate that the perceived value of returns of an IT project is increased significantly with the presence of the option to implement this project in stages (stage option). The stage option has a significant unique contribution to the prediction of the dependent variable. This result comes to contradict previous studies (Tiwana et al. 2007; Hult et al. 2010; Goswami et al. 2008) which found that stage option is not perceived by decision makers as significantly valuable. The contradicting finding in our study can be explained by the fact that the respondents of the survey had to evaluate innovative technology projects (RFID projects) which can be considered in general as costly applications with high uncertainty and time consuming implementations. Breaking up such an IT investment into conditional steps creates value by giving management the possibility to change the time, scale or the configuration of follow-on investments (Nalin Kulatilaka et al. 1999). If the first stage of an IT investment has a positive outcome, managers can go further to the second step, whereas if the first stage is unfavorable they can stop investing further. Thus, the possibility of staging and incrementally investing in such projects, in order to minimize the risk of big losses, is positively evaluated by the respondents leading to higher project value.

- ***What is the impact the recognition of <u>deferral options</u> on the perceived value of returns of an information technology innovative project?***

A surprising result is the fact that although the option to delay (deferral option) has a significant effect on the perceived value of returns, its effect is negative. This result is inconsistent with previous studies (Hult et al. 2010) which find a positive relationship between the option to delay and the perceived value of an IT project, under conditions of high uncertainty. There are three possible explanations for this result. First, the deferral option may have a negative impact on the perceived value of returns of an IT project, because of the *"option cost of delay"* which is supported by a previous study (Angelou & Economides 2009). According to this factor, when a firm defers an investment it loses some investment benefits (Angelou & Economides 2009). The authors argue that postponing an investment may be costly due to expected revenue losses, which would not have been occurred if the firm had invested in the IT project (Angelou & Economides 2008a). A second interpretation is that deferring an investment has a negative impact on the perceived IT project value because of the competition threat. *"It is not advisable to delay an investment because the firm doesn't earn early cash flows and loses competitive advantage owing to competitor moves* (Jan 2011). Delaying an investment takes away from a manager the opportunity to act as a first mover and gain a competitive advantage. Previous empirical work (Lankton & Luft 2008) suggests that the presence of a competitor will decrease the value of a deferral option. A third explanation of this result is the fact that a firm, when deferring an IT investment, might lose the opportunity to gain direct experience with this technology (Fichman et al. 2005).

These three reasons may have led the respondents to perceive the deferral option as a factor which significantly decreases the perceived value of returns.

7.2.3 RQ 3: Is this impact strengthened or mitigated across different types of IT projects?

This thesis empirically supports that Real Options are perceived by managers as significant in specific IT project types. Drawing on Real Options theory and IS classification, the study empirically compares different IT settings and examines their respective embedded option value based on managers' views. Results demonstrate that the IT project scope, purpose and span moderate the effect that the presence of Real Options has on the IT project value. The following paragraphs explain in detail the key findings.

- **What <u>different types of RFID deployment</u> occur? What <u>dimensions</u> differentiate RFID deployment?**

The examined by this thesis IT project types occurred based on the literature on IS classification and the three case studies that were conducted for the RFID investment evaluation (Chapter 4). These types were utilised to examine whether they include a differentiated real option value.

Case studies revealed that the examined RFID applications were different based on specific dimensions. First, RFID applications were considered as standalone applications in one of the three organisations whereas, in the other two they were considered as family applications which support a series of business processes which share cost and benefits and result in a chain of inter-related applications. To classify these RFID deployments the term 'scope' was utilised. Second, the examined RFID applications were different based on the purpose they fulfill. Other applications were strategic while others transactional as they were supporting existing daily business processes. Finally it was revealed that the RFID applications varied based on a third dimension that of 'span'. In particular, in one organisation (case II) RFID application was a project which required the collaboration of supply chain partners, whereas in the other two organisations the projects were going to be developed internally within each one company.

The case studies showed that these types of RFID applications were related to a different kind of value (e.g. supply chain visibility, cost and benefit synergies), including real option value. For example, it was revealed that the RFID application in the second case organisation which was a large scale, strategic and supply chain project had triggered the generation of the option to delay investment due to high levels of uncertainty and cost of the implementation. The next sub research questions tested this expectation and other relevant expectations for the other types of real options.

Based on the above IT project typology the following sub-research questions were addressed.

- ***Does the <u>scope of an IT project</u> (whether it is a family or standalone application) moderate the effect that real options have on the perceived value of returns of this project?***

The moderating effect of the scope of the IT project (whether it is a standalone or family application) on the impact of Real Options on the perceived value of returns is tested. The effect of the stage option on the value of a family IT project is strong and significant whereas this impact is not significant in standalone applications. The option to delay has a stronger impact on the perceived value of returns of the IT project in family applications than in standalone projects where the effect is insignificant. Thus, the results indicate that the scope of the IT project moderates the effect of real options on the IT project value.

Regarding the finding for the stage option, it is supported by scholars who have acknowledged that "synergies are related to the stage option" (Angelou & Economides 2008a; Pendharkar 2010). Family applications are applications which are interrelated with a high level of benefit and cost synergies. Hence, they are good candidates for stage options. In addition, family applications can be considered as applications which are large scale investments. Based on the theory (L. C. Wu & C. S. Ong 2008; Wickramatillake et al. 2007), large scale investments are good candidates for options due to high level of uncertainty. Thus, an option to delay such investments would be highly valuable.

In addition, the impact of growth options was found strong when assessing family applications. This finding is supported by the theory according to which IT platforms are good candidates for growth options. (Q. Dai et al. 2007; Fichman 2004; Taudes et al. 2000). *"An IT platform is broadly defined as a general-purpose technology that enables a family of applications and related business opportunities* (Fichman 2004)*"*. Thus, it as expected by the theory that family applications can trigger growth options. However, managers associate significantly the option to grow an IT project with its value not only in family applications but also in standalone applications. In both groups the option to grow has a significant effect on the perceived IT project value of returns meaning that the scope of the IT project does not moderate the impact of the growth option on the perceived value of the project. This can be explained by the fact that managers may perceive a standalone application as an initial investment for further IT applications, thus resulting in a family project consisting of several applications.

The managers in the study associate significantly the option to grow, stage and defer an investment in family applications with their value. On the contrary, the option to stage or defer an investment in standalone applications is not significant. As we have predicted in the development of the hypotheses, the synergies between the IT applications, as it happens within the family IT projects, make the exploitation of options more significant than in standalone applications.

- ***Does the <u>purpose of an IT project</u> (whether it is strategic, informational or transactional application) moderate the effect that real options have on the perceived value of returns of this project?***

Results indicate that the effect of real options on the perceived value of an assessed IT project varies significantly depending on the purpose of the IT project (transactional, strategic and informational). In particular, the impact of options on the perceived project value is strengthened in the strategic and lessened in the transactional projects for the two types of options (growth and stage). In strategic IT projects the effect of the growth and stage option on the IT project value of returns is significant. On the other hand, the perceived value of transactional IT projects is not significantly influenced by the presence of growth and stage options. In this case, the impact of options on their value is insignificant.

This finding supports our prediction based on the theory (Clemons 1991; Bowman & Hurry 2010) that strategic investments may be considered as investments which create future growth opportunities in contrast to transactional projects. One of the requirements of real options is that the value is created by opportunities of future growth rather than current cash flow (Amram & Nalin Kulatilaka 1999). This value is created through strategic investments as they are large scale investments with more long-term than short-term aims, in contrast to transactional projects. In addition, the magnitude, risks and uncertainties that strategic information technology projects have in contrast to projects which concern repetitive routine firm processes justifies the high importance that the stage option has for the managers. When large technology projects are deployed, risks can be alleviated with the employment of preliminary modules or prototypes (Wu & Ong 2008).

In addition, results showed that the impact of growth options on the value of the assessed project is strengthened in informational IT projects in contrast to transactional IT projects. In particular, the impact of the growth option is significant in informational IT projects. However, a surprising result is the fact that the option of a manager to stage an IT investment does not significantly affect the perceived value of an informational IT project as it happens with the strategic IT investments. An explanation for this result could be that informational IT projects often require that they are implemented in full in order to provide the necessary information they are meant to. Thus, the possibility of breaking up full investments in informational projects into smaller stages in order to avoid any future losses diminishes.

Furthermore as it was hypothesized, results revealed that due to the low cost, risk and small scale of a transactional IT project, the option to defer its deployment and postpone its investment in a future time in order to alleviate any current uncertainties is not significant. However, an unanticipated finding is that the relationship between the presence of a deferral option and the value of an IT project is not only insignificant for transactional IT projects but also for strategic and informational IT projects. This means that the perceived value of a strategic or an informational IT project is not influenced by the opportunity that managers may have to postpone an investment. A possible interpretation for this result is that the respondents find that strategic or informational projects include high competition risk. Thus, delaying such an IT investment could put a firm in an unfavorable position compared to the competitors who may gain the advantage of the first mover. According to the literature (Eric K Clemons & Weber 1990) *"rejecting a technology program leaves the firm vulnerable to other players".* This impact may be more significant in strategic projects which concern the strategy and the long term path of an organization. Lankton & Luft (2008) also suggest that a potential competitor decreases the value of the option to postpone an investment from a current exploitation to a future period of time. Although high uncertainty in strategic IT projects make the option to delay more valuable, the results for this hypothesis indicate the opposite. According to Tiwana et al. (2007), uncertainty cannot easily be minimized if a firm does not gain direct experience with the technology. This makes the deferral option difficult to exercise.

Overall, comparing the significance of the three sub-models for the three types of IT projects, it is concluded that a higher percentage of the project value variance is explained by the presence of options in the strategic and the informational IT projects (R^2=0.45 and R^2=0.31 respectively) than in the transactional IT projects (R^2=0.20).

- ***Does the <u>span of an IT project</u> (whether it is an internal or supply-chain application) moderate the effect that real options have on the perceived value of returns of this project?***

Furthermore, we tested the effect of real options on the perceived value of returns depending on whether the IT project is developed internally in a firm or in collaboration with its supply chain partners. The analysis reveals that the three options have a strong and significant impact on the IT project value only when the assessed project is a supply chain one. Thus, it can be argued that the effect of real options on the project value is moderated by the span of the IT project (supply chain or internal IT project) and that in supply chain projects this effect is strengthened whereas in internal IT projects this effect is lessened and insignificant.

This finding is consistent with the Real Options theory, according to which increased level of uncertainty increases the option value. According to the literature (Humphreys et al. 2001; Bensaou & Venkatraman 1996), supply chain projects involve additional high uncertainties and risks in contrast to projects which are implemented inside a firm. Especially in supply chain collaboration practices enabled by electronic means, such as the RFID technology, the challenges are very high. Prior studies (Pramatari 2007; Pramatari et al. 2009) refer to supplier-retailer coordination challenges which create a lot of barriers for the implementation of the assessed supply chain applications. Thus, the necessity of exercising the options in supply chain projects to alleviate this high level of uncertainty is increased. "*Real Options are especially valuable when projects involve a high level of uncertainty combined with opportunities to dispel that uncertainty as new information becomes available"* (Copeland & Antikarov 2001 in Wu & Ong 2008).

While previous work (Hult et al. 2010) suggests that the stage option is not significant for supply chain projects, even in high levels of uncertainty, what is interesting in this study is that it shows that the stage option has a significant impact on the perceived value of a supply chain project. This difference can be explained by the fact that the work of Hult et al. (2010) refers to supply chain projects in general, whereas this study is focused on information technology supply chain projects. Investments in IT are subject to significant uncertainties (Lankton & Luft 2008) and IT investments differ from other investments as they are among the largest projects, with a high rate of failure and a disastrous impact of such failures (Wu & Ong 2008). This diverse and difficult context of the IT investments creates a lot of uncertainties, which make flexibility to minimize the risks more important and valuable in IT than in non-IT investments. This flexibility can be expressed through the exploitation of a stage option.

In addition, results show that in the supply chain IT context, the growth option influences more significantly (in contrast to the stage and the deferral option) the value of an IT project. This result is explained by that supply chain IT projects, due to their embedded complexity and flexibility, are perceived as fruitful environments for growth opportunities and extension prospects. Previous research (Tiwana et al. 2006) has supported that growth options are perceived as highly valuable in contrast to the other types of options as they may include value of several assets than only one as it happens with other types of options.

7.2.4 **Overview of the thesis's findings which support or contradict pertinent theory**

Overall this doctoral research has applied theory either for the development of the hypotheses or the interpretation of the results. The theory is related to the Real Options theory and its use for the support of IT investment decisions, IS classification theory, and IT innovation adoption theories (e.g. TOE framework). The discussion in the previous findings showed where this thesis' results support and where contradict previous findings and theory. This was discussed for each one research question. The following table offers an overview of the discussion in the previous sections.

Table 7.1 How much the thesis findings support or contradict the theory?

How much what has been found supports the theory?		How much what has been found contradicts the theory?		
Thesis Finding	**Theory Support**	**Thesis finding**	**Previous findings/theory**	**Explanation of the thesis contradicting finding (Why?)**
Impact of Real Options				
Growth option is positively related to the perceived value of returns of an IT project.	(Tiwana et al. 2006; Hult et al. 2010)	Stage option is positively related to the perceived value of returns of an IT project.	Non significant impact (Tiwana et al. 2007; Hult et al. 2010; Goswami et al. 2008)	In this thesis: RFID projects can be considered as costly applications with high uncertainty and time consuming implementations. Breaking up such an IT investment into conditional steps creates value (Nalin Kulatilaka et al. 1999)
		Delay option is negatively related to the perceived value of returns of an IT project.	Delay option is positively related to the perceived value of returns of an IT project (Hult et al. 2010). Not significant impact (Tiwana et al. 2007)	• *"Option cost of delay"* (Angelou & Economides 2009) • Competition threat (Jan 2011) • Loss of opportunity to gain direct experience with this technology (Fichman et al. 2005)
Determinants of Real Options				
Technology strategy positively influences growth option recognition	(McGrath 1997) (Moosmayer & Koehn 2011) (Scarso 1996)	Technology bandwagon is not significantly associated with growth option recognition.	It would have a significant value (Katz & Shapiro 1985; Katz & Shapiro 1986; Strader et al. 2007; Asvanund et al. 2004)	• "In the case of positive network externalities (which is the case in this study), where adoption benefits increase with the number of previous adopters it may be convenient to wait (Scarso 1996)". Thus the value of the option to grow and invest now diminishes.
Organisational learning and innovative capabilities is positively associated with the growth option recognition.	(Cohen & Levinthal 1990; Zahra & George 2002; Scarso 1996; Fichman 2004)	Technology adaptation is not significantly associated with growth option recognition. *(However is significant for adopters)*	Modularity of the technology is a determinant and source of a growth option (Scarso 1996) (Angelou & Economides 2009a)	Non-adopters have not got the experience to assess IT adoption and appreciate any possible features (i.e. modularity, divisibility) which can be key for a successful outcome.

How much what has been found supports the theory?		How much what has been found contradicts the theory?		
Thesis Finding	**Theory Support**	**Thesis finding**	**Previous findings/theory**	**Explanation of the thesis contradicting finding (Why?)**
Moderating impact of IT project type on the value of Real Options				
For family IT projects the effect of real options (growth, stage, and deferral) on the value of returns is strengthened. For standalone IT projects the effect (of stage and deferral options) is lessened.	• IT platforms are good candidates for growth options. (Q. Dai et al. 2007; Fichman 2004; Taudes et al. 2000) -IT platforms can support family applications • Synergies are related to the stage option (Angelou & Economides 2008a; Pendharkar 2010)	For standalone applications the impact of growth options is strong too.	It was expected that for small scale projects the impact of growth options will be lessened due to lower level of uncertainty (Wickramatillake et al. 2007).	Managers may perceive a standalone application as an initial investment for further IT applications, thus resulting in a family project consisting of several applications.
For strategic IT projects the effect of growth and stage option is strengthened in contrast to transactional IT projects where it is lessened. For informational IT projects the effect of growth is strengthened in contrast to transactional IT projects where it is lessened.	• Strategic projects create future growth opportunities (Clemons 1991; Bowman & Hurry 2010) • Small-scale applications offer few options in contrast to other larger-scale investments (Wu and Ong (2008)	For informational IT projects the effect of stage option is not significant.	As non transactional IT projects they can be considered as non small scale applications, thus they may offer options.	Informational IT projects often require that they are implemented in full in order to provide the necessary information they are meant to. Thus, the possibility of breaking up full investments in informational projects into smaller stages diminishes.
		For strategic and informational IT projects the effect of deferral option is not significant.	Strategic projects, in contrast to transactional IT projects, entail a high level of uncertainty, as there are “unfamiliar risks and difficulties that executives confront” (Clemons & Weber 1990a.)Thus, based on Real Options theory as uncertainty increases the value of the real options will increase too.	• “Rejecting a technology program leaves the firm vulnerable to other players (Eric K Clemons & Weber 1990)" • A potential competitor decreases the value of the option to postpone an investment (Lankton & Luft (2008) • Uncertainty cannot easily be minimized if a firm does not gain direct experience with the technology Tiwana et al. (2007). This makes the deferral option difficult to exercise.
For supply chain IT projects the effect of real options (growth, stage, deferral) on the value on returns is strengthened, whereas for transactional is lessened.	• "Supply chain (IT) projects have high uncertainty" Bensaou & Venkatraman (1996), Pramatari et al. (2009), (Humphreys et al. 2001; Bensaou & Venkatraman 1996) • The effect of real options on the value of a project differs between a supply chain and firm-level one (Hult et al. 2010)			

7.3 Theoretical Contribution

The main contribution of this doctoral thesis lies in the following areas:

- Based on a thorough literature review in three areas (IT investment evaluation and adoption, RFID technology in the Supply Chain and Real Options) and a qualitative and quantitative approach this doctoral research develops a theoretical framework to examine the predicting power of real options on the investment evaluation and adoption of Information Technology projects,
- Tests this model in a real context and in particular: RFID investment evaluation and adoption,
- Empirically examines and identifies the factors that influence and trigger the recognition and ultimately the value of Real Options and in particular growth options in IT investment evaluation process,
- Based on three conducted case studies it develops and applies a classification scheme (typology) for RFID investment projects based on specific dimensions (i.e. scope, purpose and span),
- It empirically examines the moderating role of the above IT typology on the relationship between real options and their impact on the perceived value of IT projects.

The table below illustrates the main contribution of this thesis based on the research gaps identified in the literature and the respective research questions. The following paragraphs offer a detailed discussion on the theoretical contribution of this thesis.

Table 7.2 Research Gaps and Research Questions

Research Gap in the literature	Research Question	Sub-Research Questions
Empirically study the behavioral implications of Real Options-(How do managers value Real Options?) *"Little is known about the relative value that managers ascribe to the different types of options that may be embedded in IT projects" (Tiwana et al., 2006) -Empirical tests of Real Options are few (Tiwana, et al. 2007, DS)* *Little research on how the use of RO in capital budgeting affects the behavior and decisions of managers (Denison, 2009)* *Previous literature on RFID evaluation rarely does it take into consideration the flexibility*	What is the impact of real options on the perceived value of returns of an information technology project?	• What is the impact of the recognition of growth options on the perceived value of returns of an IT innovative project? • What is the impact of the recognition of stage options on the perceived value of returns of an IT innovative project? • What is the impact the recognition of deferral options on the perceived value of returns of an IT innovative project?

and the different kind of options that an RFID investment can yield" (Curtin et al. 2007)"		
Empirically examine which parameters influence recognition of real options in IT projects. *"Future research can be directed towards designing empirical studies to gain a better understanding on the role of Real Options in organisational adoption of IT innovation-such as RFID (Goswami et al. 2008; Goswami et al. 2010)"* *"Little is known of **how** managers' understanding of factors external to the organization, the technology and the organizational context influences the decision process leading to IT adoption (Goswami et al. 2008)*	What are the determinants which influence real option recognition in an IT project?	• What is the impact of the technology strategy on the recognition of a growth option? • What is the impact of the organisational learning and innovative capabilities on the recognition of a growth option? • What is the impact of the technology bandwagon on the recognition of a growth option? • What is the impact of the technology adaptation on the recognition of a growth option?
Identify and empirically examine whether the type of IT project moderates the impact of Real Options on the IT project value *Different types of IT projects might carry differential option value* (L. C. Wu & C. S. Ong 2008; Tiwana et al. 2006; X. Li & Johnson 2002)	Is this impact strengthened or mitigated across different types of IT projects?	• Does the scope of an IT project (whether it is a family or standalone application) moderate the effect that real options have on the perceived value of returns of this project? • Does the purpose of an IT project (whether it is strategic, informational or transactional application) moderate the effect that real options have on the perceived value of returns of this project? • Does the span of an IT project (whether it is an internal or supply-chain application) moderate the effect that real options have on the perceived value of returns of this project?

The thesis overall contributes to the literature with the following ways:

- **Reinforces previous few studies by empirically testing the impact of Real Option types on the perceived IT project value and ultimately its adoption**

One of the main contributions of this study lies in the areas of IT innovation firm adoption and its link with the behavorial implications of IT investment evaluation through Real Options reasoning. This study empirically tests the impact of the recognition of real options and in particular growth, stage and deferral options on the IT innovation value and ultimately adoption. Although previous studies in this research field have examined empirically the impact of several factors on the IT project value and its firm adoption, the majority of them ignore the effect of real options as a variable which can influence adoption. This study had the aim to fulfill this gap. In accordance with previous research on IT Real Options, this study highlighted the role of growth, stage and deferral option recognition as factors which influence significantly the decision making process of managers in regards to the perceived value of an IT innovation and ultimately its adoption.

Specifically for the behavorial impact of IT Real Options this study contributes with the following ways. First it shows evidence for that growth option is positively related to the perceived value of an IT projects. Previous research (Tiwana et al. 2006; Hult et al. 2010) has supported the above. Second it contradicts specific previous studies regarding the impact of stage and deferral options. In particular, while previous studies have shown that delay option is positively related to the perceived value of an it project (Hult et al. 2010) or it is not significant (Tiwana et al. 2007) the thesis findings have shown that the delay option is negatively related to the perceived value of returns of an IT project. This finding is supported by the "option cost to delay" (Angelou & Economides 2009) which refers to the revenue losses of an option to delay investments, the competition threat (Jan 2011) and the loss of opportunity to gain direct experience with the technology (Fichman et al. 2005). However, the thesis findings support the results of Goswami et al. (2008) where the option to delay investments had a negative impact on the intention to adopt RFID technology.

In addition, this thesis findings (i.e. stage option is significantly and positively related to the perceived value of returns of an IT project) contradict previous research (Tiwana et al. 2007; Hult et al. 2010; Goswami et al. 2008) which have not found stage option as significant. In this thesis, RFID technology is tested which is a costly technology with high uncertainty, thus the option to break such an investment it is found in this study very valuable.

- **Empirically examines and identifies the factors that influence and trigger the recognition and ultimately the value of Real Options and in particular growth options in IT investment evaluation process**

This study contributes also to the IT Real Options field with the following way. Although related research (Fichman 2004; McGrath & MacMillan 2000; Scarso 1996; Y. J. Kim & Sanders 2002) proposes the factors which influence the recognition and utilization of technology options, very few studies have been conducted to measure and test empirically the impact of these factors based on decision maker's views. Although very few determinants have been examined in the literature, other important factors have remained as propositions and not empirically investigated. This thesis had the aim to fulfill this gap, by empirically testing a set of proposed by the literature determinants of the technology growth option. Results identify the most significant factors of the proposed ones. In particular, it is shown that technology strategy characteristics (i.e. how much strategic, sustainable and radical is the business impact of the evaluated technology) and organisational learning and innovative capabilities (the ability of an organisation to be innovative and gain knowledge from a technology implementation, while exploiting this knowledge to other related IT applications) are the most significant factors which contribute to the generation of growth options. Thus, this study highlights the importance of examining the parameters which can be seen as sources which contribute to growth option recognition and exploitation when evaluating an IT project. As a result, this work has supported and empirically tested reasoning in the literature which underlines that identification and appraise of technology options are directly connected and influenced not only by technical attributes of the technology but also by some individual features of the firm and its business (Scarso 1996). As a result of this work, it is highlighted that researchers, apart from investigating whether or not growth or other types of options are recognised by managers and affect their decisions, need to empirically test and establish a set of determinants which lead to the creation of these options. This separate and staged modeling can act as a more straightforward and simple way of measuring the perceived option value of an innovative information technology project.

While research on technology real options based on quantitative tools prevails, "*there will be circumstances in which options thinking applies quite well but the options resist precise quantification (Verdu et al. 2012)*". In this case, intuitive evaluation of real options and exploitation of qualitative (such as the above) real option determinants can be highly valuable for investment decision making. In cases, where models require many simplifications and assumptions, intuition contributes to better risk management (Fichman 2004).

- **Distinguishes the significance of the real option determinants between <u>adopters and non adopters</u>**

In addition, the impact of the above determinants on growth option recognition is tested in this thesis separately for two groups: adopters and non-adopters in order to investigate any discrepancies. While the majority of the pertinent literature on IT Real Options examines option value and its impact on the intention to adopt the assessed IT, this work examines its impact on actual adoption. Results show that although all the other examined determinants have the same significance on option value in the two different groups, the technology adaptation characteristics demonstrate a different impact. It is shown that although the technology adaptation features (i.e. the capability of the technology to be implemented in stages and different ways and interpretations) is a non-significant factor for non-adopters, it is significant for the adopters group. This result gives insights for researchers to test several determinants of option value in specific settings and groups of decision makers in order to get a more precise and valid results.

- ❖ **Empirically tests and demonstrates the mediating role of growth option recognition in IT innovation evaluation and adoption**

This thesis, helped to better explain how specific technological and organisational parameters promote or inhibit the perceived value of an IT project through the recognition of growth options. This thesis showed that the recognition of growth options acts as a mediator between specific organisational and technological attributes and the perceived value of returns and ultimately adoption of an IT innovative project. Thus, this work enlightens the significance of real options as a variable which facilitates the understanding of the mechanism under which specific capabilities influence managers' decisions regarding the adoption of IT innovations. Second, findings make evident the fact that the utilization of Real Options analysis is not a panacea for the understanding of the evaluation and adoption process of innovative information technology projects. There are specific circumstances derived from an organisation, its environment and the technology itself under which real options are recognised by managers and as a result become present. These circumstances have to be considered by firms when exploiting Real Options analysis. Otherwise, misleading decisions can be made based on this analysis. Hence, it can be suggested that one key means by which specific technological or organisational determinants can affect IT project perceived value of returns is by stimulating growth opportunities embedded within this project.

- ❖ **Examines and supports the moderating effects of the IT project type on the value of Real Options**

One of the main contributions of this thesis lies in the area of IT investment evaluation through the deployment of Real Options theory. While the pertinent literature (L. C. Wu & C. S. Ong 2008; Tiwana et al. 2006; X. Li & Johnson 2002) in this field suggests that different types of IT projects might carry different real option value, the great majority of empirical research considers IT projects as a homogeneous group. Very little research has been conducted to test and empirically compare different types of IT projects and examine whether they entail a different real option value. This study supplements previous research on IT Real Options by investigating the impact of three types of options (growth, stage and deferral) on the perceived value of returns in different IT project types. However, to our knowledge *this study is the <u>first quantitative study</u> which empirically tests the differentiated impact of Real Options in specific IT project types* based on their differences in terms of scope, purpose and span. The key finding is that the impact of real options on the perceived value of an IT project is moderated by the IT project type. The significance of real options is not the same across different IT project types. This finding comes to elucidate previous research discrepancies regarding the impact of real options on the value of an IT project or the intention to adopt it. Future research should examine this issue further and either develop option models that are tailor made to specific types of IT projects or examine and explain any possible discrepancies of the perceived real option value among different types of IT projects.

Overall, the above findings which concern the moderating effect of the IT project type come to support the theory of Real Options which supports that as uncertainty increases, the value of the options increases too. It is found that in small scale applications (i.e. standalone, internal or transactional RFID applications) the impact of real options on the perceived value of returns of an IT project is insignificant (with the exception of the impact of growth options in standalone applications). This finding reinforces previous scholars who support that Real Options add little value for some projects (L. C. Wu & C. S. Ong 2008) which have a low level of uncertainty such as simple well-defined applications, or information technology projects which do not take long to implement. According to the previous scholars these applications are well suited to NPV analysis because their cost and benefits can be determined relatively easily (L. C. Wu & C. S. Ong 2008). The thesis finding empirically supported this expectation.

- **Identifies and empirically examines the <u>attributes of information technology projects</u> which can embed higher real option value.**

In addition, this study contributes to the identification of the characteristics of specific IT project types which can lead to higher option values. In particular, results indicate that the synergies among IT applications which can result in a family IT project create a significant real option value in contrast to standalone IT applications where the option value is lessened. Moreover, growth and stage opportunities have a more significant impact on the perceived project value in strategic or informational IT projects than in transactional projects. As far as the span of an IT project is concerned, this study shows that the examined three types of options influence significantly managers' decisions regarding the assessed IT project value when this project is extended in a supply chain context rather than developed inside a firm (internal IT project).

- **Extends and reinforces previous literature which highlights the importance of investigating IT real options in specific settings**

This work gives insights to the importance that is given to the presence of options in different IT environments. Emphasis is given to understand and identify the boundaries of applicability for real options methodology. It is concluded that the significance of real options is higher in specific groups of IT projects than in IT projects in general. Results indicate that the variance of the perceived value of an IT project can be explained better by the presence of real options when the IT project types are narrowed down to specific groups with certain characteristics (e.g. large scale IT projects) than when the IT projects are evaluated as a homogeneous group. This study shows that the highest overall option value is embedded in large scale IT projects, such as synergetic IT projects, strategic applications or projects which entail the collaboration of several supply chain partners. The above results encourage future researchers to study real options in specific settings and environments than treat them as an entity. This need and its significance has been highlighted by previous studies too (Lankton & Luft 2008), which were focused in testing other particular settings (e.g. high competition levels, high demand etc.) and their moderating impact on real option value. However pertinent research is rare, as the majority of the studies consider the application of Real Options to Information technology projects as an entity.

- **Empirically investigates the significance of Real Options in the case of RFID technology investment evaluation and adoption**

Finally, this study extends the literature of IT Real Option value in the case of RFID. Research on the evaluation and adoption of RFID technology based on the behavorial implications of real options reasoning has been rare. Previous research has underlined the importance of studying this technology under the Real Options perspective. This work had the aim to fulfill this gap with the following main aspects:

- It extended very few previous studies (Goswami et al. 2008; Goswami et al. 2010) on the behavorial implications of Real Options reasoning for the investment evaluation of RFID technology. This thesis presented that managers recognise real options embedded in RFID projects but it is differentiated from the previous studies by considering a different set of parameters which trigger the recognition of Real Options or moderate their impact on the perceived RFID project value. This thesis addressed the consistent call of several scholars (Curtin et al. 2007) to investigate RFID evaluation by considering managerial flexibility and the different kind of options that the technology can yield.

- In addition, this research deployed real options perspective to understand the decision-making process that managers go through the adoption of radio frequency identification (RFID) technology. Previous literature (Thiesse et al. 2011; S.-I. Chang et al. 2008; C.-Y. Lin & Y.-H. Ho 2009; Goswami et al. 2008; Goswami et al. 2010) has highlighted the need to understand 'how' managers' understanding of factors (derived from the technology itself, the organisation or the environment) influence the decision process leading to RFID adoption. This study showed that decision makers' cognitive ability to recognise real options and in particular growth options in assessed RFID technology projects have a significant role in intervening between several IT innovation organisational and technological factors and the ultimate decision to adopt these projects.

- Furthermore, the particular thesis based on three real case RFID projects, proposed an RFID deployment classification based on specific dimensions. It further offered empirical evidence that this classification moderates the impact of real options on the perceptions of managers regarding the RFID project value. To our knowledge this thesis is the first attempt to empirically investigate whether different classes of RFID projects incorporate a diverse real option value based on managers' intuition. It is shown that RFID projects which are strategic, supply chain and family applications entail more significant real option value than that of RFID projects which are characterised as transactional, internal and standalone implementations.

- Last but not least, this study developed a parametric and dynamic model to evaluate RFID investments in the supply chain, based on a cost-benefit (NPV) approach. Although it did not utilise an option pricing model, it showed through sensitivity analysis that NPV approach can be the basis to estimate real options value which can be further elaborated with the utilisation of advanced option pricing formulas. The exploited approach took into consideration the neglected by previous studies quotation: "*Exploiting synergies, investment projects can be considered as a 'bundle' of interrelated investment opportunities, the earlier of which are prerequisites for others to follow* (Panayi and Trigeorgis, 1998)". This model has showed that when RFID is considered as a series of interrelated applications rather than as standalone applications, then the estimated value increases.

- **It proposes a framework for the review and the classification of previous literature on IT Real Options from 1990-2012**

The thesis offers a thorough literature review on the field of Real Options for the Information technology applications justification and adoption. Although the IS literature has acknowledged the importance of utilizing the Real Options theory for the IT justification, an academic literature review which combines the synthesis and critical analysis of the two main research streams in this area (i.e. normative and intuitive) is still lacking. This thesis aimed to fill this gap. Through a systematic and comprehensive review on the field of Real Options for IT justification this study provided readers with a theoretical classification framework, in order to act as a guide and usable resource for researchers and practitioners. The pertinent literature is classified based mainly on the evaluation approach that each study follows and the respective determinants of Real Option value (i.e. qualitative and quantitative real option value determinants). Furthermore, the thesis underlines the main concepts, conclusions and under-explored areas of the two different research streams, while setting directions and priorities for future research. The specific review can support future researchers and can help them to position their research on this classification map proposed by the specific thesis.

7.4 **Practical Contribution**

Apart from the theoretical implications of this thesis, the findings have practical implications. The practical contribution of this thesis is discussed based on the question: *What issues managers need to address?*

Managers should involve in their decision making process for the investment evaluation and adoption of an IT project <u>Real Options reasoning</u>

Managers are recommended that when evaluating an IT innovative project and making a decision regarding its adoption they should take into consideration its real option value. They must be aware of the fact that the recognition of real options can alter their adoption decision. Stage and growth options can increase the estimated value of an assessed IT project as it is shown in this thesis. However, managers should take into consideration that external conditions such as the activities of other players can moderate the impact of real options. Real Options theory supports that as uncertainty increases, the value of the options will increase too. However, in this study this has not been the case for all types of options. Results have indicated that managers, when evaluating a highly competitive IT investment such as an investment in RFID, the option to delay their investment had a negative effect on the perceived project value. Thus, managers should utilise real options as a significant factor which influences the value of IT projects with caution.

Decision makers are advised to be aware of the <u>determinants which trigger the generation of Real Options in IT projects</u>

In order for managers to be able to understand whether an IT innovation has the possibility to offer options they should examine specific determinants which trigger the generation of options. Apart from the monetary factors which influence the value of Real Options (e.g. the exercise price, the expiration date etc.) managers should understand the significance and exploit the predictive ability of several intangible and non-monetary variables. For example regarding the prediction of the growth options embedded within an IT project managers are suggested to examine whether there are the right sources to trigger the recognition and deployment of a growth option for a particular IT project. Based on the findings of this thesis, managers should be aware of the fact that characteristics of an IT innovative project which are related to the strategy of an organisation (i.e. the level of radicalness, competitive advantage and sustainability of competitive advantage that an IT project offers to a company) and organisational capabilities (learning, innovative capabilities and the capability of an organisation to acquire knowledge and utilise it to further domains) are strong predictors of growth option recognition. The first variable is the most influential factor affecting growth option recognition. On the contrary, network effects and technology adaptation characteristics (i.e. divisibility and interpretive flexibility) do not seem to hold significant power in predicting the existence of growth opportunities embedded in an assessed IT project.

Managers can embed the examined intangible option value determinants into a decision making tool to facilitate their decision making towards an IT investment.

The outlined parameters which can trigger the recognition of real options and more specifically growth options can be incorporated in qualitative or quantitative modeling tools for the support of the IT evaluation and adoption decisions when managers assess an IT project. Based on the significance of the examined factors, respective weights can be assigned to each one of the qualitative factors. A decision making tool which combines Analytical Hierarchy Process and Options methodology can help managers to decide upon investing in an IT project based on the real options that it includes and based on the sources that stimulate the significance of these options.

Managers should realize that the IT justification process is rather a complex and dynamic process, which has to take into consideration multiple sources of tangible and intangible uncertainties and intuition rather than a simple evaluation of cost and benefits. As a result, managers' investment decisions can be more rigorous and complete. In addition, the integration of the intuitive and the normative evaluation approaches into one holistic model can offer the opportunity to compare these two approaches and investigate any possible inconsistencies. Managers can be aware of these discrepancies and understand when intuition is consistent with or undermines the formal RO application to IT investment evaluation, thus be more cautious for its implementation.

Practitioners should be aware of the fact that Real Options is not a panacea. The significance of their impact on the perceived value of returns of an IT project is dependent upon the type of the IT project that is assessed.

In this thesis it is shown that the significance of the presence of real options is strengthened in particular types of IT projects. As a result, managers should carefully deploy the Real Options analysis for their IT investment decisions mainly in projects where a fertile environment is developed for the exploitation of real options. For example, when managers have to evaluate large-scale IT projects such as supply chain IT implementations or strategic projects with long-term aims, they should consider Real Options analysis as a process and tool to assess them. Results show that in this kind of projects, the managers' investment decisions are highly influenced by the presence of growth or stage opportunities that these investments encompass. On the other hand, when evaluating small scale applications which concern routine firm processes or they are developed within the firm boundaries rather than within supply chain contexts, managers can utilize more traditional evaluation tools instead of the Real Options analysis. For example results from this thesis demonstrated that in internal applications the impact of the recognized real options did not influence managerial decisions. This is an important practical implication, as the invalid utilization of Real Options analysis may render misleading results. Based on the thesis findings (study II in Chapter 6), the table below gives specific guidelines as per the use of Real Options analysis in respect to specific types of IT projects.

Table 7.3 Real Options value per type of IT project. Managerial implications.

Type of IT project	Expected Real Options	Managerial Implications
For all the types of IT projects	Growth, stage and deferral	Although managers when evaluating an IT project recognise **growth, stage and deferral** options which have a significant impact on the perceived IT project value, they should be aware of the fact that the option to **defer an investment can have a negative impact on the evaluation of an IT project**, due to external conditions (e.g. competition threat, revenue losses). Thus, they should be very cautious when exploiting RO analysis. In addition, managers when assessing an **IT project portfolio** are recommended to **divide it into specific IT project types/groups** (e.g. based on the categorisation below) where the Real Option analysis is more suitable to be applied to, rather than evaluating this portfolio as a homogeneous group.
Scope of the IT project		
Stand alone application	Growth	Regarding managers' decisions on the evaluation of standalone IT applications, managers should have in mind to take into consideration the **growth opportunities** of such an investment.
Family application	Growth, stage and deferral	For the evaluation of a family application managers are strongly recommended to apply Real Options analysis to find **growth, stage and opportunities to delay such an investment**. However, managers have to consider that delaying an investment can have a negative impact on the value of the assessed IT family application.
Purpose of the IT project		
Transactional	-	For the evaluation of transactional IT projects, managers can focus on applying **Traditional Evaluation tools** such Discounted Cash Flow, instead of Real Options analysis.
Informational	Growth	Regarding the evaluation of informational IT projects, managers should focus on finding the **growth opportunities** of such an

		investment, instead of stage or deferral options.
Strategic	Growth and stage	For the evaluation of strategic IT projects, managers are strongly recommended to apply Real Options analysis to assess growth and stage options but be cautious for the utilisation of the analysis for the option to delay such investments since its significance is questionable.
Span of the IT project		
Internal	-	For the evaluation of internal IT projects, managers can focus on applying **Traditional Evaluation Methods** such as Discounted Cash Flow, instead of Real Option analysis.
Supply chain	Growth, stage and deferral	For the evaluation of supply chain IT projects, managers are strongly recommended to apply Real Options reasoning to support their decisions.

Why is this important?

"*It is necessary to employ an approach that will produce sufficient benefits to warrant the time and effort spent making the decision. A lack of understanding of the process and range of choices in method and criteria can cause managers to waste time and energy on an approach that yields no better results than simple rules of thumb* (Gunasekaran et al. 2006)". Managers need to understand when Real Options suits the justification process as misuse of the approach can result in misleading results. "*The acceptance of an IT/IS investment is intrinsically linked to the evaluation mode chosen (i.e., the IS appraisal method itself)*" (Sharif & Irani 2006). The above implications are graphically illustrated in the figure below. The horizontal axis at the bottom represents the degree of collaboration that an IT project implementation requires among one firm and its supply chain partners (supply chain or internal project). The horizontal axis on the top represents the level of synergy that an IT project has with other IT projects (standalone or family application). The vertical axis signifies the purpose of an IT project, whether it is transactional, informational or strategic. According to this matrix, if an IT project is placed in the top left quadrant (transactional, stand-alone and internal application) managers are recommended to consider applying traditional assessment methodologies for its evaluation as it is difficult to recognize real options in this context. On the contrary, as we move to the right bottom quadrant, representing IT projects that are strategic, require collaboration among other supply chain partners and have synergies with other applications, managers are advised to utilize Real Options analysis. The effect of the recognition of real options on the perceived value of this type of IT projects is expected to be significant. As a result, this matrix can support managers to assess and structure a portfolio of IT projects in order to increase the potential of high option value.

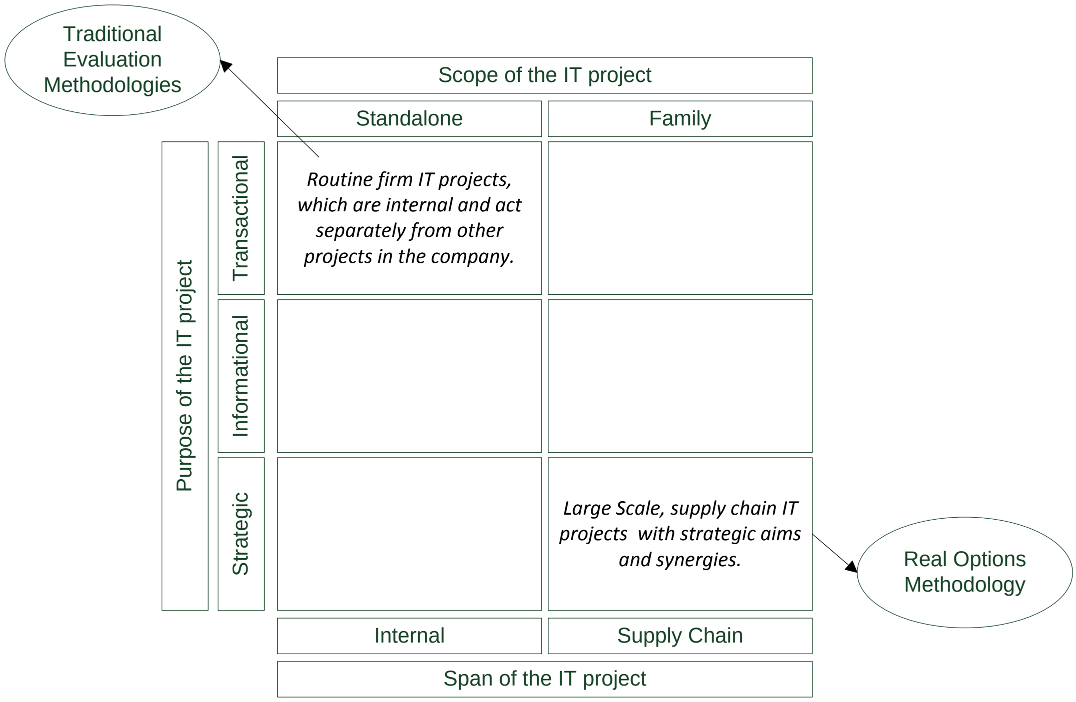


Figure 7.1 IT classification matrix

As a result this typology can facilitate decision making process of managers as it can help managers to identify the types of IT projects that are perceived based on the RO approach as the:

- the most valuable projects (Which are good candidates for a RO evaluation)
- the projects with the highest uncertainty
- The projects with the highest flexibility

More specifically for the case of RFID technology, this thesis has the following practical implications:

Decision makers should consider Real Options reasoning for the justification of RFID technology projects

RFID technology investments are characterised by high uncertainty, irreversibility and managerial flexibility in regards to their exploitation. These parameters make traditional evaluation methodologies inadequate to capture the true value of these investments. Managers should embed in their decision making and evaluation process of RFID investments Real Options analysis which takes into consideration managerial flexibility. This thesis empirically showed that RFID technology investment evaluation can be supported through the exploitation of Real Options. In the three case studies which were examined the members of the three organisations acknowledged the value of several types of real options (opportunities to grow, stage, scale or delay investments) and this acknowledgement influenced their decisions. In addition, the quantitative study which is conducted in this thesis came to reinforce this finding as it is showed that the evaluation of RFID investment projects were influenced by the real options that managers recognise in the assessed projects.

Practitioners should give emphasis to organisational and technological parameters which trigger the creation of Real Options embedded in RFID investments

Managers should take into consideration that growth opportunities can be a result of several organisational and technological parameters. In particular, organisational learning and innovative capabilities and the ability of an organisation to exploit this knowledge and experience into future RFID applications, can trigger growth options. In addition, practitioners should have in mind that the more radical, strategic and sustainable is the impact of an RFID application the more likely is that this application will lead to future growth opportunities.

Managers and IT practitioners should consider RFID implementation as a series of interrelated applications and not as standalone investments (i.e. growth opportunities)

During the evaluation of RFID investments, managers are advised to take into consideration the synergies among the assessed RFID applications. The cost-benefit analysis model which was developed for the evaluation of the RFID applications in the three case studies showed that when the option to grow an initial RFID application into future related ones was considered, the overall value of the investment was higher than the net present value of a stand-alone RFID application. In particular, it was shown that when two examined RFID applications are evaluated in isolation from each other, then the investment is rejected, as the NPV is negative for the two individual applications. On the contrary, when these two applications are evaluated jointly taking into consideration their interdependencies, the investment is adequately justified and not rejected, as the joint NPV is positive (Dimakopoulou et al. 2010). This means that managers should consider RFID applications as a related group of investments, which can share costs and accumulate business value (Dimakopoulou et al. 2010). This can help an organisation assess their investment and decide whether or not to deploy RFID technology.

Decision makers should consider that RFID deployment varies in terms of specific dimensions

Practitioners should take into account that RFID technology cannot be evaluated as an entity and homogeneous group. RFID technology applications differ in terms of their aim (Strategic/transactional/informational), the level of interdependence with other related RFID applications (family/standalone applications) and the level of the collaboration that they require with other partners of the supply chain (internal/supply chain applications). In addition, they should be aware of the fact that these types of RFID technology applications include different kind of value. For example, family applications can share a high amount of benefit and cost synergies. Managers can evaluate RFID applications based on this typology and understand the different characteristics that each one type of RFID applications offers.

The importance of understanding the above differentiation (IT typology) and the respective value is high, as based on these revealed dimensions of scope, purpose and span for an IT innovative supply chain application such as RFID, a "typology that classifies patterns of RFID implementation into separate parts can be generated (Roh et al. 2009)". Based on this typology managers and decision makers can position RFID exploitation in an implementation map and compare their company's RFID deployment with other types of deployment. In this way, they can choose the types of RFID applications that suit the best to their organisation's goals. Realising the benefits of each one category, managers can exploit RFID with the greatest way. Realising for example the RFID attributes of family applications, decision makers can share cost among the RFID applications and result in higher overall value. The proposed typology in this thesis can be combined with other types of typologies in RFID adoption by other authors (Roh et al. 2009). Combination of these typologies can help decision makers to understand the unique feature of each one RFID application and apply the one that is customised according to their organisation's needs.

End-user companies should take into consideration that the significance of Real Options depends on the type of the RFID project which is implemented.

Managers should be very cautious when exploiting Real Options reasoning for their investment decisions and deploy them under specific settings, environments and contexts. Managers are recommended to prefer traditional evaluation methodologies for small-scale RFID applications, whereas they are advised to utilise

Real Options thinking for larger scale investments which can be considered as strategic, supply chain and family applications.

The table below is based on Lee's study (H. L. Lee 2007) which classifies RFID effect and impact into three categories. We have utilised two of these categories (substitutional and structural effect) to show that RFID applications on the left column can be evaluated based on traditional evaluation approaches (as it is expected that real options will add little value), whereas for the RFID applications on the right column, it is expected that the real options that they embed will be highly valuable. The applications on the left can be stand-alone applications and they support mainly transactional processes without the requirement of supply chain collaboration. On the contrary, RFID applications which have structural effect mainly require the collaboration among supply chain partners and the application of a series of inter-related applications. At the same time they concern strategic applications. Based on the findings of the specific doctoral thesis, it is expected that intuition of real options will be highly valuable for the applications on the right column. Managers can utilise the above categorisation of RFID applications to apply Real Options methodology and respective evaluation tools, where it is more suitable.

Table 7.4 RFID applications (adapted from Lee, 2007)

Examples of small scale RFID enabled applications (substitution effect)	Examples of large scale RFID enabled applications (structural effect)
• Receiving operations • Put-away operations • Inventory audits • Check outs	• Location based specific promotional information • Tracking shopper movement in the store • RFID enabled customer relationship management • Customer seeking product information on demand inside the store • Reverse logistics

RFID suppliers can highlight the significance of the real options to increase manager's perceptions towards the value and the use of an information technology project.

RFID providers can exploit Real Options reasoning in order to improve their way of communicating RFID to candidate end-users as a long-term decision which can be enhanced through the consideration of growth, stage or deferral opportunities.

7.5 Limitations and Future Research

Although this thesis offers valuable insights for researchers and practitioners, it should be evaluated in light of its limitations. However, these limitations can be considered as sources of future research.

7.5.1 Related to the conceptual framework

Study other information technology contexts than RFID

First, the study has been conducted within a very specific context, that of the evaluation of RFID technology. Thus, results may have been influenced by the fact that the participants were assessing the value of this particular technology. However, the utilization of this context has been considered as one of the most appropriate ones to test the hypotheses of this thesis. RFID technology, due to its flexibility and modularity, can result in many different IT project types, based on the business aim that a manager would like to address. Thus, this attribute of the technology gave us the opportunity to compare within the same setting of RFID the option value of different IT project types, which is one of the main purposes of this work. In addition, taking into consideration the RFID context, this study allowed the comparison of IT projects which differ based on specific attributes (their scope, purpose and span) rather than the technology itself. This choice eliminates the possibility to have results affected by the different technologies a project is established on. Future research can test different settings other than RFID to examine and analyze any discrepancies with these findings. In addition, interesting future works can compare results and the impact of real options in different kinds of technologies.

Extend examination of additional types of options and option value determinants

Second, the specific evaluation is focused on a specific type of options: growth option for the first study (Chapter 5) and growth, stage and deferral options for the second study (Chapter 6). However, this choice is justified (see Section 4.7), as these types of options have been derived from the case study analysis. Future research can study the impact of other types of real options (e.g. switch options, abandon options) on the perceived value of returns to elaborate this thesis' results. In addition, in the first study of this thesis, particular option value determinants were examined as they have been proposed by the literature. Future research can investigate the impact of other additional determinants (e.g. competition or partner's pressure, synergies among the examined IT projects) on growth option value. In addition, future studies can investigate the sources of other option types and answer questions such as: What are the factors which determine the recognition and the exploitation of the option to defer or switch an information technology project?

Study real options impact on objective parameters

This study was based on the perceptions of managers regarding the impact of real options on the value of returns of an IT project. However, interesting insights could be derived from research with objective measurements rather than perceptions. For example, future research can study the impact of the utilisation of Real Options for technology or other investments on the actual performance of the company. Future research can compare strategies with one-shot, full scale investments with incremental, stage wise and entry through trial investments (i.e. real option based investments) (Bowman & Hurry 1993) to see any discrepancies of their impact on the actual performance of the project investment or the performance of the company.

Consider alternative IT classifications

Further, the examined types of information technology projects were based on specific classifications, based on the IS classification literature and the cross-case findings. Future studies can utilize other ways of classifying IT projects. As literature (L. C. Wu & C. S. Ong 2008; Tiwana et al. 2006; X. Li & Johnson 2002) underlines the fact that *options do not add value to every type of information technology investment,* future research can incorporate alternative ways of IT project categorisation and empirically investigate how the significance of real option value is differentiated across the different types of IT projects. An interesting framework which is proposed by Lee, 2007 is the following. The author classifies IT technology based on its evolution. Each one type of technology applications within each one evolution stage has its own attributes. Pertinent literature (Tiwana et al. 2006) has suggested as future relevant research to study how the real option value of a project changes as this project progresses through various stages. For example, future research can study RFID technology in a longitudinal study and examine the differentiated real option value across the evolution stages of RFID, based on Lee's classification.

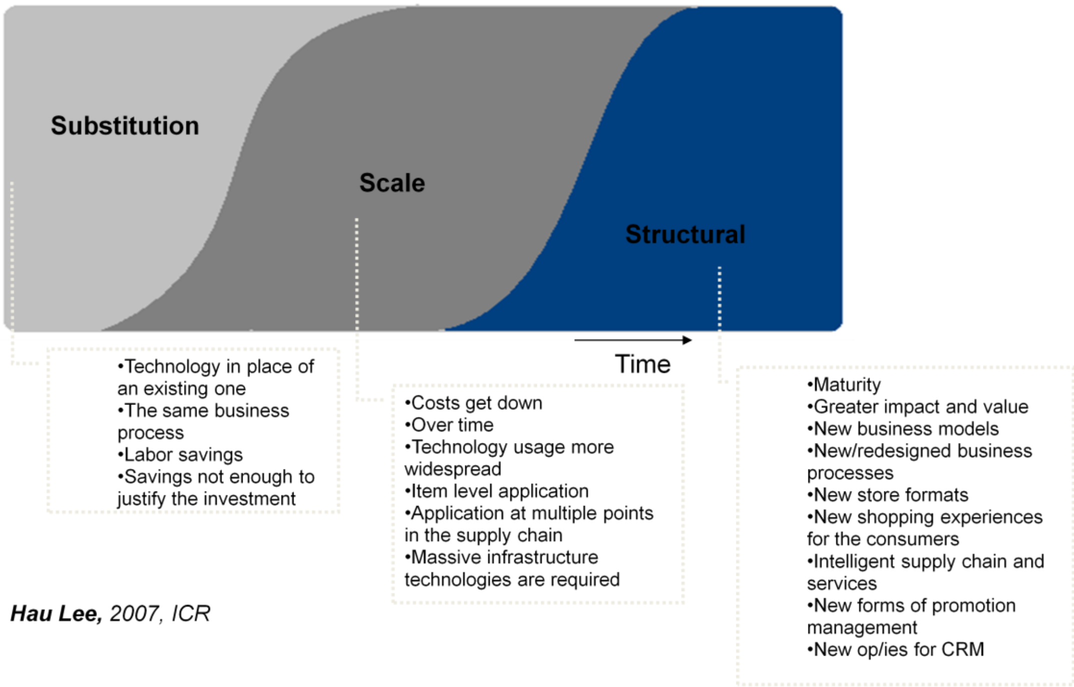


Figure 7.2 The 3-S Model of Technology Evolution stages (Adapted from (H. L. Lee 2007)**)**

7.5.2 Related to the methodology

Extend the research in a bigger sample/ target group

Moreover, the sample of the two studies conducted in the confirmatory phase of the thesis, may be considered as small. However, it fulfills (Tabachnick & Fidell 2001) formula according to which the sample size should be N > 50+ 8m (m= the number of the independent variables). In our case for study 1 (chapter 5) we had 5 independent variables, whereas in the study 2 (chapter 6) we had 3 independent variables. This equals based on the formula above to 90 and 74 sample sizes respectively. The sample size was higher than these amounts, thus it can be considered as satisfactory. Second, the number of the size was based on a European sample of companies which are highly familiar with the RFID technology. Hence, the specific number is quite satisfactory, as the aim of the study was to take answers from a wider sample of companies rather than be country-specific.

Third, this limitation is alleviated by the fact that the predictive ability of the independent variables (Study I-Chapter 5) was high (R^2=46%) and in study II-Chapter 6 the significance of the tested sub-models was high too. In particular, the variance of the assessed IT project value was highly explained (45%) in specific sub-models (groups of IT project types) by the independent variables.

Measurement issues

For some of the measured constructs (i.e. real option types) single item measurements were utilised (Study II-Chapter 6). However, this limitation is alleviated by the fact that the predictive ability of the independent variables (i.e. real options) was high especially in the cases where it was hypothesized to be high (i.e. in the sub-groups of specific IT projects). Second, in the conducted survey it was decided to have the opportunity to include rather more factors than more items per each one factor. Since research on this field is rare, in this way we had the aim to investigate the predictive ability of several factors. A third explanation and justification of this choice is that based on empirical studies (Bergkvist & Rossiter 2007; Rossiter 2002) , results show that when a factor is "concrete" (i.e. it consists of an object which is easily and uniformly imagined by respondents), a single-item approach is sufficient. These scholars (Bergkvist & Rossiter 2007; Rossiter 2002) have shown that the predictive ability of single-item measures are the same with these of the multiple-item scales. The authors' result fails to support the classic argument that multiple-item measures are more valid than single-item measures for all types of constructs. Other scholars have supported this finding by indicating that if a construct's scope is narrow, uni-dimensional and unambiguous for the respondents using single-item measures is the best approach, while at the same time is beneficial as it generally increases response rates (Joe F. Hair et al. 2012)[5]. In our case, the items of the real options constructs were derived and extracted from scientifically utilised measurements and items by previous studies (Tiwana et al. 2006; Goswami et al. 2008; Tiwana et al. 2007; Goswami et al. 2010) (see Appendix 2(b) for the scales). Their meaning is considered as concrete as they were easily understood by the participants and had a clear sense.

A fourth important issue which justifies our choice is the work of Diamantopoulos et al. (2012) according to which specific conditions favor the use of single-item measures. These conditions are satisfied in our case for study II (chapter 6). More specifically: based on the authors it is better to utilise single-item approaches in the case we have 1) *small samples*. In our case in study II which was discussed in Chapter 6, the size of the sub-groups (except for two of them) was quite small (N<50). 2) *The items of the originating multi-item scale are highly homogeneous and* 3) *semantically redundant*- In the few previous studies (Tiwana et al. 2007; Hult et al.

[5] Hair et al. 2011 (Journal of the Academy Marketing Science), have conducted an extensive research in 30 top ranked journals and concluded that 46.30% of the identified 204 PLS-SEM applications has included single-item measures.

2010; Goswami et al. 2008), which utilize a multi-scale for the measurement of the examined options (growth, stage and deferral) the items of the utilized scales inside the same construct are highly correlated with high levels of homogeneity (Cronbach's alpha>0.80 and composite reliability which ranges from 0.85 and 0.95). And 4) *The cross-item correlations are expected to be low*. Based on Goswami et al. study (2008), the discriminant validity is justified, as the utilized items for the growth, stage and deferral option variables have higher factor loadings in their corresponding constructs respectively than in other constructs. In addition, the correlations among the different constructs of growth, deferral and stage option are very low and lower than 0.3 according to previous studies (Hult et al. 2010; Tiwana et al. 2007). Future research can study the particular real option prediction model and framework utilising the multiple scale approach to investigate any possible discrepancies.

Study interaction effects of the moderating variables

In the specific thesis (chapter 6) each one group of IT project types is examined separately as a pure category. However, in practice an IT project type can be at the same time, supply chain, family and strategic application. We have not examined hybrid types of IT projects in order to avoid complications in analysis, interpretation and discussion. Future research can examine the interaction effects for the specific or other types of options and investigate their impact on IT evaluation and decision making process. Future studies could examine two or more simultaneously different types of IT projects and investigate their possible differentiated option value. For example, a future study can examine what is the perceived option value of supply chain IT projects which support family applications at the same time.

REFERENCES

Alavi, M. & Carlson, P., 1992. A Review of MIS Research and Disciplinary Development. *Journal of Management Information Systems*, 8(4), pp.45–62.

Alegre, Joaquín & Chiva, R., 2008. Assessing the impact of organizational learning capability on product innovation performance: An empirical test. *Technovation*, 28(6), pp.315–326.

Alleman, J., Madden, G. & Kim, Hak, 2008. Real Options Methodology Applied to the ICT Sector: A Survey. *Communications & Strategies*, 70(2), pp.27–44.

Amram, M. & Kulatilaka, Nalin, 1999. *Real Options: Managing Strategic Investments in an Uncertain World*, Boston: Harvard Business School Press.

Anandarajan, A. & Wen, H.J., 1999. Evaluation of information technology investment. *Management Decision*, 37(4), pp.329–339.

Angelou, G.N. & Economides, A.A., 2009a. A compound real option and AHP methodology for evaluating ICT business alternatives. *Telematics and Informatics*, 26(4), pp.353–374.

Angelou, G.N. & Economides, A.A., 2008a. A Decision Analysis Framework for Prioritizing a Portfolio of ICT Infrastructure Projects. *IEEE Transactions on Engineering Management*, 55(3), pp.479–495.

Angelou, G.N. & Economides, A.A., 2009b. A multi-criteria game theory and real-options model for irreversible ICT investment decisions. *Telecommunications Policy*, 33(10-11), pp.686–705.

Angelou, G.N. & Economides, A.A., 2008b. A real options approach for prioritizing ICT business alternatives: a case study from broadband technology business field. *Journal of the Operational Research Society*, 59(10), pp.1340–1351.

Angelou, G.N. & Economides, A.A., 2005. Flexible ICT investments analysis using real options Georgios N . Angelou and. *International Journal of Technology Policy and Management*, 5(2), pp.146–166.

Apostolopoulos, T. & Pramatari, K, 1997. Information technology investment evaluation: Investments in telecommunication infrastructure. *International Journal of Information Management*, 17(4), pp.287–296.

Aral, S. & Weill, P., 2007. IT Assets, Organizational Capabilities, and Firm Performance: How Resource Allocations and Organizational Differences Explain Performance Variation. *Organization Science*, 18(5), pp.763–780.

Asvanund, A. et al., 2004. An Empirical Analysis of Network Externalities in Peer-to-Peer Music-Sharing Networks. *Information Systems Research*, 15(2), pp.155–174.

Attaran, M., 2007. RFID: an enabler of supply chain operations. *Supply Chain Management: An International Journal*, 12(4), pp.249–257.

Bacon, C.J., 1992. The Use of Decision Criteria in Selecting Information Systems/Technology Investments. *MIS Quarterly*, 16(3), p.335.

Bagozzi, R. P. & Yi, Y., 1988. On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, 16(1), pp.74–94.

Bagozzi, Richard P. & Yi, Youjae, 2011. Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science*, 40(1), pp.8–34.

Balasubramanian, P., Kulatilaka, N. & Storck, J., 2000. Managing information technology investments using a real-options approach. *The Journal of Strategic Information Systems*, 9(1), pp.39–62.

Bardaki, C., Kourouthanassis, Panos & Pramatari, Katerina, 2012. Deploying RFID-Enabled Services in the Retail Supply Chain: Lessons Learned toward the Internet of Things. *Information Systems Management*, 29(3), pp.233–245.

Bardhan, I., Bagchi, S. & Sougstad, R., 2004. Prioritizing a Portfolio of Information Technology Investment Projects. *Journal of Management Information Systems*, 21(2).

Barney, J., 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(1), pp.99–120.

Baron, R.M. & Kenny, D. a, 1986. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of personality and social psychology*, 51(6), pp.1173–1182.

Bartels, A., 2012. *Global Tech Market Outlook For 2012 And 2013*,

Bélissent, J., 2009. *The State Of Global Enterprise IT Budgets : 2009 To 2010, Forrester Research*, Benaroch, M., 2002. Managing Information Technology Investment Risk : A Real Options Perspective. *Journal of Management Information Systems*, 19(2), pp.43–84.

Benaroch, M., 2001. Option-Based Management of Technology Investment Risk. *IEEE Transactions on Engineering Management*, 48(4), pp.428–444.

Benaroch, M. et al., 2007. Option-Based Risk Management: A Field Study of Sequential Information Technology Investment Decisions. *Journal of Management Information Systems*, 24(2), pp.103–140.

Benaroch, M. & Kauffman, R.J., 1999. A Case for Using Real Options Pricing Analysis to Evaluate Information Technology Project Investments. *Information Systems Research*, 10(1), pp.70–86.

Benaroch, M. & Kauffman, R.J., 2000. Justifying Electronic Banking Network Expansion Using Real Options Analysis. *MIS Quarterly*, 24(2), pp.197–225.

Benaroch, M., Lichtenstein, Y. & Robinson, K., 2006. Real Options in Information Technology risk management: An empirical validation of risk-option relationships. *MIS Quarterly*, 30(4), pp.827–864.

Benaroch, M., Shah, S. & Jeffery, M., 2006. On the Valuation of Multistage Information Technology Investments Embedding Nested Real Options. *Journal of Management Information Systems*, 23(1), pp.239–261.

Bensaou, M. & Venkatraman, N., 1996. Inter-organisational Relationship and Information Technology: A conceptual Synthesis and a Reseach Framework. *European Journal of Information Systems*, 5, pp.84–91.

Bergeron, F., Raymond, L. & Rivard, S., 2001. Fit in strategic information technology management research: an empirical comparison of perspectives. *Omega*, 29(2), pp.125–142.

Bergkvist, L. & Rossiter, J.R., 2007. The Predictive Validity of Multiple-Item Versus Single-Item Measures of the Same Constructs. *Journal of Marketing Research*, 44(2), pp.175–184.

Von Bertalanffy, L., 1969. *General System Theory: Foundations, Development, Applications*, New York: G. Braziller.

Black, F. & Scholes, M., 1973. The pricing of Options and Corporate Liabilities. *The Journal of Political Economy*, 81(3), pp.637–654.

Blome, C. & Schoenherr, T., 2011. Supply chain risk management in financial crises—A multiple case-study approach. *International Journal of Production Economics*, 134(1), pp.43–57.

Bottani, E. & Rizzi, A., 2008. Economical assessment of the impact of RFID technology and EPC system on the fast-moving consumer goods supply chain. *International Journal of Production Economics*, 112(2), pp.548–569.

Bowman, E.H. & Hurry, D., 1993. Strategy through the Option lens: An integrated view of resource investments and the incremental-choice process. *Academy of Management Review*, 18(4), pp.760–782.

Bowman, E.H. & Moskowitz, G.T., 2001. Options Analysis and Strategic Decision Making. *Organization Science*, 12(6), pp.772–777.

Brach, M.A., 2003. *Real options in practice*, Hoboken, NJ: John Wiley and. Sons.

Brand, D. et al., 2004. A Benefit/Cost Analysis of the Commercial Vehicle Information Systems and Networks (Cvisn) Program. *Research in Transportation Economics*, 8(04), pp.379–401.

Brown, I. & Russell, J., 2007. Radio frequency identification technology: An exploratory study on adoption in the South African retail sector. *International Journal of Information Management*, 27(4), pp.250–265.

Bryman, a., 2006. Integrating quantitative and qualitative research: how is it done? *Qualitative Research*, 6(1), pp.97–113.

Busby, J.S. & Pitts, C.G.C., 1997. Real options in practice: an exploratory survey of how finance officers deal with flexibility in capital appraisal. *Management Accounting Research*, 8(2), pp.169–186.

Campbell, J.A., 2002. Real options analysis of the timing of IS investment decisions. *Information & Management*, 39(5), pp.337–344.

Chang, S.-I. et al., 2008. The Determinants of RFID Adoption in the Logistics Industry - A Supply Chain Management Perspective. *Communications of the Association for Information Systems*, 23(September 2008), pp.197–218.

Chau, Patrick Y K & Tam, K.Y., 1997. Factors Affecting the Adoption of Open Systems : An Exploratory Study. *MIS Quarterly*, 21(1), pp.1–24.

Chen, T., Zhang, J. & Lai, K.-K., 2009. An integrated real options evaluating model for information technology projects under multiple risks. *International Journal of Project Management*, 27(8), pp.776–786.

Chen, Y.-S., Lin, M.-J.J. & Chang, C.-H., 2009. The positive effects of relationship learning and absorptive capacity on innovation performance and competitive advantage in industrial markets. *Industrial Marketing Management*, 38(2), pp.152–158.

Chin, W.W., 2000. Frequently Asked Questions – Partial Least Squares & PLS-Graph. Home Page.[On-line].

Chiva, R., Alegre, Joaquin & Lapiedra, R., 2007. Measuring organisational learning capability among the workforce. *International Journal of Manpower*, 28(3/4), pp.224–242.

Chou, T.-Y., Chou, S.T. & Tzeng, G.-H., 2006. Evaluating IT/IS investments: A fuzzy multi-criteria decision model approach. *European Journal of Operational Research*, 173(3), pp.1026–1046.

Chung, B. & Skibniewski, M.J., 2007. Cost-Benefit Analysis of ERP Modules in Construction Firms. *AACE International Transactions*.

Chwelos, P., Benbasat, I. & Dexter, A.S., 2001. Research Report: Empirical Test of anEDI Adoption Model. *Information Systems Research*, 12(3), p.2001.

Clemons, E.K. & Gu, B., 2003. Justifying information technology investments: balancing the need for speed of action with certainty before action. *Journal of Management Information Systems*, 20(2), pp.11–48.

Clemons, Eric K, 1991. Evaluation of Strategic investments in Information Technology. *Communications of the ACM*, 34(1).

Clemons, Eric K & Weber, B.W., 1990. Strategic Information Technology Investments : Guidelines for Decision Making. *Journal of Management Information Systems*, 7(2), pp.9–28.

Cohen, W.M. & Levinthal, D.A., 1990. Absorptive Capacity : A New Perspective on and Innovation Learning. *Administrative Science Quarterly*, 35(1), pp.128–152.

Copeland, T. & Antikarov, V., 2001. *Real Options-A Practitioner's Guide*, New York: Texere LLC.

Creswell, J., 2003. *Research Design: Qualitative,Quantitative and Mixed Method approaches* 2nd editio. C. Thousand Oaks, ed.,

Curtin, J., Kauffman, R.J. & Riggins, F.J., 2007. Making the "MOST" out of RFID technology: a research agenda for the study of the adoption, usage and impact of RFID. *Information Technology and Management*, 8(2), pp.87–110.

Dai, Q., Kauffman, R.J. & March, S.T., 2007. Valuing information technology infrastructures: a growth options approach. *Information Technology and Management*, 8(1), pp.1–17.

Denison, C. a., 2009. Real Options and Escalation of Commitment: A Behavioral Analysis of Capital Investment Decisions. *The Accounting Review*, 84(1), p.133.

Diamantopoulos, A. et al., 2012. Guidelines for choosing between multi-item and single-item scales for construct measurement: a predictive validity perspective. *Journal of the Academy of Marketing Science*, 40(3), pp.434–449.

Diamantopoulos, A. & Winklhofer, H.M., 2001. Index Construction with Formative Indicators : An Alternative to Scale DeveloprTient. *Journal of Marketing Research*, 38(2), pp.269–277.

Dimakopoulou, A. et al., 2010. Investment Evaluation of RFID Technology Applications: An Evolution Perspective. In D. C. Ranasinghe, Q. Z. Sheng, & S. Zeadally, eds. *Unique Radio Innovation for the 21st Century: Building Scalable and Global RFID Networks*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 411–434.

Dimakopoulou, A. & Pramatari, Katerina, 2009. Investment Evaluation Of RFID Technology Applications: A Real Options Perspective. In *Mediterranean Conference on Information Systems (MCIS)*. pp. 1151–1166.

Dixit, A.K. & Pindyck, R.S., 1994. *Investment under uncertainty*, Princeton, N.J.: Princeton University Press.

Doerr, K., Gates, W. & Mutty, J., 2006. A hybrid approach to the valuation of RFID/MEMS technology applied to ordnance inventory. *International Journal of Production Economics*, 103(2), pp.726–741.

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *The Academy of Management Review*, 14(4), p.532.

Farbey, B., 1999. Moving IS evaluation forward: learning themes and research issues. *The Journal of Strategic Information Systems*, 8(2), pp.189–207.

Fichman, R.G., 2004. Real Options and IT Platform Adoption: Implications for Theory and Practice. *Information Systems Research*, 15(2), pp.132–154.

Fichman, R.G., Keil, Mark & Tiwana, A., 2005. Beyond Valuation: *California Management Review*, 47(2).

Fichman, R.G. & Moses, S.A., 1999. An Incremental Process for Software Implementation. *Sloan Management Review*, (Winter), pp.39–52.

Fleisch, E & Tellkamp, C., 2005. Inventory inaccuracy and supply chain performance: a simulation study of a retail supply chain. *International Journal of Production Economics*, 95(3), pp.373–385.

Fornell, C. & Larcker, D.F., 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, 18(1), pp.39–50.

Frambach, R.T. & Schillewaert, N., 2002. Organizational innovation adoption: a multi-level framework of determinants and opportunities for future research. *Journal of Business Research*, 55(2), pp.163–176.

Galliers, R., 1992. *Information Systems Research -Issues,methods and practical guidelines*, Oxford: Blackwell Scientific Publications.

Gibson, C.F. & Nolan, R.L., 1974. Managing the Four Stages of EDP Growth. *Harvard business review*, (January-February).

Goswami, S. et al., 2010. Real Options from RFID Adoption : A Strategic Choice Perspective. In *Academy of Management Annual Meeting (AOMM), Montreal, Canada, August 2010*. pp. 1–19.

Goswami, S., Teo, H.H. & Chan, Hock Chuan, 2008. Real Options from RFID Adoption: The Role of Institutions and Managerial Mindfulness. In *Proceedings of the 29th Annual International Conference on Information Systems (ICIS), Paris, France, December 2008.* pp. 1–17.

Grandon, E.E. & Pearson, J.M., 2004. Electronic commerce adoption: an empirical study of small and medium US businesses. *Information & Management*, 42(1), pp.197–216.

Green, M., 2004. Survey : Executives Rank Disruptions Top Threats Midyear Poii Reveais Easier Commerciai Renewals. *Best's Review*, 10(5), p.105.

Greene, J.C., Caracelli, V.J. & Graham, W.F., 1989. Toward a Conceptual Framework for Mixed-Method Evaluation Designs. *Educational Evaluation and Policy Analysis*, 11(3), pp.255–274.

Gunasekaran, A. et al., 2001. A model for investment justification in information technology projects. *International Journal of Information Management*, 21(5), pp.349–364.

Gunasekaran, A., Ngai, E.W.T. & McGaughey, R.E., 2006. Information technology and systems justification: A review for research and applications. *European Journal of Operational Research*, 173(3), pp.957–983.

Hair, J.F. et al., 2006. *Multivariate data analysis* 6th Editio., New Jersey.: Pearson Prentice Hall.

Hair, Joe F. et al., 2012. An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, 40(3), pp.414–433.

Hair, Joseph F. et al., 2013. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, USA: Thousand Oaks: Sage Publications, Inc.

Hair, Joseph F. et al., 2009. *Multivariate Data Analysis*, Prentice Hall.

Hallikainen, P., Kivijärvi, H. & Nurmimäki, K., 2002. Evaluating Strategic IT Investments : An Assessment of Investment Alternatives for a Web Content Management System. In *Proceedings of the 35th Hawaii International Conference on System Sciences*. pp. 1–10.

Hardgrave, B.C., Armstrong, D.J. & Riemenschneider, C.K., 2007. RFID assimilation hierarchy. In *40th Annual Hawaii International Conference on System Sciences, Big Island, HI.*

Harmantzis, F. & Tanguturi, V., 2007. Investment decisions in the wireless industry applying real options. *Telecommunications Policy*, 31(2), pp.107–123.

Henderson, D., Sheetz, S.D. & Trinkle, B.S., 2012. The determinants of inter-organizational and internal in-house adoption of XBRL: A structural equation model. *International Journal of Accounting Information Systems*, 13(2), pp.109–140.

Henderson, R., 1993. Underinvestment and Incompetence as Responses to Radical Innovation: Evidence from the Photolithographic Alignment Equipment Industry. *The RAND Journal of Economics*, 24(2), p.248.

Henderson, R. & Clark, K.B., 1990. Architecturai Innovation : The Reconfiguration of Existing Product Tech- nologies and the Failure of Established Firms. *Administrative Science Quarterly*, 35(March), pp.9–30.

Henseler, Jörg, 2011. Why generalized structured component analysis is not universally preferable to structural equation modeling. *Journal of the Academy of Marketing Science*.

Henseler, Jorg, Ringle, C.M. & Sinkovics, R.R., 2009. The use of Partial Least Squares path modeling in international marketing Jörg Henseler, C. M. Ringle, & R. R. Sinkovics, eds. *Advances in International Marketing*, 20, pp.277–319.

Herath, Hemantha S B & Park, C.S., 2002. Multi-Stage Capital Investment Opportunities as Compound Real Options. *The Engineering Economist*, 47(1), pp.1–27.

Herath, Hemantha S. B. & Herath, T.C., 2008. Investments in Information Security: A Real Options Perspective with Bayesian Postaudit. *Journal of Management Information Systems*, 25(3), pp.337–375.

Hilhorst, C. et al., 2008. Using Dempster–Shafer theory and real options theory to assess competing strategies for implementing IT infrastructures: A case study. *Decision Support Systems*, 46(1), pp.344–355.

Ho, R., 2006. *Handbook of Univariate and Multivariate data analysis and interpretation with SPSS*, Rockhampton, Australia: Taylor & Francis.

Howell, S.D. & Jagle, A.J., 1997. Laboratory Evidence on How Managers Intuitively Value Real Growth Options. *Journal of Business Finance and Accounting*, 24(7&8), pp.915–935.

Hult, G.T.M., Craighead, C.W. & Ketchen, D.J., 2010. Risk Uncertainty and Supply Chain Decisions : A Real Options Perspective. *Decision Sciences*, 41(3), pp.435–458.

Humphreys, P.K., Lai, M.K. & Sculli, D., 2001. An inter-organizational information system for supply chain management. *International Journal of Production Economics*, 70(3), pp.245–255.

Iacovou, C.L., Benbasat, I. & Dexter, A.S., 1995. Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology. *MIS Quarterly*, 19(4), p.465.

Iniestra, J. & Gutierrez, J., 2009. Multicriteria decisions on interdependent infrastructure transportation projects using an evolutionary-based framework. *Applied Soft Computing*, 9(2), pp.512–526.

Irani, Z, 2002. Applying concepts of fuzzy cognitive mapping to model: The IT/IS investment evaluation process. *International Journal of Production Economics*, 75(1-2), pp.199–211.

Irani, Z & Love, P.E.D., 2002. Developing a frame of reference for ex-ante IT/IS investment evaluation. *European Journal of Information Systems*, 11(1), pp.74–82.

Irani, Zahir, 2002. Information systems evaluation: navigating through the problem domain. *Information & Management*, 40(1), pp.11–24.

Jan, Y.-C., 2011. Strategic investment in Taiwan chain and franchise stores: A Real Options and game-theoretic approach. *Journal of Business Research*, 5(4), pp.25–38.

Jones, P. et al., 2004. Radio frequency identification in the UK: opportunities and challenges. *International Journal of Retail & Distribution Management*, 32(3), pp.164–171.

Jones, P. et al., 2005. The benefits, challenges and impacts of radio frequency identification technology (RFID) for retailers in the UK. *Marketing Intelligence & Planning*, 23(4), pp.395–402.

Joshi, K. & Pant, S., 2008. Development of a framework to assess and guide IT investments: An analysis based on a discretionary–mandatory classification. *International Journal of Information Management*, 28(3), pp.181–193.

Judd, C.M. & Kenny, D A, 1981. Process Analysis: Estimating Mediation in Treatment Evaluations. *Evaluation Review*, 5(5), pp.602–619.

Kakola, T.K., 1995. Increasing the interpetive flexibility of information systems through embedded application systems. *Accounting,Management and Information Technology*, 5(1), pp.79–102.

Karagiannaki, A., Mourtos, I. & Pramatari, K., 2007. Simulating and Evaluating the Impact of RFID on Warehousing Operations: a case study. In *Proceedings of Summer Computer Simulation Conference, San Diego, USA.*

Karagiannaki, A., Pramatari, K. & Doukidis, G., 2010. Using Simulation To Design & Evaluate RFID Implementations in the Supply Chain. In *Proceedings of the Operational Research Society Simulation Workshop 2010 (SW10), 23-24 March 2010, Worcestershire,*.

Katz, M. & Shapiro, C., 1985. Network externalities, competition and compatibility. *The American Economic review*, 75(3), pp.424–440.

Katz, M. & Shapiro, C., 1986. Technology Adoption in the presence of network externalities. *Journal of Political Economy*, 94(4), pp.822–841.

Ke, W. et al., 2009. How do mediated and non-mediated power affect electronic supply chain management system adoption? The mediating effects of trust and institutional pressures. *Decision Support Systems*, 46(4), pp.839–851.

Keil, M & Flatto, J., 1999. Information systems project escalation: a reinterpretation based on options theory. *Accounting, Management and Information Technologies*, 9(2), pp.115–139.

Kenny, David A., 2012. Mediation. Available at: http://davidakenny.net/cm/mediate.htm.

Kim, H, Weiss, M. & Morel, B., 2009. Real options and technology management: Assessing technology migration options in wireless industry. *Telematics and Informatics*, 26(2), pp.180–192.

Kim, J. et al., 2008. Value analysis of location-enabled radio-frequency identification information on delivery chain performance. *International Journal of Production Economics*, 112(1), pp.403–415.

Kim, S. & Garrison, G., 2010. Understanding users' behaviors regarding supply chain technology: Determinants impacting the adoption and implementation of RFID technology in South Korea. *International Journal of Information Management*, 30(5), pp.388–398.

Kim, Y.J. & Sanders, G.L., 2002. Strategic actions in information technology investment based on real option theory. *Decision Support Systems*, 33, pp.1 – 11.

King, W.R., Grover, V. & Hunfnagel, E., 1989. Using Information and Information Technology for Sustainable Competitive Advantage : Some Empirical Evidence. *Information & Management*, 17, pp.87–93.

Kogut, B. & Kulatilaka, Nalin, 1994. Options Thinking and platform investments: Investing in Opportunity. *California Management Review*, Winter, pp.52–71.

Kok, A.G., Van Donselaar, K.H. & Van Woensel, T., 2008. A break-even analysis of RFID technology for inventory sensitive to shrinkage. *International Journal of Production Economics*, 112(2), pp.521–531.

Kuan, K.K.Y. & Chau, Patrick Y.K., 2001. A perception-based model for EDI adoption in small businesses using a technology–organization–environment framework. *Information & Management*, 38(8), pp.507–521.

Kulatilaka, Nalin, 1995. The value of flexibility: A general model of Real Options. In *Real Options in Capital investment:Models,Strategies and Applications Edited by Lenos Trigeorgis, Westport,Connecticut,London*. pp. 89–107.

Kulatilaka, Nalin, Balasubramanian, P. & Storck, John, 1999. Using Real Options to frame the IT investment problem. In Lenos Trigeorgis, ed. *Real Options and Business strategy,Applications to decision making*. London: Risk Books.

Kulatilaka, Nalin & Venkatraman, N., 2001. Strategic options in the Digital Era. *Business Strategy Review*, 12(4), pp.7–15.

Kumar, R., 1999. Understanding DSS value: an options perspective. *Omega ,The International Journal of Management Science*, 27(3), pp.295–304.

Kumar, R.L., 1996. A Note on Project Risk and Option Values of Investments in Information Technologies. *Journal of Management Information Systems*, 13(1), pp.187–193.

Kumar, R.L., 2002. Managing risks in IT projects : an options perspective. *Information & Management*, 40(1), pp.63–74.

Lankton, N. & Luft, J., 2008. Uncertainty and Industry Structure Effects on Managerial Intuition About Information Technology Real Options. *Journal of Management Information Systems*, 25(2), pp.203–240.

Laudon, K.C. & Laudon, J.P., 2006. *Management Information Systems-Managing the Digital firm* Ninth. Bob Horan, ed., New Jersey.: Pearson Prentice Hall.

Lee, G. & Xia, W., 2006. Organizational size and IT innovation adoption: A meta-analysis. *Information & Management*, 43(8), pp.975–985.

Lee, H.L., 2007. Peering through a gleass darkly. *International Commerce Review*, 7(1), pp.60–68.

Lee, I. & Lee, B.-C., 2010. An investment evaluation of supply chain RFID technologies: A normative modeling approach. *International Journal of Production Economics*, 125(2), pp.313–323.

Lee, J.W. & Kim, S.H., 2000. Using analytic network process and goal programming for interdependent information system project selection. *Computers & Operations Research*, 27(4), pp.367–382.

Lee, K.-J., Shyu, D.S. & Dai, M.-L.D., 2009. The Valuation of Information Technology Investments by Real Options Analysis. *Review of Pacific Basin Financial Markets and Policies*, 12(4), pp.611–628.

Lee, L.S., Fiedler, K.D. & Smith, J.S., 2008. Radio frequency identification (RFID) implementation in the service sector: A customer-facing diffusion model. *International Journal of Production Economics*, 112(2), pp.587–600.

Lee, Y.-C. & Lee, S.-S., 2011. The valuation of RFID investment using fuzzy real option. *Expert Systems with Applications*, 38(10), pp.12195–12201.

Leimeister, S. et al., 2009. A cross-national comparison of perceived strategic importance of RFID for CIOs in Germany and Italy. *International Journal of Information Management*, 29(1), pp.37–47.

Leonard-Barton, D., 1990. A dual methodology for case studies: synergistic use of longitudinal single site with replicated multiple sites. *Organization Science*, 1(2).

Leonard-Barton, D., 1988. Implementation as Mutual Adaptation of Technology and Organisation. *Research Poliy*, 17, pp.251–267.

Levinthal, D.A. & March, J.G., 1993. The Myopia of Learning. *Strategic Management Journal*, 14, pp.95–112.

Li, X., 2009. Preemptive Learning, Competency Traps, and Information Technology Adoption: A Real Options Analysis. *IEEE Transactions on Engineering Management*, 56(4), pp.650–662.

Li, X. & Johnson, J.D., 2002. Evaluate IT investment Opportunities Using Real Options Theory. *Information resources Management Journal*, 15(3), pp.32–47.

Liesio, J., Mild, P. & Salo, a, 2008. Robust portfolio modeling with incomplete cost information and project interdependencies. *European Journal of Operational Research*, 190(3), pp.679–695.

Lin, C.-Y., 2009. An Empirical Study on Organizational Determinants of RFID Adoption in the Logistics Industry. *Journal of technology management & innovation*, 4(1), pp.1–8.

Lin, C.-Y. & Ho, Y.-H., 2009. RFID technology adoption and supply chain performance: an empirical study in China's logistics industry. *Supply Chain Management: An International Journal*, 14(5), pp.369–378.

Lucas, H.C., 1999. *Information Technology and the Productivity Paradox.*, New York: Oxford University Press.

MacMillan, I.C. et al., 2006. Using Real Options Discipline for Highly Uncertain Technology Investments. *Reseach Technology Management*, 49(1), pp.29–38.

Mahmood, M.A. & Soon, S.K., 1991. A Comprehensive Model for Measuring the Potential Impact of Information Technology on Organizational Strategic Variables. *Decision Sciences*, 22(4), pp.869–897.

Margrabe, W., 1978. The value of an option to exchange one asset for another. *The Journal of Finance*, XXXIII(I), pp.177–186.

McGrath, R.G., 1997. A Real Options Logic for Initiating Technology Positioning Investments. *Academy of Management Review*, 22(4), p.974.

McGrath, R.G., 1999. Falling Forward:Real Options Reasoning and Enterpreneurial Failure. *The Academy of Management Review*, 24(1), pp.13–30.

McGrath, R.G., Ferrier, W.J. & Mendelow, A.L., 2004. Real Options as engines of choice and heterogeneity. *Academy of Management Review*, 29(1), pp.86–101.

McGrath, R.G. & MacMillan, I.C., 2000. Assessing technology projects using Real Options Reasoning. *Reseach Technology Management*, pp.35–49.

Mejza, M.C. & Wisner, J.D., 2001. The Scope and Span of Supply Chain Management. *The International Journal of Logistics Management*, 12(2), pp.37 – 55.

Miller, K.D. & Shapira, Z., 2004. An empirical test of heuristics and biases affecting real option valuation. *Strategic Management Journal*, 25(3), pp.269–284.

Mokhlis, S., Salleh, H.S. & Mat, N.H.N., 2009. Commercial Bank Selection : Comparison between Single and Multiple Bank Users in Malaysia. *International Journal of Economics and Finance*, 1(2), pp.263–273.

Moon, K.L. & Ngai, E.W.T., 2008. The adoption of RFID in fashion retailing: a business value-added framework. *Industrial Management & Data Systems*, 108(5), pp.596–612.

Moosmayer, D.C. & Koehn, A., 2011. THE MODERATING ROLE OF MANAGERS' UNCERTAINTY AVOIDANCE VALUES ON THE PERFORMANCE IMPACT OF RADICAL AND INCREMENTAL INNOVATION. *International Journal of Business Research*, 11(6), pp.32–40.

Myers, M.D., 1997. Qualitative Research in Information Systems. *MIS Quarterly*, (June), pp.241–242.

Myers, S.C., 1977. Determinants of Corporate Borrowing. *Journal of Financial Economics*, 5(2), pp.147–175.

Ngai, E.W.T., Moon, K.K.L., Liu, J., et al., 2008. Extending CRM in the Retail Industry: An RFID-Based Personal Shopping Assistant System. *Communications of the Association for Information Systems*, 23(16).

Ngai, E.W.T., Moon, K.K.L., Riggins, F.J., et al., 2008. RFID research: An academic literature review (1995–2005) and future research directions. *International Journal of Production Economics*, 112(2), pp.510–520.

Ngai, Eric W.T., Chau, D.C.K. & Chan, T.L.A., 2011. Information technology, operational, and management competencies for supply chain agility: Findings from case studies. *The Journal of Strategic Information Systems*, 20, pp.232–249.

Oh, W. & Pinsonneault, A., 2007. On the assessment of the strategic value of information technologies: Conceptual and analytical approaches. *MIS Quarterly*, 31(2), pp.239–265.

Oliveira, T. & Martins, M.F., 2011. Literature Review of Information Technology Adoption Models at Firm Level. *The Electronic Journal Information Systems Evaluation*, 14(1), pp.110–121.

Orlikowski, W.J., 1996. Improvising Organizational Transformation Over Time : A Situated Change Perspective. *Information Systems Research*, 7(1).

Orlikowski, W.J. & Iacono, C.Su., 2001. Research Commentary: Desperately Seeking the "IT" in IT Research- A call to Theorizing the IT Artifact. *Information Systems Management*, 12(2), pp.121–134.

Özogul, C.O., Karsak, E.E. & Tolga, E., 2009. A real options approach for evaluation and justification of a hospital information system. *Journal of Systems and Software*, 82(12), pp.2091–2102.

Pallant, J., 2005. Logistic regression (Ch 14). In *SPSS survival manual*. Sydney: Allen & Unwin.

Palvia, P.C., 1997. Developing a model of the global and strategic impact of information technology. *Information & Management*, 32(5), pp.229–244.

Pan, M. & Jang, W.-Y., 2008. DETERMINANTS OF THE ADOPTION OF ENTERPRISE RESOURCE PLANNING WITHIN THE TECHNOLOGY- ORGANIZATION-ENVIRONMENT FRAMEWORK : TAIWAN ' S COMMUNICATIONS INDUSTRY. *Journal of Computer Information Systems*, 48(3), pp.94–102.

Panayi, S. & Trigeorgis, Lenos, 1998. Multi-Stage Real Options : The Cases of Information Technology Infrastructure and International Bank Expansion. *The Quarterly Review of Economics and Finance*, 38(Special issue), pp.675–692.

Patil, M., 2004. Investments in RFID : A Real Options Approach. *A Patni White Paper*.

Pendharkar, P.C., 2010. Valuing interdependent multi-stage IT investments: A real options approach. *European Journal of Operational Research*, 201(3), pp.847–859.

Petter, S., Straub, D. & Rai, A., 2007. Specifying Formative Constructs in Information Systems Research. *MIS Quarterly*, 31(4), pp.623–656.

Podsakoff, P.M. et al., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *The Journal of applied psychology*, 88(5), pp.879–903.

Porter, M.E., 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*, New York: Free Press.

Porter, M.E., 2001. Strategy and the Internet. *Harvard Business Review*, (March), pp.62–78.

Prajogo, D. & Olhager, J., 2011. Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. *International Journal of Production Economics*, 135(1), pp.522–514.

Pramatari, K.C., Doukidis, G.J. & Kourouthanassis, P., 2005. Towards “smarter” supply and demand-chain collaboration practices enabled by RFID technology. In P. K. and P. L. F. (eds. . Vervest P., V.H.E., ed. *Smart Business Networks*. Springer Verlag.

Pramatari, Katerina, 2007. Collaborative supply chain practices and evolving technological approaches. *Supply Chain Management: An International Journal*, 12(3), pp.210–220.

Pramatari, Katerina, Evgeniou, T. & Doukidis, Georgios, 2009. Implementation of collaborative e-supply-chain initiatives: *Journal of Information Technology*, 24(3), pp.269–281.

Presley, A., 2006. ERP investment analysis using the strategic alignment model. *Management Research News*, 29(5), pp.273–284.

Ramamurthy, K. (Ram), Sen, A. & Sinha, A.P., 2008. An empirical investigation of the key determinants of data warehouse adoption. *Decision Support Systems*, 44(4), pp.817–841.

Ranganathan, C., Dhaliwal, J.S. & Teo, T.S.H., 2004. Assimilation and Diffusion of Web Technologies in Supply- Chain Management: An Examination of Key Drivers and Performance Impacts. *International Journal of Electronic Commerce*, 9(1), pp.127–161.

Rekik, Y., Sahin, E. & Dallery, Y., 2008. Analysis of the impact of the RFID technology on reducing product misplacement errors at retail stores☆. *International Journal of Production Economics*, 112(1), pp.264–278.

Ringle, C.M., Sarstedt, M. & Straub, D., 2012. A Critical look at the Use of PLS-SEM in MIS Quarterly. *MIS Quarterly*, 36(1), pp.iii–xiv.

Rogers, E.M., 1995. *Diffusion of Innovations* Fourth Edi., Free Press.

Roh, J.J., Kunnathur, A. & Tarafdar, M., 2009. Classification of RFID adoption: An expected benefits approach. *Information & Management*, 46(6), pp.357–363.

Rossiter, J.R., 2002. The C-OAR-SE procedure for scale development in marketing. *International Journal of Research in Marketing*, 19(4), pp.305–335.

Roussos, G. et al., 2002. A case study in pervasive retail. In *2nd ACM International Workshop on Mobile Commerce*. pp. 90–95.

Santhanam, R. & Kyparisis, G.J., 1996. Theory and Methodology A decision model for interdependent information system project selection. *European Journal Of Operational Research*, 89(2), pp.380–399.

Dos Santos, B.L., 1991. Justifying Investments in New Information Technologies. *Journal of Management Information Systems*, 7(4), pp.71–90.

Sanyal, S. & Sett, P.K., 2011. Applying real options theory to HRM: an empirical study of IT software firms in India. *The International Journal of Human Resource Management*, 22(1), pp.72–102.

Sarstedt, M. & Ringle, C.M., 2011. Multigroup analysis in partial least squares (pls) path modeling : Alternative methods and empirical results. *Measurement and Research Methods in International Marketing*, 22, pp.195–218.

Saunders, M.N.K., Lewis, P. & Thornhill, A., 2003. *Research methods for business students* 3rd ed., Harlow: FT Prentice Hall.

Saya, S., Pee, L.G. & Kankanhalli, A., 2010. The impact of Institutional influences on perceived technological characteristics and real options in cloud computing adoption. In *Thirty First International Conference on Information Systems (ICIS)*.

Scarso, E., 1996. Timing the adoption of a new technology: an option-based approach. *Management Decision*, 34(3), pp.41–48.

Schilling, M. a., 1998. Technological Lockout: An Integrative Model of the Economic and Strategic Factors Driving Technology Success and Failure. *The Academy of Management Review*, 23(2), p.267.

Schwartz, E.S. & Zozaya-Gorostiza, C., 2003. Investment Under Uncertainty in Information Technology: Acquisition and Development Projects. *Management Science*, 49(1), pp.57–70.

Sharif, A.M. & Irani, Zahir, 2006. Exploring Fuzzy Cognitive Mapping for IS Evaluation. *European Journal of Operational Research*, 173(3), pp.1175–1187.

Slack, N., Chambers, S. & Johnston, R., 2001. *Operations management* 3rd ed., Englewood Cliffs, NJ: Prentice-Hall.

Small, M.H. & Chen, I.J., 1997. Economic and strategic justification of AMT inferences from industrial practices. *International Journal of Production Economics*, 49(1), pp.65–75.

Smit, H.T.J. & Trigeorgis, Lenos, 2006. Real options and games: Competition, alliances and other applications of valuation and strategy. *Review of Financial Economics*, 15(2), pp.95–112.

Smit, H.T.J. & Trigeorgis, Lenos, 2007. Strategic Options and Games in Analysing Dynamic Technology Investments. *Long Range Planning*, 40(1), pp.84–114.

Sobel, M.E., 1982. Asymptotic confidence intervals for indirect effects in structural equation models S. Leinhardt, ed. *Sociological Methodology*, 13(1982), pp.290–312.

Spanos, Y.E. & Lioukas, S., 2001. An examination into the causal logic of rent generation: contrasting Porter’s competitive strategy framework and the resource-based perspective. *Strategic Management Journal*, 22(10), pp.907–934.

Strader, T.J., Ramaswami, S.N. & Houle, P. a, 2007. Perceived network externalities and communication technology acceptance. *European Journal of Information Systems*, 16(1), pp.54–65.

Straub, D.W., 1989. Validating Instruments in MIS Research. *MIS Quarterly*, 13(2), pp.147–169.

Su, N. et al., 2009. Shared Services Transformation: Conceptualization and Valuation from the Perspective of Real Options. *Decision Sciences*, 40(3), pp.381–402.

Subirana, B. et al., 2003. Measuring the Impact of Information Technology on Value and Productivity using a Process-Based Approach : The case for RFID Technologies. *MIT Sloan Working Paper.*, (Working paper No.4450-03), pp.1–23.

Subramaniam, M. & Youndt, M. a., 2005. the Influence of Intellectual Capital on the Types of Innovative Capabilities. *Academy of Management Journal*, 48(3), pp.450–463.

Tabachnick, B.G. & Fidell, L.S., 2001. Chapter 13. In *Using Multivariate Statistics*. New York: HarperCollins.

Tallon, P.P. et al., 2002. Using Real Options Analysis for evaluating uncertain investments in information technology : insights from the ICIS 2001 debate. *Communications of the Association for Information Systems*, 9, pp.136–167.

Tallon, P.P. & Pinsonneault, A., 2011. Competing perspectives on the link between strategic information technology alignment and organisational agility: Insights from a mediation model. *MIS Quarterly*, 35(2), pp.463–486.

Taudes, A., 1998. Software growth options. *Journal of Management Information Systems*, 15(1), pp.165–185.

Taudes, A., Feurstein, M. & Mild, A., 2000. Option analysis of software platform decisions: a case study. *MIS Quarterly*, 24(2), pp.227–243.

Thiesse, F. et al., 2011. The rise of the “next-generation bar code”: an international RFID adoption study. *Supply Chain Management: An International Journal*, 16(5), pp.328–345.

Thong, J.Y.L., 1999. An Integrated Model of Information Systems Adoption in Small Businesses. *Journal of Management Information Systems*, 15(4), pp.187–214.

Tiwana, A. et al., 2007. The Bounded Rationality Bias in Managerial Valuation of Real Options: Theory and Evidence from IT Projects. *Decision Sciences*, 38(1), pp.157–181.

Tiwana, A., Keil, Mark & Fichman, R.G., 2006. Information Systems project Continuation in Escalation Situations : A Real Options Model. *Decision Sciences*, 37(3), pp.357–392.

Tornatzky, L.G. & Fleischer, M., 1990. *The Processes of Technological Innovation* A. K. Chakrabarti, ed., Lexington Books.

Tourangeau, R., Rips, L.J. & Rasinski, K., 2000. *The Psychology of Survey Response*, England: Cambridge University Press.

Trigeorgis, L., 1996. *Real Options: Managerial Flexibility and Strategy in Resource Allocation.*, MIT Press. Cambridge, Massachusetts.

Trigeorgis, Lenos, 1993. The Nature of Option Interaotions and the Valuation of Investments with Multiple Real Options. *Journal of Financial and Quantitative Analysis*, 28(1).

Tsai, M.-C., Lai, K.-H. & Hsu, W.-C., 2012. A study on the institutional forces influencing the adoption intention of RFID by suppliers. *Information & Management*, null(null).

Tsai, M.-C., Lee, W. & Wu, H.-C., 2010. Determinants of RFID adoption intention: Evidence from Taiwanese retail chains. *Information & Management*, 47(5-6), pp.255–261.

Tsekrekos, A.E., 2003. The effect of first-mover's advantages on the strategic exercise of real options. In Dean A. Paxson, ed. *Real R&D Options*. Great Britain: Butterworth Heinemann,Elsevier Science Ltd., pp. 185–207.

Tseng, M.-L., Wu, K.-J. & Nguyen, T.T., 2011. Information technology in supply chain management: a case study. *Procedia - Social and Behavioral Sciences*, 25, pp.257–272.

Turban, E. & Volonino, L., 2010. *Information Technology for Management: Transforming Organisation in the Digital Economy* 7th Editio., John Wiley & Sons Inc.

Turner, J. & Lucas, H.C.J., 1985. *Developing strategic information systems*, Boston, MA.: Guth,W. (Ed.), Handbook of Business Strategy, Chapter 21, Warren, Gorham and Lamont.

Tzeng, S.-F., Chen, W.-H. & Pai, F.-Y., 2008. Evaluating the business value of RFID: Evidence from five case studies. *International Journal of Production Economics*, 112(2), pp.601–613.

Uhrich, F. et al., 2008. *RFID in Retailing and Customer Relationship Management*,

Ustundag, A., Kılınç, M.S. & Cevikcan, E., 2010. Fuzzy rule-based system for the economic analysis of RFID investments. *Expert Systems with Applications*, 37(7), pp.5300–5306.

Venkatraman, N., 1991. IT-Induced Business Reconfiguration. In M. S. Scott Morton, ed. *The Corporation of the 1990s Information Technology and Organizational Transformation*. Oxford University Press, pp. 122–158.

Venkatraman, N., Henderson, J.C. & Oldach, S., 1993. Continuous strategic alignment: Exploiting information technology capabilities for competitive success. *European Management Journal*, 11(2), pp.139–149.

Verdu, A.J., Tamayo, I. & Ruiz-Moreno, A., 2012. The moderating effect of environmental uncertainty on the relationship between real options and technological innovation in high-tech firms. *Technovation*, 32(9-10), p.Available online 22 June 2012. http://dx.doi.org/1.

Verma, D. & Sinha, K.K., 2002. Toward a theory of project interdependencies in high tech R & D environments. *Journal of Operations Management*, 20(5), pp.451–468.

Vijayaraman, B.S., Osyk, B. a & Chavada, D., 2008. An Exploratory Study of RFID Adoption in the Paperboard Packaging Industry. *Journal of technology management & innovation*, 3(4), pp.95–111.

Violino, B., 2005. Leveraging the Internet of things. *RFID Journal*, November/D, pp.1–2.

Voudouris, I. et al., 2012. Effectiveness of technology investment: Impact of internal technological capability, networking and investment's strategic importance. *Technovation*, 32(6), pp.400–414.

Wamba, S.F. et al., 2008. Exploring the impact of RFID technology and the EPC network on mobile B2B eCommerce: A case study in the retail industry. *International Journal of Production Economics*, 112(2), pp.614–629.

Wang, S.-J., Liu, S.-F. & Wang, W.-L., 2008. The simulated impact of RFID-enabled supply chain on pull-based inventory replenishment in TFT-LCD industry. *International Journal of Production Economics*, 112(2), pp.570–586.

Wang, Y.-M., Wang, Y.-S. & Yang, Y.-F., 2010. Understanding the determinants of RFID adoption in the manufacturing industry. *Technological Forecasting and Social Change*, 77(5), pp.803–815.

Weill, P., 1992. The Relationship Between Investment in Information Technology and Firm Performance: A Study of the Valve Manufacturing Sector. *Information Systems Research*, 3(4), pp.307–333.

Whang, S., 1992. Contracting for Software Development. *Management Science*, 38(3), pp.307–324.

Wickramatillake, C.D. et al., 2007. Measuring performance within the supply chain of a large scale project. *Supply Chain Management: An International Journal*, 12(1), pp.52–59.

Williamson, E.A., Harrison, D.K. & Jordan, M., 2004. Information systems development within supply chain management. *International Journal of Information Management*, 24, pp.375–385.

Wolfe, A., 1994. Organisational innovation: Review, critique and suggested research directions. *Journal of Management*, 31(3), pp.405–431.

Wu, F. et al., 2008. An approach to the valuation and decision of ERP investment projects based on real options. *Annals of Operations Research*, 168(1), pp.181–203.

Wu, Fang et al., 2006. The impact of information technology on supply chain capabilities and firm performance: A resource-based view. *Industrial Marketing Management*, 35(4), pp.493–504.

Wu, L., Ong, C. & Hsu, Y., 2008. Active ERP implementation management: A Real Options perspective. *Journal of Systems and Software*, 81(6), pp.1039–1050.

Wu, L.C. & Ong, C.S., 2008. Management of information technology investment: A framework based on a Real Options and Mean–Variance theory perspective. *Technovation*, 28(3), pp.122–134.

Wu, Xiaodan, Yue, D. & Bai, J., 2009. A real options approach to strategic RFID investment decision. *2009 IEEE International Conference on RFID*, pp.314–321.

Wu, Xiaoran & Subramaniam, C., 2009. New Understanding of RFID Adoption and Infusion in Retail Supply Chain Xiaoran Wu Chandrasekar Subramaniam The Belk College of Business. *42nd Hawaii International Conference on System Sciences*, pp.1–10.

Yauch, C. a. & Steudel, H.J., 2003. Complementary Use of Qualitative and Quantitative Cultural Assessment Methods. *Organizational Research Methods*, 6(4), pp.465–481.

Yavas, A. & Sirmans, C.F., 2005. Real Options: Experimental Evidence. *The Journal of Real Estate Finance and Economics*, 31(1), pp.27–52.

Yeo, K. & Qiu, F., 2003. The value of management flexibility—a real option approach to investment evaluation. *International Journal of Project Management*, 21(4), pp.243–250.

Yin, R., 2009. *Case Study Research -Design and Methods* Fourth Edi., SAGE Publications.

Yourdon, E., 1989. *Modern Structured Analysis*, New Jersey: Yourdon Press, Prentice-Hall International.

Zahra, S.A. & George, G., 2002. ABSORPTIVE CAPACITY : A REVIEW , RECONCEPTUALIZATION , AND EXTENSION. *Academy of Management Review*, 27(2), pp.185–203.

Zhang, C. & Dhaliwal, J., 2009. An investigation of resource-based and institutional theoretic factors in technology adoption for operations and supply chain management. *International Journal of Production Economics*, 120(1), pp.252–269.

Zhu, K. & Kraemer, K.L., 2005. Post-Adoption Variations in Usage and Value of E-Business by Organizations: Cross-Country Evidence from the Retail Industry. *Information Systems Research*, 16(1), pp.61–84.

APPENDIX 1-PILOT SURVEY

Questionnaire for the pilot survey in Greece

Έρευνα για την τεχνολογία RFID

Αυτή η έρευνα διεξάγεται από το εργαστήριο ELTRUN του Οικονομικού Πανεπιστημίου Αθηνών, στο πλαίσιο του Ευρωπαϊκού ερευνητικού έργου *«RACE Network-RFID in Europe»*, (http://www.race-networkrfid.org). Στόχος της έρευνας είναι **να διερευνήσει τις απόψεις των επιχειρήσεων σχετικά την τεχνολογία RFID, τα ενδεχόμενα οφέλη και εμπόδια υλοποίησης καθώς και τις δυνατότητες που έχουν οι ίδιοι οργανισμοί για να υιοθετήσουν αυτήν την τεχνολογία.**

Η ανωνυμία θα διατηρηθεί και όλες σας οι απαντήσεις θα είναι εμπιστευτικές και θα χρησιμοποιηθούν μόνο για τις ανάγκες της έρευνας. Μετά το τέλος της έρευνας αυτής θα σας αποσταλούν τα αποτελέσματα.

ELTRUN
Athens University of Economics & Business

Εργαστήριο Ηλεκτρονικού Επιχειρείν- ELTRUN

Αθήνα, Οκτώβριος 2010

1. Οι παρακάτω ερωτήσεις εξετάζουν το βαθμό εξοικείωσής σας με την τεχνολογία RFID.

Α. Πόσο εξοικειωμένοι είστε με την τεχνολογία RFID; *(Δηλώστε το βαθμό εξοικείωσής σας, επιλέγοντας έναν αριθμό από το 1 μέχρι το 7).*

Δε γνωρίζω για την τεχνολογία RFID	1	2	3	4	5	6	7	Είμαι ειδικός σε θέματα της RFID τεχνολογίας.

Β. Επιλέξτε μια από τις παρακάτω προτάσεις, βάζοντας Χ σε αυτήν που θεωρείτε ότι αντιπροσωπεύει καλύτερα την άποψή σας για την τεχνολογία RFID.

	Η τεχνολογία RFID μπορεί να υποστηρίξει μια οικογένεια εφαρμογών και επιχειρηματικών διαδικασιών χρησιμοποιώντας μια κοινή υποδομή (ετικέτες, αναγνώστες κλπ.)
	Η τεχνολογία RFID μπορεί να υποστηρίξει μια μεμονωμένη εφαρμογή στο πλαίσιο μιας συγκεκριμένης επιχειρηματικής διαδικασίας.

2. Οι παρακάτω ερωτήσεις εξετάζουν το επενδυτικό ενδιαφέρον της εταιρείας σας για την τεχνολογία RFID καθώς και την αξία που προσδίδετε σε αυτήν.

Α. Η τεχνολογία RFID θα προσθέσει αξία στην εταιρεία σας; Επιλέξτε ένα νούμερο από το 1 μέχρι το 7 ανάλογα με το επίπεδο της αξίας που θεωρείτε ότι έχει η RFID τεχνολογία.

Πιστεύω οτι η τεχνολογία RFID δε θα προσθέσει αξία στην εταιρεία μου	1	2	3	4	5	6	7	Πιστεύω οτι η τεχνολογία RFID θα προσθέσει αξία στην εταιρεία μου

Β. Σκοπεύετε να επενδύσετε στην τεχνολογία RFID;

Δε σκοπεύω να επενδύσω στην τεχνολογία RFID	1	2	3	4	5	6	7	Σκοπεύω να επενδύσω στην τεχνολογία RFID

Γ. Αν σκοπεύετε να επενδύσετε στην τεχνολογία RFID, πότε σκέπτεστε να το κάνετε αυτό;

Στο άμεσο μέλλον	1	2	3	4	5	6	7	Μετά από αρκετά χρόνια

Με βάση την απάντησή σας στην προηγούμενη ερώτηση 2Γ αναφέρετε το κατά πόσο συμφωνείτε με τις παρακάτω προτάσεις. Η εταιρεία μου θα επενδύσει στο άμεσο μέλλον στην τεχνολογία RFID λόγω:	Διαφωνώ απόλυτα			Είμαι ουδέτερος/η			Συμφωνώ απόλυτα
του πλεονεκτήματος που θα κερδίσει αν επενδύσει από τους πρώτους	1	2	3	4	5	6	7
της υψηλής πίεσης από τους ανταγωνιστές μας στη βιομηχανία	1	2	3	4	5	6	7
των μελλοντικών εφαρμογών που μπορούν να προκύψουν από μια αρχική επένδυση στην τεχνολογία RFID	1	2	3	4	5	6	7
Με βάση την απάντησή σας στην προηγούμενη ερώτηση 2Γ αναφέρετε το κατά πόσο συμφωνείτε με τις παρακάτω προτάσεις. Η εταιρεία μου θα καθυστερήσει για πολλά χρόνια την επένδυσή της στην τεχνολογία RFID για να:							
περιμένει να μειωθεί η αβεβαιότητα που υπάρχει για την τεχνολογία RFID	1	2	3	4	5	6	7
περιμένει να μειωθεί το κόστος της τεχνολογίας RFID	1	2	3	4	5	6	7
αποκτήσει περισσότερη πληροφόρηση για την τεχνολογία RFID	1	2	3	4	5	6	7

Παρακαλώ αναφέρετε κατά πόσο διαφωνείτε ή συμφωνείτε με τις παρακάτω προτάσεις , σχετικά με την επίδραση της τεχνολογίας RFID και τις δυνατότητες του οργανισμού σας για να την υλοποιήσει.	Διαφωνώ απόλυτα			Είμαι ουδέτερος/η			Συμφωνώ απόλυτα
Η RFID τεχνολογία θα δημιουργήσει θεμελιώδεις αλλαγές στις επιχειρηματικές διαδικασίες του οργανισμού μου.	1	2	3	4	5	6	7
Η επιβάρυνση της εταιρείας μου για την απαιτούμενη τεχνική εκπαίδευση και γνώση σχετική με την υλοποίηση της τεχνολογίας RFID θα είναι χαμηλή.	1	2	3	4	5	6	7
Η αξία της τεχνολογίας RFID θα αυξηθεί όσο αυξάνεται και ο αριθμός των εταιρειών που την υλοποιούν.	1	2	3	4	5	6	7
Η τεχνολογία RFID πρόκειται να αποκτήσει ηγετική θέση σε σχέση με άλλες παρόμοιες τεχνολογίες, όπως η barcode τεχνολογία.	1	2	3	4	5	6	7
Μια επένδυση στην τεχνολογία RFID μπορεί να υποστηρίξει πλήθος εφαρμογών και διαφορετικές επιχειρηματικές διαδικασίες.	1	2	3	4	5	6	7
Η υλοποίηση της τεχνολογίας RFID μπορεί να πραγματοποιηθεί σταδιακά. Ένα αρχικό στάδιο υλοποίησης μπορεί να προσφέρει επιχειρηματικά οφέλη ακόμη και αν δεν υλοποιηθούν και τα επόμενα στάδια.	1	2	3	4	5	6	7
Η RFID τεχνολογία έχει στρατηγική σημασία για την επιχείρησή μου.	1	2	3	4	5	6	7
Τα αναμενόμενα οφέλη που μπορεί η τεχνολογία RFID να προσφέρει για τα σημαντικά προϊόντα/υπηρεσίες της εταιρείας μου, θα είναι δύσκολο να αντιγραφθούν από ανταγωνιστές.	1	2	3	4	5	6	7
Η εταιρεία μου έχει τους απαραίτητους πόρους (π.χ. τεχνικές δεξιότητες, ανθρώπινο δυναμικό) για μια αποτελεσματική υλοποίηση της τεχνολογίας RFID.	1	2	3	4	5	6	7
Η εταιρεία μου κατέχει την απαραίτητη γνώση, τις δεξιότητες και το κίνητρο για να εκπαιδευτεί και να "μάθει" μέσα από την υλοποίηση της τεχνολογίας RFID.	1	2	3	4	5	6	7
Μέσω της επένδυσης στην τεχνολογία RFID, η εταιρεία μου μπορεί να επεκτείνει τις γνώσεις και τις δεξιότητές της και τη δυνατότητα να τις χρησιμοποιήσει μελλοντικά σε άλλα πεδία και τεχνολογικές εφαρμογές.	1	2	3	4	5	6	7
Παρακαλώ αναφέρετε κατά πόσο διαφωνείτε ή συμφωνείτε με τις παρακάτω προτάσεις, σχετικά με τα πιθανά οφέλη ή εμπόδια υλοποίησης της τεχνολογίας RFID.							
Το κόστος της εκπαίδευσης και της οργάνωσης του ανθρώπινου δυναμικού για την υλοποίηση της τεχνολογίας RFID στην εταιρεία μου είναι μεγάλο.	1	2	3	4	5	6	7
Το κόστος της υποδομής της τεχνολογίας RFID για την εταιρεία μου είναι υψηλό.	1	2	3	4	5	6	7
Το κόστος των τεχνολογιών που χρειάζονται για την υποστήριξη της τεχνολογίας είναι υψηλό.	1	2	3	4	5	6	7
Δεν έχουν καθιερωθεί ακόμη διεθνή πρότυπα για την εφαρμογή της τεχνολογίας RFID.	1	2	3	4	5	6	7
Το γεγονός οτι η τεχνολογία RFID μπορεί να υλοποιηθεί με διαφορετικούς τρόπους και συνδυασμούς, αυξάνει την αβεβαιότητα σχετικά με το ποιός από αυτούς τους τρόπους είναι ο καλύτερος.	1	2	3	4	5	6	7
Είναι δύσκολο να εκτιμηθεί το κόστος και το όφελος που μπορούν να προκύψουν από την εφαρμογή της τεχνολογίας RFID.	1	2	3	4	5	6	7
Η τεχνολογία RFID πρόκειται να βοηθήσει την εταιρεία μου να βελτιώσει:							
Τη σχέση της με τις εταιρείες με τις οποίες συνεργάζεται	1	2	3	4	5	6	7
Την ενοποίηση της εφοδιαστικής της αλυσίδας στην οποία ανήκει	1	2	3	4	5	6	7
Τη δυνατότητα παρακολούθησης των αποθεμάτων της	1	2	3	4	5	6	7
Την αποδοτικότητά της (π.χ. αποδοτικότητα των υπαλλήλων στην παραλαβή παραγγελιών)	1	2	3	4	5	6	7

Την αυτοματοποίηση των επιχειρηματικών της διαδικασιών	1	2	3	4	5	6	7
Τον εντοπισμό των αντικειμένων της εταιρείας (π.χ. προϊόντων, περιουσιακών στοιχείων)	1	2	3	4	5	6	7
Τη διαχείριση της αποθήκης της (π.χ. τη μείωση των ελλείψεων στα προϊόντα)	1	2	3	4	5	6	7
Την ασφάλεια και τη μείωση των κλοπών	1	2	3	4	5	6	7
Τη μείωση των λαθών των επιχειρηματικών της διαδικασιών	1	2	3	4	5	6	7
Τη δυνατότητά της να είναι πιο ανταγωνιστική	1	2	3	4	5	6	7
Την ποιότητα των υπηρεσιών της προς τους πελάτες της	1	2	3	4	5	6	7
Τη ποιότητα της πληροφορίας	1	2	3	4	5	6	7
Τη ρευστότητά της	1	2	3	4	5	6	7
Τη μείωση του κόστους	1	2	3	4	5	6	7
Την επιχειρηματική της ευελιξία (π.χ. δυνατότητα να επενδύσει σε διαφορετικούς συνδυασμούς επιχειρηματικών εφαρμογών της τεχνολογίας RFID)	1	2	3	4	5	6	7
Παρακαλώ αναφέρετε κατά πόσο διαφωνείτε ή συμφωνείτε με τις παρακάτω προτάσεις, σχετικά με την υιοθέτηση της τεχνολογίας RFID από την αγορά.							
Η μελλοντική ζήτηση για την τεχνολογία RFID θα είναι μεγάλη.	1	2	3	4	5	6	7
Οι ανταγωνιστές της εταιρείας μου έχουν ήδη υλοποιήσει την τεχνολογία RFID.	1	2	3	4	5	6	7
Ο ανταγωνισμός που αντιμετωπίζει η εταιρεία μου είναι μεγάλος.	1	2	3	4	5	6	7
Η εταιρεία μου πρόκειται να υιοθετήσει την τεχνολογία RFID με στόχο να διατηρήσει την ανταγωνιστικότητά της στην αγορά.	1	2	3	4	5	6	7
Οι εταιρείες με τις οποίες συνεργάζεται η επιχείρησή μου χρησιμοποιούν ήδη την τεχνολογία RFID.	1	2	3	4	5	6	7
Η εταιρεία μου πρόκειται να υιοθετήσει την τεχνολογία RFID λόγω της πίεσης που δέχεται από τις επιχειρήσεις με τις οποίες συνεργάζεται, σχετικά με την ανάγκη χρήσης αυτής τεχνολογίας.	1	2	3	4	5	6	7
Οι επιχειρήσεις με τις οποίες συνεργάζεται η εταιρεία μου είναι έτοιμες να υιοθετήσουν την τεχνολογία RFID, όταν η εταιρεία μου επενδύσει σε αυτήν.	1	2	3	4	5	6	7

Δημογραφικά στοιχεία

1. Σε ποιον κλάδο οικονομικής δραστηριότητας ανήκει η εταιρεία σας;

- [ ] Πρωτογενή τομέα
- [ ] Λιανεμπόριο
- [ ] Κατασκευές
- [ ] Ενέργεια
- [ ] Εστιατόρια και ξενοδοχεία
- [ ] Υγεία
- [ ] Πληροφορική και επικοινωνίες
- [ ] Μεταφορές και logistics
- [ ] Δημόσιος τομέας
- [ ] Άλλο:……………………………………………………………………………………………………….

2. Ποιος είναι ο αριθμός των υπαλλήλων που εργάζονται στην εταιρεία σας;

- [ ] <10
- [ ] 10-50
- [ ] 51-250
- [ ] >250

3. **Ποιος είναι κατά μέσο όρο ο τζίρος (σε εκατομμύρια ευρώ) που έχει η εταιρεία σας το χρόνο;**

- [ ] <2
- [ ] 2-5
- [ ] 5-10
- [ ] 10-50
- [ ] >50

4. **Σε ποιό τμήμα της επιχείρησής σας εργάζεστε;**

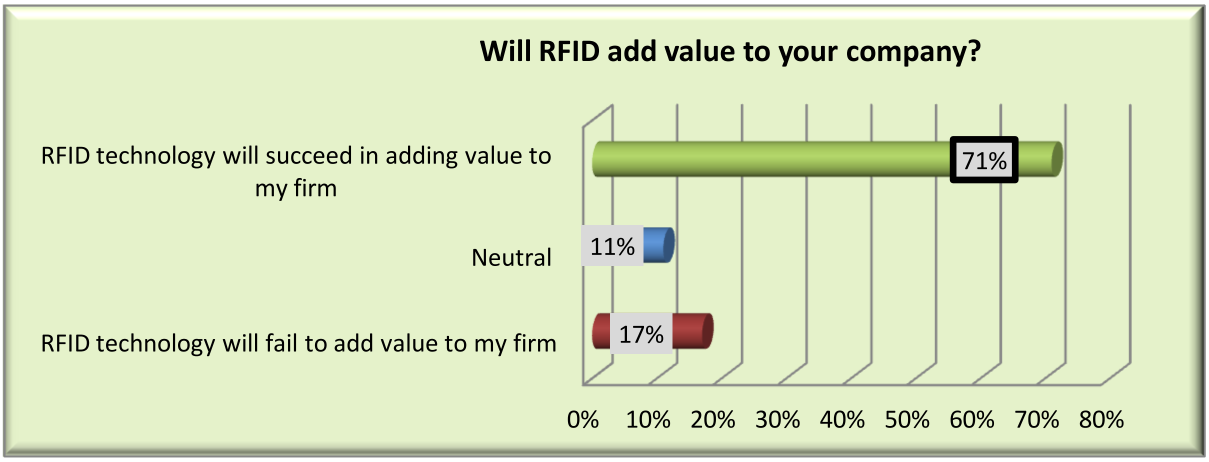
- [ ] Πληροφοριακών συστημάτων/Πληροφορικής
- [ ] Οικονομικών/ Λογιστικής
- [ ] Logistics
- [ ] Marketing και Πωλήσεις
- [ ] Ανθρώπινο Δυναμικό (HR)
- [ ] Διοίκηση
- [ ] Άλλο:………

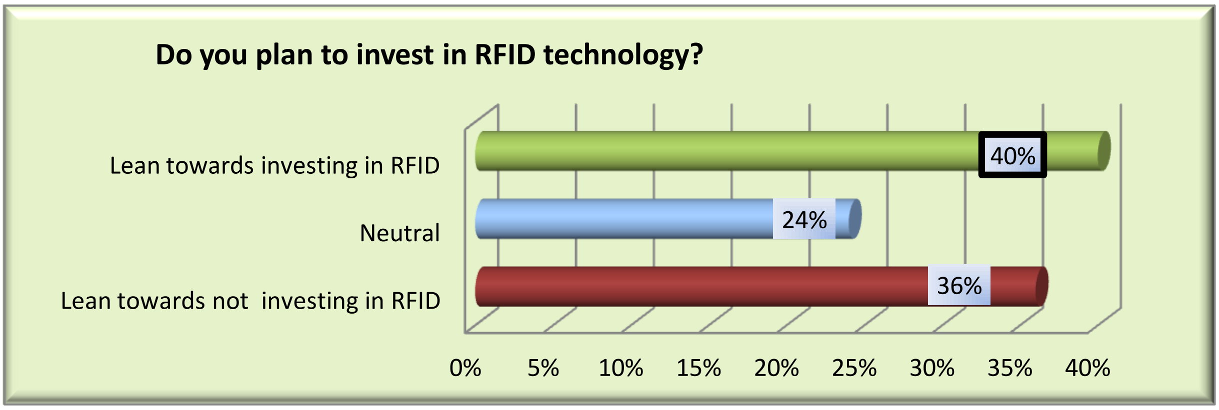
5. **Ποια είναι η θέση σας στην εταιρεία;**

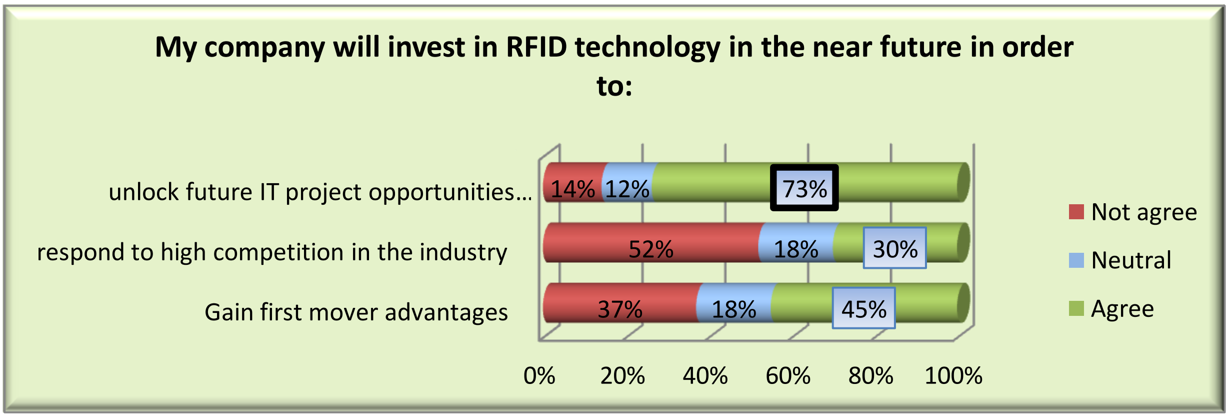
- [ ] Διευθυντής
- [ ] Υποδιευθυντής
- [ ] Προϊστάμενος
- [ ] Υπάλληλος
- [ ] Εξωτερικός συνεργάτης
- [ ] Άλλο:……

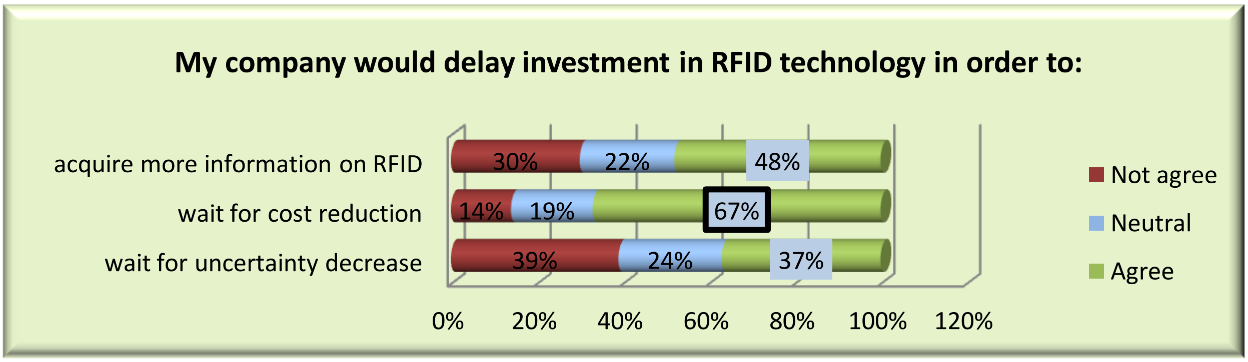
Ευχαριστούμε πολύ για τη συμμετοχή σας.

Indicative descriptive results of the Pilot Study held in Greece









APPENDIX 2- FULL SCALE SURVEY

(a) Questionnaire for the European Field studies II & III

Survey on RFID technology in Europe

This study is conducted by the RFID in Europe Network, an EU sponsored Thematic Network (http://www.race-networkrfid.org) and is intended to monitor the interest and perceptions of European organizations regarding RFID technology.

Anonymity for anyone answering the questionnaire is preserved and all the answers are considered confidential.

Please answer all the questions that follow by indicating the degree you agree or disagree with each statement.

RFID in EUROPE
Raising Awareness and Competitiveness

February, 2011

How familiar are you with RFID technology? (Please select a number from 1 to 7 according to the level of your familiarity)

I don't know anything about RFID technology	1	2	3	4	5	6	7	I am an expert in RFID technology

Has your company deployed or considered to deploy an RFID project? (Please select the application area of the project(s) and the status of deployment)

	Not applicable	Under consideration	Pilot	Roll out
Inbound/Outbound logistics	o	o	o	o
Inventory audit/count	o	o	o	o
Asset tracking	o	o	o	o
Anti-theft control / Security	o	o	o	o
Personnel management	o	o	o	o
Traceability	o	o	o	o
Other	o	o	o	o

Please choose ONE of the above RFID projects that is relevant to your business and use it as a reference when answering the rest of the questionnaire.

What is this project about? (Please choose from the list the main application area of this project)

a) Inbound/Outbound logistics
b) Inventory audit/count
c) Asset tracking
d) Anti-theft control / Security
e) Personnel management
f) Traceability
g) Other

Select which of the following sentences best describes this RFID project.

a) This RFID project supports a family of applications and business processes based on the same platform (tags, readers etc.)
b) This RFID project supports a stand-alone application for a specific business process.

Select which of the following sentences apply regarding the scope of this RFID project.

a) This RFID project is implemented internally by the organisation without the need to collaborate with other supply chain partners.

b) This RFID project is a supply chain project and requires collaboration with the organisation's supply chain partners.

Select which of the following sentences best describes the primary purpose of this project.

a) Strategic, i.e., to provide a competitive advantage
b) Transactional, i.e., to capture and process data related to routine organizational transactions
c) Informational, i.e., to provide information for planning and decision-making

The following questions examine the investment interest and perceived value of this RFID project.

Have you already invested in this RFID project? Yes ☐ No ☐

If no, do you plan to invest in this RFID project?

Lean toward not investing in RFID	1	2	3	4	5	6	7	Lean toward investing in RFID

If you plan to invest in this RFID project, when do you consider to do so?

After many years	1	2	3	4	5	6	7	In the near future (less than one year)

Does this RFID project add value to your organisation?

This RFID project fails to add value to my organisation	1	2	3	4	5	6	7	This RFID project succeeds in adding value to my organisation

Please indicate whether the following parameters are low or high	Low						High
The expected value of the potential returns/payoffs for my organisation as a result of the RFID project deployment is:	1	2	3	4	5	6	7
The quantifiable returns of this RFID project for my organisation are:	1	2	3	4	5	6	7
The intangible benefits of this RFID project for my organisation are:	1	2	3	4	5	6	7
The variance of returns from this RFID project is:	1	2	3	4	5	6	7

Select which of the following sentences best describes the measurable benefits and cost of this RFID project, for your organization.

1	2	3	4	5	6	7
For my organisation this project's *cost* ***greatly exceeds*** *its benefits.*	For my organisation this project's *cost* ***slightly exceeds*** *its benefits*	For my organisation this project's *cost* ***somewhat exceeds*** *its benefits*	For my organisation this project's *cost* ***equals*** *its benefits.*	For my organisation this project's *benefits* ***somewhat exceed*** *its cost.*	For my organisation this project's *benefits* ***slightly exceed*** *its cost.*	For my organisation this project's *benefits* ***greatly*** *exceed its cost.*

Please indicate the degree you agree or disagree with the following statements regarding the impact of RFID and your organization's capabilities.	Strongly Disagree			Neutral			Strongly Agree
This RFID project produces fundamental changes in the activities of my organization	1	2	3	4	5	6	7
This RFID project can be implemented in different ways and feasible configurations	1	2	3	4	5	6	7
The implementation of this RFID project can be completed in stages. Each stage of the implementation can result in a positive payoff, even if no further implementation stages are pursued	1	2	3	4	5	6	7
This RFID project is a necessary foundation for my organisation to develop interrelated follow-on projects in the future.	1	2	3	4	5	6	7
This RFID project has got a strategic importance for my organisation	1	2	3	4	5	6	7
The improvements that this RFID project offers to my organisation will defend against rapid duplication by competitors.	1	2	3	4	5	6	7
My organisation possesses resources (human, technical, organizational) which can contribute to the effective deployment of this RFID project	1	2	3	4	5	6	7
My organization is able to exploit its capabilities (e.g. technologically up-to-date staff, diversity and high degree of organizational skills) in order to learn and gain knowledge through the implementation of this RFID project	1	2	3	4	5	6	7
Through the deployment of this RFID project my organisation will expand its knowledge and skills and acquire the ability to utilize them in other domains	1	2	3	4	5	6	7
The resources (budget, personnel, hardware and software) allocated for this RFID technology project could easily be redeployed for another purpose in my organisation	1	2	3	4	5	6	7
This RFID project can be easily expanded in my organization	1	2	3	4	5	6	7
Please indicate whether the following parameters are low or high	Low						High
For my organisation the burden of the required organizational learning and technical knowledge for the adoption of this RFID project is:	1	2	3	4	5	6	7
The flexibility of my organisation to re-formulate its decisions regarding RFID investment and deployment based on updated information on RFID (e.g. prices, cost of the technology) is:	1	2	3	4	5	6	7

Please indicate the degree you agree or disagree with the following statements regarding the expected barriers associated with RFID technology adoption.	Strongly Disagree			Neutral			Strongly Agree
There is a lack of established standards relating to RFID implementation	1	2	3	4	5	6	7
Many uncertainties regarding RFID implementation could be resolved if the investment in this project was postponed/delayed	1	2	3	4	5	6	7
Please indicate whether the following parameters are low or high	Low						High
The cost of this RFID project for my organization is:	1	2	3	4	5	6	7
The uncertainty regarding how well RFID technology will work during the implementation of this RFID project is:	1	2	3	4	5	6	7
The financial, technical and human resource risks regarding the implementation of this RFID project are:	1	2	3	4	5	6	7
The uncertainty regarding RFID market adoption is:	1	2	3	4	5	6	7

Please indicate the degree you agree or disagree with the following statements regarding the adoption of RFID technology:	Strongly Disagree			Neutral			Strongly Agree
The value of RFID technology will increase as more companies adopt it	1	2	3	4	5	6	7
RFID technology is likely to achieve a dominant position and offer substantial performance over other competing automatic identification technologies (such as barcode technology, smart card technology etc.)	1	2	3	4	5	6	7
My organisation 's competitors already utilize RFID technology	1	2	3	4	5	6	7
The competition in my organisation 's industry is high	1	2	3	4	5	6	7
My organisation is likely to adopt this RFID project in order to maintain its competitiveness in the market	1	2	3	4	5	6	7
My organisation 's business partners already exploit RFID technology	1	2	3	4	5	6	7
My organisation has received pressure by its trading partners for implementing this RFID project	1	2	3	4	5	6	7
My organisation 's business partners are ready to adopt RFID when my organisation is ready to do so	1	2	3	4	5	6	7
Please indicate whether the following parameter is low or high	Low						High
The potential long-term market demand for RFID technology is:	1	2	3	4	5	6	7

Demographics

In what industry /sector does your organisation belong to?

- Primary industry
- Retail
- Wholesale
- Energy
- Restaurants and Hotels
- Health sector
- IT
- Logistics
- Public sector
- Services
- Production
- Construction
- Transmutation Industry
- Recycling and secondary raw material production
- Industry (shipbuilding, chemicals, textiles, tobacco)
- Food and Wine Industry
- FMCG industry (consumer goods except for food and wine)
- Other (please indicate):

What is the number of employees working in your organisation ?

- <10
- 10-50
- 51-250
- >250

What is the average annual turnover (in million Euros) of your organisation ?

- <2
- 2-5
- 5-10
- 10-50
- >50

Which department do you work in?

- IT
- Accounting
- Logistics
- Marketing ,Sales and Services
- Human Resource
- Directors
- Other (please indicate):

What is your position in the organisation ?

- CEO/ owner/ director
- Senior management
- Middle management
- Employee
- External partner
- Other (please indicate):

Please write your country:……………………

Thank you for your participation!

(b) Measures and pertinent literature utilised for the data collection instrument in the field studies.

Variable	Item utilized in this study	Items/definitions proposed by pertinent literature
Real Options	Growth Option: This project is a necessary foundation for my organization to develop interrelated follow-on projects in the future (Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010; Panayi & Lenos Trigeorgis 1998).	<u>3-items scales:</u> ○ (Tiwana et al. 2007) For our organization, this project is: (a) necessary for unlocking future IT project opportunities, (b) a necessary foundation for developing future IT capabilities, (c) first in a chain of interrelated follow-on projects in the future. ○ (Goswami et al. 2010) IT adoption (a) is a necessary foundation for future IT capabilities; (b) gives us the possibility of implementing add-on applications later; (c) opens up the possibility of designing new IS products and services around the RFID technology ○ (Hult et al. 2010) (a) This supply chain project is very necessary for us to unlock future opportunities; (b) This supply chain project is a very necessary foundation for us to develop future capabilities (c) This supply chain project is very important to the advancement of our organization.
	Stage Option: The implementation of this project can be completed in stages. Each stage of the implementation can result in a positive payoff, even if no further implementation stages are pursued (Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010).	<u>3- 4 item scales:</u> ○ (Tiwana et al. 2007)This project could easily be: (a) funded incrementally in stages, (b) completed in incremental stages, (c) completed as a series of smaller projects, (d) decomposed into smaller independent sub-projects. ○ (Goswami et al. 2008) (a) Stage option RFID adoption can be incrementally funded through investment in stages; (b) can be carried out in a series of incremental steps; (c) can be done through a step-wise execution of the adoption project ○ (Hult et al. 2010) (a) This supply chain project could easily be funded incrementally in stages; (b) This supply chain project could easily be completed in incremental stages (c) This supply chain project could easily be completed in a series of smaller projects.
	Defferal Option: Many uncertainties regarding this project implementation could be resolved if the investment in this project was postponed/ delayed (Tiwana et al. 2006; Tiwana et al. 2007; Hult et al. 2010).	<u>3-item scales:</u> ○ (Tiwana et al. 2007) If this project were postponed by two years (a) many technical uncertainties would be resolved, (b) project uncertainty would be reduced, (c) project requirements would be clearer. ○ (Goswami et al. 2010) (a) In our firm RFID adoption can be deferred to some future period (b)there is more sense in not adopting RFID at the present (c) it is preferable to wait and see before deciding to adopt RFID ○ (Hult et al. 2010) (a) Many financial uncertainties could be resolved if this supply chain project were postponed (b) Many human resource uncertainties could be resolved if this supply chain project were postponed (c) Many technical uncertainties could be resolved if this supply chain project were postponed.
Radicalness	This RFID project produces fundamental changes in the activities of my organization Adopted from (R. Henderson 1993; R. Henderson & Clark 1990)	A radical innovation (R. Henderson 1993; R. Henderson & Clark 1990; Moosmayer & Koehn 2011) • is "drastic" i.e. the older technology cannot compete with it • opens up whole new markets and potential applications • creates great difficulties for established firms and can be the basis for the successful entry of new firms • establishes a new dominant design and, hence, a new set of core design concepts embodied in components that are linked together in a new architecture • changes the core design concepts of the product • is based on the development and implementation of new products, processes, and technologies • represents fundamental change • forces capabilities of established organisations to ask a new set of questions, to draw on new technical and commercial skills, and to employ new problem-solving approaches
Strategic importance of IT	This RFID project has got a strategic importance for my organisation (Porter 2001)	<u>3 items scale</u> on a 1 to 7 Likert scale- *How you would evaluate <u>the importance of the technology investment</u> at the time the decision was made with respect to the following statements:* (Voudouris et al. 2012) The technology investment would determine:

	Based on: The extent to which products or processes potentially improved by the innovation are central to the competitive position or value proposition of the firm (Fichman 2004).	• the future technological development of the firm • the overall development of the firm • the competitiveness of the firm <u>6-items scale</u> on a 1 to 7 Likert scale (Bergeron et al. 2001) for the strategic use of IT- IT is used to: • Reduce your production costs • Make substabtial savings • Improve your firm's productivity • Increase your firm's profitability • Improve the quality of products/services • Respect the deadlines requested by your customers <u>Scale for the strategic use of IT</u> (5 Likert) by (Mahmood & Soon 1991). *To what extent do you think your IT does:* **Competitive rivalry: (1)** Help firms make a first strike against competitors ;(2) Help firms provide substitutes before their competitors do **Suppliers: (1)** Help firms gain leverage over their suppliers (2) Reduce transaction cost by making it easier for suppliers to handle orders **Market: (1)** Improve competitive efficiency of the firm;(2) Reinforce customer loyalty; (3) Identify market trends ;(4) Help firms serve new segments **Products and Services: (1)** Provide firms unique opportunities for product/service innovation;(2) Be built into existing products/services to enhance their value;(3) **Economics of Production: (1)** Reduce the cost of designing new products;(2) Improve level of production **Internal organisational efficiency: (1)** Increase firm's profit margins; (2) Increase firm's market shares *Respondents were asked whether or not their firms had made strategic use of information technology in the following areas* derived from Porter. (King et al. 1989) • supplier relations • customer service • product service differentiation • new product planning • cost competitiveness • market segmentation <u>4 items scale</u> for the corporate competitive advantage (Y.-S. Chen et al. 2009) can be adapted for IT. • whether the company has the competitive advantage of low cost compared to other competitors; • whether the company has better managerial capability than other competitors; • whether the company's profitability is better; • whether the company is the first mover in some important fields and occupies the important position.
Sustainability of competitive advantage	The improvements that this RFID project offers to my organisation will defend against rapid duplication by competitors. (McGrath 1997; Barney 1991)	Sustained competitive advantage is the long-term benefit of implementing some unique value creating strategy which any current or potential competitors do not implement simultaneously, along with the inability to duplicate the benefits of this strategy (Barney 1991).
Innovative capabilities	My organisation possesses resources (human, technical, organizational) which can contribute to the effective deployment of this RFID project	The following items (Xiaoran Wu & C. Subramaniam 2009) had this stem and response scale: *“How would you rate your organization’s capability to generate the following types of innovations in the products/ services you have introduced in the last five years?* (1 _ weaker than competition; 4 _ similar to competition; 7 _ stronger than competition).” **Incremental Innovative Capability**: (a) Innovations that reinforce your

	(Fichman 2004) based on (Rogers 1995; Wolfe 1994; Tornatzky & Fleischer 1990)	prevailing product/ service lines;(b) Innovations that reinforce your existing expertise in prevailing products/services (c) Innovations that reinforce how you currently compete. **Radical Innovative Capability**: (a) Innovations that make your prevailing product/service lines obsolete (b) Innovations that fundamentally change your prevailing products/services (c) Innovations that make your existing expertise in prevailing products/services obsolete.
Learning related endowments	My organization is able to exploit its capabilities (e.g. technologically up-to-date staff, diversity and high degree of organizational skills) in order to learn and gain knowledge through the implementation of this RFID project Adopted from (Chiva et al. 2007; Joaquín Alegre & Chiva 2008)	The Organisational Learning Capability (OLC) measurement instrument developed by (Chiva et al. 2007; Joaquín Alegre & Chiva 2008) consists of the skills and characteristics that enable an organization to learn. It contains the following five dimensions (which are measured with in total 14 items and constitute the essential factors that represent the OLC latent concept). It is based on a 7-point Likert scale, where 1 represented total disagreement and 7, total agreement. **<u>13-items Scale for the OLC latent concept:</u>** **(1) Experimentation:** V1. People here receive support and encouragement when presenting new ideas; V2. Initiative often receives a favorable response here, so people feel encouraged to generate new ideas **(2) Risk taking:** V3. People are encouraged to take risks in this organization ; V4. People here often venture into unknown territory **(3) Interaction with the external environment:** V5. It is part of the work of all staff to collect, bring back, and report information about what is going on outside the company ; V6. There are systems and procedures for receiving, collating and sharing information from outside the company ; V7. People are encouraged to interact with the environment: competitors, customers, technological institutes, universities, suppliers, etc. **(4) Dialogue:** V8. Employees are encouraged to communicate; V9. There is a free and open communication within my work ; V10. Managers facilitate communication; V11. Cross-functional teamwork is a common practice here **(5) Participative decision making:** V12. Managers in this organization frequently involve employees in important decisions; V13. Policies are significantly influenced by the employees' views ; V14. People feel involved in main company decision
Contributions to exploitable absorptive capacity	Through the deployment of this RFID project my organisation will expand its knowledge and skills and acquire the ability to utilize them in other domains Adopted from (Cohen & Levinthal 1990; Zahra & George 2002)	Absorptive capacity (ACAP) refers not only to the acquisition or assimilation of information by an organization but also to the organization's ability to exploit it (Cohen & Levinthal 1990); The ability to value, assimilate, and apply new knowledge (Cohen & Levinthal 1990; Schilling 1998) <u>3 item scale</u> (Cohen & Levinthal 1990) in (Y.-S. Chen et al. 2009) (1) whether the company has the ability to apply new external knowledge commercially and invent new product; (2) whether the company of the corporation has the ability to understand ,analyze and interpret information from external knowledge; (3) whether the company has the ability to combine existing knowledge with the newly acquired and assimilated knowledge <u>ACAP scale/items</u> (Cohen & Levinthal 1990; Schilling 1998)**:** **(1)Acquisition** -*Please specify to what extent your company uses external resources to obtain information (e.g., personal networks, consultants, seminars, internet, database, professional journals, academic publications, market research, regulations concerning environment/technique/health/security):* (a) The search for relevant information concerning our industry is every-day business in our company; (b) Our management motivates the employees to use information sources within our industry; (c) Our management expects that the employees deal with information beyond our industry. **(2) Assimilation** -*Please rate to what extent the following statements for the communication structure in your company:* (a)In our company ideas and concepts are communicated cross-departmental. Our management emphasizes cross-departmental support to solve problems;(b)In our company there is a quick information flow, e.g., if a business unit obtains important information it communicates this

		information promptly to all other business units or departments; (c) Our management demands periodical cross-departmental meetings to interchange new developments, problems, and achievements. **(3) Transformation**- *Please specify to what extent the following statements fit the knowledge processing in your company:* (a) Our employees have the ability to structure and to use collected knowledge;(b) Our employees are used to absorb new knowledge as well as to prepare it for further purposes and to make it available;(c) Our employees successfully link existing knowledge with new insights; (d) Our employees are able to apply new knowledge in their practical work. **(4) Exploitation**- *Please specify to what extent the following statements fit the commercial exploitation of new knowledge in your company (NB: Please think about all company divisions such as R&D, production, marketing, and accounting):* (a) Our management supports the development of prototypes;(b) Our company regularly reconsiders technologies and adapts them accordant to new knowledge; (c) Our company has the ability to work more effective by adopting new technologies.
Recognition of (positive) network externalities	The value of RFID technology will increase as more companies adopt it (Fichman 2004) based on: The utility of the network increases with the number of the users (Asvanund et al. 2004)	<u>3-item scale</u> for Perceived network externalities for Instant Messaging (NETIM) (Strader et al. 2007) (a) Many people use instant messaging (b) Many of my friends use instant messaging (c) Many of my family members use instant messaging.
Network dominance of the class/instance	RFID technology is likely to achieve a dominant position and offer substantial performance over other competing automatic identification technologies (such as barcode technology, smart card technology etc.) adapted from (Fichman 2004)	-
Interpretive flexibility	This RFID project can be implemented in different ways and feasible configurations (adopted from (Fichman 2004) Based on (Orlikowski 1996): Interpretive flexibility is defined as the extent to which a technology permits multiple interpretations on the part of adopters about how it should be implemented and used.	“Flexibility in how people design, interpret, and use technology (Kakola 1995) ; Systems modularity-flexibility: an ICT platform which is more generic and modular (Angelou & Economides 2008a). <u>Items for IT flexibility by (Tallon & Pinsonneault 2011) in MISQ:</u> To what extent do you agree with the following statements? (1: Do not agree; 7: Agree completely) **Hardware Compatibility** • Software applications can be easily transported and used across multiple platforms • Our user interfaces provide transparent access to all platforms and applications • Our firm offers multiple interfaces or entry points (e.g. web access) to external users • Our firm makes extensive use of middleware to integrate key enterprise applications **Software Modularity** • Reusable software modules are widely used throughout our systems development unit • Legacy systems within our firm do not hamper the development of new IT applications • Functionality can be quickly added to critical applications based on end-user requests • Our firm can easily handle variations in data formats and standards **Network Connectivity** • Our company has a high degree of systems interconnectivity

		• Our systems are sufficiently flexible to incorporate electronic links to external parties • Remote users can seamlessly access centralized data • Data is captured and made available to everyone in the firm in real time
Divisibility	The implementation of this RFID project can be completed in stages. Each stage of the implementation can result in a positive payoff, even if no further implementation stages are pursued (Fichman 2004)	Permitting the division of "a technology into stages or segments, each of which delivers some benefits even if no further segments are adopted (Fichman & Moses 1999)". • Possibility to decouple modules for serial implementation • how granular are the components • to what extent are the product components designed to accommodate a standalone operation • Possibility to start on a small scale and to develop the system (project) gradually • Possibility to start on a small scale and develop the system gradually (Leonard-Barton 1988) (Fichman & Moses 1999)
Value of returns	The expected value of the potential returns/payoffs for my organisation as a result of the RFID project deployment is: (Fichman 2004) This project will fail to add value to my firm/This project will succeed in adding value to my firm (Tiwana et al. 2006)	(9-item semantic scale, from 1 to 7)-How you would assess the value of this project to your organisation if it were pursued? (Tiwana et al. 2007) Worthless/worthwhile; Unimportant/important ;Non-essential/essential ;Of no value/of great value ;Completely useless/highly useful ;Difficult to justify/easy to justify; Unnecessary investment/critical investment ;Inappropriate/appropriate ;Of no benefit/of great benefit 5 scale measurement from (Leonard-Barton 1990) Overall how you would rate the success of this project? (total failure=1 /to total success=5) (NPV measurement) Select which of the following sentences best describes the measurable benefits and cost (Tiwana et al. 2007) • For my organisation this project's cost greatly exceeds its benefits. • For my organisation this project's cost slightly exceeds its benefits • For my organisation this project's cost somewhat exceeds its benefits • For my organisation this project's cost equals its benefits. • For my organisation this project's benefits somewhat exceed its cost. • For my organisation this project's benefits slightly exceed its cost. • For my organisation this project's benefits greatly exceed its cost.

APPENDIX 3- CASE STUDY I

(a) Questionnaire for the Case Study I (Retailing Telecommunications company)

Ερωτηματολόγια για την αξιολόγηση των σεναρίων χρήσης της τεχνολογίας RFID στα καταστήματα του οργανισμού τηλεπικοινωνιακών υπηρεσιών και προϊόντων.

Διαδικασία παραλαβής παραγγελθέντων προϊόντων στα καταστήματα

α. Ερωτήματα για την υπάρχουσα διαδικασία

1. Σημειώστε το χρόνο που ενασχοληθήκατε με τη διαδικασία από τη στιγμή της παραλαβής μέχρι τη στιγμή της αποθήκευσης των προϊόντων. Επαναλάβετε το ίδιο για 4 ακόμη ημέρες.

Ημέρες	Ώρα παραλαβής προϊόντων(α)	Ώρα αποθήκευσης προϊόντων (β)	Χρόνος διαδικασίας (β-α)
1η			
2η			
3η			
4η			
5η			

2. Πόσο συχνά μέσα στο μήνα λαμβάνετε μια λανθασμένη παραγγελία στο κατάστημα;

❑1 φορά
❑2-5 φορές
❑5-10 φορές
❑10-15 φορές
❑>15 φορές

3. Τι ποσοστό του χρόνου του, μέσα στην ημέρα, αφιερώνει ένας υπάλληλος για την παραλαβή και αποθήκευση προϊόντων παραγγελίας;

❑5-20%
❑20-40%
❑40-60%
❑60-80%
❑80-100%

4. Σημειώστε ποιος είναι ο αριθμός των υπαλλήλων στο κατάστημα που ασχολούνται με την παραλαβή και αποθήκευση προϊόντων.

❑1 άτομο
❑2 άτομα
❑3 ή παραπάνω

5. Σημειώστε ποια είναι η θέση των ατόμων που ασχολούνται με την παραλαβή και αποθήκευση των προϊόντων.

❑Junior υπάλληλος
❑υπεύθυνος αποθήκης
❑πωλητής
❑διευθυντής καταστήματος

Παρακαλώ επιλέξτε ένα από τα νούμερα (1-7) για κάθε μία από τις παρακάτω προτάσεις, που αφορούν την υπάρχουσα διαδικασία της παραλαβής και αποθήκευσης των προϊόντων.

6. Η διαδικασία της παραλαβής και αποθήκευσης των προϊόντων παραγγελίας είναι:

Αργή	1	2	3	4	5	6	7	Γρήγορη
Απλή	1	2	3	4	5	6	7	Πολύπλοκη
Ευχάριστη	1	2	3	4	5	6	7	Βαρετή
Δύσκολη	1	2	3	4	5	6	7	Εύκολη
Αποτελεσματική	1	2	3	4	5	6	7	Αναποτελεσματική

7. Ο βαθμός ικανοποίησης του προσωπικού σχετικά με την υπάρχουσα διαδικασία είναι:

Μεγάλος	1	2	3	4	5	6	7	Μικρός

8. Ο χρόνος απασχόλησης του προσωπικού μέσα στην ημέρα για την παραλαβή και αποθήκευση προϊόντων είναι:

Πολύς	1	2	3	4	5	6	7	Λίγος

9. Το λειτουργικό κόστος (αριθμός υπαλλήλων και χρόνος διαδικασίας) για αυτή τη διαδικασία πιστεύετε ότι είναι:

Μεγάλο	1	2	3	4	5	6	7	Μικρό

10. Ό χρόνος που μένει σε εκκρεμότητα μια αφιχθείσα παραγγελία είναι:

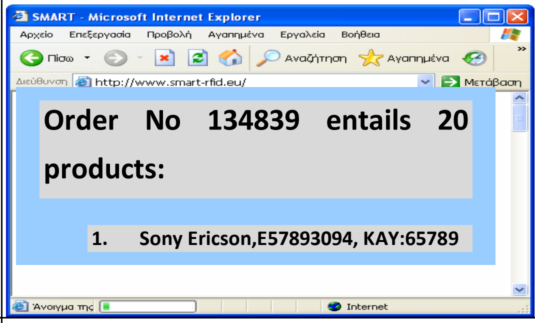
Πολύς	1	2	3	4	5	6	7	Λίγος

β. Ερωτήματα για την προτεινόμενη διαδικασία

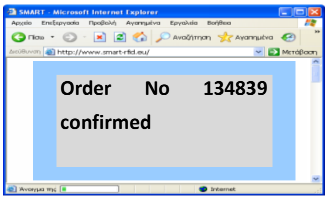
Τώρα παρακαλώ διαβάστε το παρακάτω σενάριο το οποίο αφορά την παραλαβή και αποθήκευση των προϊόντων παραγγελίας. Φανταστείτε ότι:

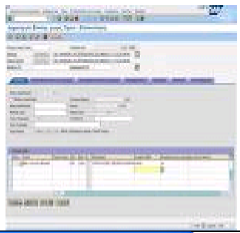
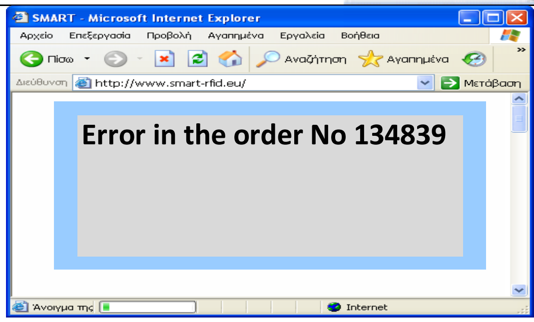
<table>
<tr>
<td>Μια κούτα με προϊόντα παραγγελίας εισάγεται στην αποθήκη του καταστήματος, χωρίς να ανοιχτεί. Στην είσοδο της αποθήκης έχει τοποθετηθεί μια συσκευή αναγνώρισης προϊόντων, η οποία συνδέεται με έναν Η/Υ.

Στην οθόνη του Η/Υ εμφανίζεται μια λίστα με τους κωδικούς, την ονομασία και το συνολικό αριθμό όλων ταυτόχρονα των προϊόντων της κούτας.</td>
<td>



</td>
</tr>
<tr>
<td>Το σύστημα ελέγχει αν τα προϊόντα της λίστας είναι ίδια με αυτά που αναγράφονται στο δελτίο αποστολής.

Αν ισχύει κάτι τέτοιο, επιβεβαιώνεται η παραγγελία και το σύστημα ανανεώνει το απόθεμα της αποθήκης του καταστήματος.</td>
<td>



</td>
</tr>
<tr>
<td>Σε περίπτωση που το σύστημα διαπιστώσει ότι τα προϊόντα της κούτας είναι διαφορετικά από αυτά που παραγγέλθηκαν, εμφανίζει στην οθόνη του Η/Υ ένα μήνυμα το οποίο ενημερώνει για το λάθος που εντοπίστηκε.</td>
<td>


</td>
</tr>
</table>

11. Σημειώστε πόσο κατανοητό είναι το παραπάνω σενάριο.

Πολύ	1	2	3	4	5	6	7	Καθόλου

12. Αν δεν υπήρχε η δυνατότητα να εφαρμοστεί το παραπάνω σενάριο σε όλα τα προϊόντα του καταστήματος, για ποια από τα παρακάτω θα ήταν πιο σημαντικό να εφαρμοστεί;

❑Κινητό τηλέφωνο
❑σταθερό τηλέφωνο
❑πακέτο σύνδεσης

❑αξεσουάρ κινητών (hands free, Bluetooth, κάρτες μνήμης, μπαταρίες, θήκες)

Παρακαλώ συμπληρώστε τις παρακάτω προτάσεις που αφορούν το περιγραφόμενο σενάριο για τη διαδικασία της παραλαβής και αποθήκευσης των προϊόντων, επιλέγοντας ένα από τα νούμερα (1-7).

Η περιγραφόμενη διαδικασία πιστεύετε ότι θα είναι:

Αργή	1	2	3	4	5	6	7	Γρήγορη
Απλή	1	2	3	4	5	6	7	Πολύπλοκη
Ευχάριστη	1	2	3	4	5	6	7	Βαρετή
Δύσκολη	1	2	3	4	5	6	7	Εύκολη
Αποτελεσματική	1	2	3	4	5	6	7	Αναποτελεσματική

14. Ο βαθμός ικανοποίησης σας σχετικά με τη διαδικασία πιστεύετε ότι θα είναι:

Μεγάλος	1	2	3	4	5	6	7	Μικρός

15. Ο χρόνος απασχόλησης του προσωπικού μέσα στην ημέρα για την παραλαβή και αποθήκευση προϊόντων πιστεύετε ότι θα είναι:

Πολύς	1	2	3	4	5	6	7	Λίγος

16. Το λειτουργικό κόστος (αριθμός υπαλλήλων και χρόνος διαδικασίας) για αυτή τη διαδικασία πιστεύετε ότι θα είναι:

Μεγάλο	1	2	3	4	5	6	7	Μικρό

17. Ό χρόνος που μένει σε εκκρεμότητα μια αφιχθείσα παραγγελία πιστεύετε ότι θα είναι:

Πολύς	1	2	3	4	5	6	7	Λίγος

Παρακαλώ συμπληρώστε τις παρακάτω προτάσεις που αφορούν το περιγραφόμενο σενάριο για τη διαδικασία της παραλαβής και αποθήκευσης των προϊόντων, επιλέγοντας ένα από τα νούμερα (1-7).

Financial perspective (Οικονομικοί παράγοντες)

Ο χρόνος απασχόλησης του προσωπικού για τη διαδικασία παραλαβής παραγγελιών θα:

Μειωθεί	1	2	3	4	5	6	7	Αυξηθεί

Ο χρόνος που μένει σε εκκρεμότητα μια αφιχθείσα παραγγελία θα:

Μειωθεί	1	2	3	4	5	6	7	Αυξηθεί

Ο αριθμός προσωπικού που απαιτείται για τη διαδικασία θα:

Μειωθεί	1	2	3	4	5	6	7	Αυξηθεί

Internal Business Processes Perspective (Παράγοντες της εσωτερικής διαδικασίας)

13. Η περιγραφόμενη διαδικασία πιστεύετε ότι θα είναι:

Αργή	1	2	3	4	5	6	7	Γρήγορη
Απλή	1	2	3	4	5	6	7	Πολύπλοκη
Ευχάριστη	1	2	3	4	5	6	7	Βαρετή
Δύσκολη	1	2	3	4	5	6	7	Εύκολη
Αποτελεσματική	1	2	3	4	5	6	7	Αναποτελεσματική

Η ποιότητα της πληροφορίας για τα προϊόντα παραγγελίας θα:

Βελτιωθεί	1	2	3	4	5	6	7	Χειροτερέψει

Customer Perspective (Παράγοντες για τον καταναλωτή)

Η γνώση της διαθεσιμότητας των προϊόντων του καταστήματος θα:

Χειροτερέψει	1	2	3	4	5	6	7	Βελτιωθεί

Η ενημέρωση των καταναλωτών για τη διαθεσιμότητα των προϊόντων θα:

Χειροτερέψει	1	2	3	4	5	6	7	Βελτιωθεί

Η ικανοποίηση των πελατών του καταστήματος θα:

Μειωθεί	1	2	3	4	5	6	7	Αυξηθεί

Innovation, Learning and perspective (Παράγοντες καινοτομίας, γνώσης και ανάπτυξης)

Ο βαθμός της καινοτομίας του συγκεκριμένου σεναρίου είναι:

Μεγάλος	1	2	3	4	5	6	7	Μικρός

Η χρόνος εκπαίδευσης του προσωπικού για την εισαγωγή της τεχνολογίας που θα υποστηρίζει τη διαδικασία θα είναι:

Πολύς	1	2	3	4	5	6	7	Λίγος

Διατίθεμαι να συμμετέχω στην εκπαίδευση για την εφαρμογή της τεχνολογίας:

Διαφωνώ ριζικά	1	2	3	4	5	6	7	Συμφωνώ απόλυτα

Διατίθεμαι να χρησιμοποιήσω αυτήν την τεχνολογία ακόμη και αν στην αρχή γίνουν λάθη στη διαδικασία.

Διαφωνώ ριζικά	1	2	3	4	5	6	7	Συμφωνώ απόλυτα

γ. Γενικές ερωτήσεις για άλλες υπηρεσίες

Παρακαλώ σημειώστε κατά πόσο (1-7) οι παρακάτω υπηρεσίες θα συνεισφέρουν στη στρατηγική του οργανισμού. Επίσης σημειώστε το κατά πόσο είναι κατανοητή η συγκεκριμένη υπηρεσία.

Πόσο κατανοητή είναι η παρακάτω υπηρεσία?				**Καθόλου**						**Πολύ**
Καθόλου κατανοητή		Αρκετά κατανοητή								
1	2	3	Α. Αυτόματη ειδοποίηση του συστήματος σε περίπτωση που εξέλθουν από το κατάστημα προϊόντα που δεν έχουν κλαπεί.	1	2	3	4	5	6	7
1	2	3	Β. Ένας πελάτης πληροφορείται για τα χαρακτηριστικά των προϊόντων που έχει επιλέξει από έναν ηλεκτρονικό σταθμό πληροφόρησης που βρίσκεται μέσα στο κατάστημα.	1	2	3	4	5	6	7
1	2	3	Γ. Ένας πελάτης εισερχόμενος σε ένα κατάστημα αναγνωρίζεται από το σύστημα και λαμβάνει προσωποποιημένες πληροφορίες για τα προϊόντα που προτιμά και προσωποποιημένες προτάσεις αγορών.	1	2	3	4	5	6	7
1	2	3	Δ. Ο έλεγχος και η καταμέτρηση των προϊόντων παραγγελίας που εισέρχονται στην αποθήκη του καταστήματος πραγματοποιείται αυτόματα.	1	2	3	4	5	6	7
1	2	3	Ε. Αυτόματη και μαζική αναγνώριση των προϊόντων που πωλούνται στο ταμείο. Έκδοση απόδειξης για όλα τα προϊόντα που βρίσκονται στο καλάθι αγοράς.	1	2	3	4	5	6	7
1	2	3	Ζ. Δυνατότητα εντοπισμού από τα κεντρικά της θέσης των προϊόντων στα καταστήματα, με σκοπό την επιστροφή αυτών από την αγορά ή τις αποθήκες.	1	2	3	4	5	6	7
1	2	3	Η. Δυνατότητα παρακολούθησης της πορείας του service εντοπίζοντας τη θέση του προϊόντος κάθε δεδομένη στιγμή.	1	2	3	4	5	6	7
1	2	3	Θ. Αυτόματη αναγνώριση του προϊόντος που φέρνει ένας πελάτης για service. Αυτόματη έκδοση και συσχετισμός των παραστατικών service.	1	2	3	4	5	6	7
1	2	3	Ι. Κατά τη διάρκεια της πώλησης, ένας πωλητής πληροφορείται για τα χαρακτηριστικά προϊόντων και για	1	2	3	4	5	6	7

			προτάσεις αγορών, από έναν ηλεκτρονικό σταθμό πληροφόρησης μέσα στο κατάστημα, με σκοπό να ενημερώσει τον εξυπηρετούμενο πελάτη.							
1	2	3	Κ. Πληροφόρηση για το ακριβές απόθεμα της αποθήκης του καταστήματος κάθε δεδομένη στιγμή.	1	2	3	4	5	6	7

Επιλέξτε ποιες από τις παραπάνω υπηρεσίες θεωρείτε πιο σημαντικές, ταξινομώντας αυτές με σειρά προτεραιότητας (Ξεκινήστε από τη πιο σημαντική)

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

(b) Cost-Benefit analysis for the Case study I (Calculations and assumptions)

Calculations and Assumptions for the Capital cost estimation:

For the estimation of the capital cost, several assumptions have been made. Due to space limitations, some examples of these assumptions and the pertinent calculations are mentioned below. Regarding the RFID equipment cost, two different types of stores have been taken into consideration. For example for the store type 1, it is assumed that 1 reader per store is shared by the two applications. Furthermore, two antennas are needed for application 1 and three antennas are required for application 2 per store of type 1. The prices of one reader, antenna and printer are assumed to be 2500, 400 and 4000 € respectively. The calculated figures are multiplied by the number of the stores (58 stores for the type 1 and 95 stores for type 2). It is assumed that RFID equipment will be also required for the central warehouse of the retailer, apart from the store. In particular, 2 readers with 2 antennas and 2 printers are required resulting in a total shared cost of 13.800 €. In addition, for the installation cost it is assumed that 3 hours per store are needed with a man-hour rate of 200 €/hour. For example, for all the stores of type (1), 34.800 € (200 € x 3 hours x 58 stores) is the total installation cost.

Calculations and assumptions for the Operational cost estimation:

RFID tags cost: For the RFID tags cost estimation, it is assumed that the tagging is made at an item level. The number of the tagged items (products) is estimated to be 1.200.000. The price of one tag is assumed to decrease each year by 10% starting from 0.12 € in year 1 and reaching the price of 0.08 € in year 5.

Tagging cost: It is assumed that 15 seconds are required per item to be tagged. Thus, the total tagging cost is estimated to be 100.000 €, based on the man-hour rate (20 € per hour) and the tagged items (1.200.000). This cost is assumed to be fixed per year.

Training cost: It is assumed that for the first year, 2 employees are required to be trained per store for 8 hours each with a cost rate of 30 € per hour. Thus, the total cost for the first year for all the 153 stores is 73.440,00 €. For the following years, it is estimated that 15% of this cost will be spent for additional training per year resulting in a cost of 11.016,00 €.

Equipment & SW update and maintenance cost: Finally, the HW maintenance and update cost are estimated as a percentage (12%) of the capital cost (Table 3) for the equipment (store equipment, central warehouse equipment, servers, PCs). Likewise, the SW updates and maintenance cost is calculated as a percentage (12%) of the software customisation capital cost. The types of the capital cost which are considered are highlighted in Table 3 (in bold). The rest of the capital cost categories (ex. Installation cost) are not considered to result in operational expenses as they take place only in the beginning of the investment. In particular, this kind of cost is calculated separately for the two applications and it is the same for each year. For example, if both applications are implemented, the estimated cost of the equipment maintenance is 85.896,00 € (Table 4) per year, whereas if the orders receiving process is implemented without the check out process, this cost will be 68.424 €.

Assumptions for the cost saving estimation:

Store type	No of stores	Total No of received orders for all the stores per year	No of sales receipts for all the stores per year
1	58	13.110	855.000
2	95	5.980	390.000

Calculations for the cost savings estimation:

(1) (Time (as is) x number of employees (as is) occupied)- time (to be) x No of employees (to be) occupied)/60 X man-hour cost X Total annual number of orders => (75mins to process one order x 2 occupied employees -15 minutes to process one order x 1 occupied employee)/60= 2,08 € cost saving per hour per order x 15 € per hour (man-hour rate)= 31.25 € is the cost saving per order x 13.110 orders per year= 409.687,50 € is the total cost saving for processing all the orders in all the stores of type 1.

(2) *Time reduction per sales receipt/60 x man-hour cost x Annual total number of sales receipts =>* 3minutes less time per sales receipt/60=0, 05 hours per sales receipt x 10 € per hour (man-hour rate) = 0, 5 € per sales receipt x 855.000 sales receipts (for the 58 stores) = 427.500,00 € is the total cost saving for the checking out process in all the stores of type 1

(3) *Time reduction per incident x Number of stores x man-hour cost x total annual number of incidents =>* 5minutes less time per incident x 104 incidents per year per store= 520 minutes per year/60= 8, 67 hours per year per store x 10 € per hour (man hour rate) = 86, 67 € per store x 58 stores= 5.026,67 € is the total cost saving for saving time on searching for the product code per year for all the stores in type 1

APPENDIX 4- CASE STUDY II

(a) Questionnaire utilised for interviews in the Supermarket Company- Case Study II

(Note: For brevity reasons, only the questionnaire utilised for the Promotion Management Service is included in the present Appendix. The questionnaire for the Dynamic Pricing Service includes the same questions)

Interviews Questionnaire

General guidelines: This questionnaire serves the purpose of guiding researchers during the interview process. Please do not collect simple scores for each evaluation dimension. Attempt to write on the open fields as much as possible encapsulating the general perception of the respondents per evaluation dimension.

User Satisfaction

Overall, how would you characterize your interaction and experience with the system?

Boring							*Exciting*	
1	2	3	4	5	6	7	8	9

Notes:

Difficult to Use							*Easy to Use*	
1	2	3	4	5	6	7	8	9

Notes:

Inflexible to Use							*Flexible to Use*	
1	2	3	4	5	6	7	8	9

Notes:

Incomplete in terms of functionality						*Complete in terms of functionality*		
1	2	3	4	5	6	7	8	9

Notes:

Dull							*Entertaining*	
1	2	3	4	5	6	7	8	9

Notes:

Difficult to Learn							*Easy to Learn*	

1	2	3	4	5	6	7	8	9

Notes:

Difficult to Understand						*Easy to Understand*		
1	2	3	4	5	6	7	8	9

Notes:

Decreases my performance						*Increases my performance*		
1	2	3	4	5	6	7	8	9

Notes:

Decreases my productivity						*Increases my productivity*		
1	2	3	4	5	6	7	8	9

Notes:

Decreases my efficiency						*Increases my efficiency*		
1	2	3	4	5	6	7	8	9

Notes:

Unaesthetic (menus/ interaction)						*Aesthetic*		
1	2	3	4	5	6	7	8	9

Notes:

System Quality

Overall, how would you characterize the following system features?

B.1 System flexibility to adapt to new requirements								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

B.2 System capability to communicate without errors with other information systems (including legacy systems)								
Low							*High*	
1	2	3	4	5	6	7	8	9
Notes:B.3 System response time to user queries								

Low							High	
1	2	3	4	5	6	7	8	9

Notes:

B.4 System capability to resume from errors								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

B.5 Difficulty of the system to support access to all available options								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

B.6 Quality of interaction elements (buttons, forms, etc)								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

(For brevity reasons the section C for Information Quality is not included in the appendix of this thesis. In addition, it is not related to the aim of this thesis)

Integration with Business Operations

Overall, how would you characterize the following?

D.1 Cost of integrating the system to the existing legacy systems								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.2 Cost of purchasing the necessary infrastructure (readers, tags, etc)								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.3 Cost of tagging the products / cases								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.4 Cost of deploying the system to the supermarket								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.5 Degree of required business transformation								
Low							*High*	
1	2	3	4	5	6	7	8	9
Preventive for investment					*Normal as any IT investment*			
1	2	3	4	5	6	7	8	9

Notes:

D.6 Required training costs (for store/ supplier personnel respectively)								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.7 Expected resistance to change (for store/ supplier personnel respectively)								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.8 Fear for RFID antennas radiation (for store/ supplier personnel respectively)								
Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

D.9 Privacy concerns (for store/ supplier personnel – stemming from the system capability to indirectly monitor their performance)

Low							*High*	
1	2	3	4	5	6	7	8	9

Notes:

Net Benefits

This section tries to capture the perceived benefits of the RFID enabled system for retailers and suppliers. Overall, how would you agree to the following statements (please provide justifications on them)?

E.1 THE RFID-ENABLED SYSTEM enhances the visibility of the supply chain								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.2 THE RFID-ENABLED SYSTEM reduces operational costs								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.3 THE RFID-ENABLED SYSTEM contributes to gain competitive advantage								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.4 THE RFID-ENABLED SYSTEM increases customer loyalty								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.5 THE RFID-ENABLED SYSTEM increases my sales and profitability								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.6 THE RFID-ENABLED SYSTEM strengthens the collaboration with my trading partners

Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.7 THE RFID-ENABLED SYSTEM strengthens my operational efficiency								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.8 THE RFID-ENABLED SYSTEM operation prerequisites that collaborative practices are followed by supply chain partners								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

E.9 THE RFID-ENABLED SYSTEM operation requires changes in the current culture of supply chain partners								
Totally Disagree							*Totally Agree*	
1	2	3	4	5	6	7	8	9

Notes:

F. Specific Questions for PM

This section captures specific issues concerning the management and execution of in-store promotions as an outcome of our effort to identify the expected business impact of the system.

- *Number of in-store promotions/ month and per year:*
- Total:
- Per product code:
- *Number of sales stemming from promotional products:*
- *Proportion to total sales:*
- *Number of replenishments per promotion stand:*
- *Frequency of out-of-shelf situations in promotion stand:*
- *Frequency of personnel checks on promotion stands:*
- *Total number of staff involved in promotional management activities:*
- *Number of staff per promotion stand:*
- *Deviations between expected time to start a promotion and actual time:*
- *Allocation if sales per different type of promotion:*
- In-store promotions (exhibit):
- Mixed promotions:

- Bundled promotions:

G. Demographics

Name: ……

Company: ………..

Position: ……..

Please specify any additional benefits stemming from the RFID-ENABLED SYSTEM pilot scenarios:

……………………………………..

Please specify any obstacles for the efficient deployment of THE RFID-ENABLED SYSTEM pilot scenarios:

………………………..

Please identify any other services that may be enhanced/ supported by THE RFID-ENABLED SYSTEM technologies:

……………………………………

(b) Cost Benefit analysis of the Promotion Management Service

Direct Benefits

The first stage includes the RFID implementation in the inventory and refers to two types of business processes. The first is the orders receiving. The current average time (15 mins) needed for an employee to receive an order with products on promotion is compared to the estimated time (5 mins) that an employee is expected to need due to the introduction of the RFID technology. The second type of business process is the audit of the inventory stock. The average time (15mins) currently needed by the personnel to check the inventory stock of promotion products (once per day) is compared to the one estimated due to the RFID introduction. It is assumed that 5 mins on average will be needed for an employee to check the inventory stock of the products on promotion through the RFID-enabled application on a PC. It is assumed that there will be no need of a physical check.

The second stage includes the RFID implementation at the Sales floor, where RFID readers are placed on the promotion stands. Currently, employees consume 5mins to check the availability of products on one promotion stand. On the contrary, it is assumed that through the RFID technology an employee will need 20 mins to check the availability of all the promotion stands in one store on the screen of a PC. In addition, it is assumed that there is no need of a physical check of the promotion stands.

Key Performance Indicators for the Benefit estimation (PM service)

					RFID	
		Key Performance Indicators	**As-Is value for checking physically the orders/stock**	**Unit**	**To-be value for checking physically the orders/ stock**	**To-be value for checking the PC**
Reader at the Backroom	**Orders receiving**	Time needed for the orders receiving (per order)	15	mins	5	0,00
		Employees involved simultaneously at the orders receiving process	1	Units	1	0,00
	Checking the inventory stock	Time needed per checking the inventory stock and availability of the promotions in one store (for all the stands in the store)	15,00	mins	0,00	5,00

		Employees involved simultaneously at one inventory checking	1,00	Unit s	0,00	1,00
		Frequency of checking the inventory of products per day	2,00	Unit s	0,00	2,00
Reader at the Sales Floor	**Checking the stock on the stand**	time needed per checking the stock and the availability of products **on one promotion stand** (with RFID on **all the promotion stands)**	5,00	mins	0,00	20,00
		employees involved simultaneously during one check	1,00	Unit s	0,00	1,00
		Frequency of checking the stock of one stand per day	2,00	Unit s	0,00	2,00

Based on the above Performance Indicators and their respective values, the estimation of the cost savings was made. These cost savings were categorized into two stages. The first stage includes the RFID investment at the backroom. Based on the calculations, it is estimated that the cost saving due to the decrease of the time needed for the orders receiving process is 9.000 Euros annually for all the stores. This is a result of the reduction of the time needed to validate the order documents with the actual products which are received in the store as a result of their automatic identification through RFID technology. The calculation is based on the assumption that 3 orders for promotion products are received per month (36 orders per year). The second parameter which is a part of the first stage (RFID investment in the backroom) refers to the annual cost saving that can be derived by the RFID implementation due to the time reduction needed to check the inventory stock. It is estimated to be 156.000 Euros for all the stores.

Regarding the second stage of the RFID investment at the Sales Floor for the promotion management, it is estimated that the annual cost saving due to the time reduction needed to check the stock and the availability of the promotion stands is 936.000 Euros for all the stores and 6240 Euros per store.

Estimated Direct Benefits of the PM Service

Stages		Benefit	AS IS			TO BE (RFID)					
			Time needed (As- Is) per year for checking orders/stock per year per store	**Time needed (As- Is) per year for checking orders/stock per year for all the stores**	**Cost (As-Is) for all the stores per year**	**Time needed (To-Be) for checking orders/stock per year per store**	**Time needed (To- Be) for checking orders/stock per year for all the stores**	**Cost (To-Be for checking orders/stock physically per year**	**Cost (To-Be)for checking the PC for all the stores/ per year)**	**COST SAVING/Sales increase per year for all the stores**	**Cost saving per store per year**
		Direct cost savings	**mins**	**mins**	**euros**	**mins**	**mins**	**euros**			
Backroom	**Orders receiving**	Annual cost saving due to the decrease of time needed for the orders receiving	540.00	81,000.00	13,500.00 €	180.00	27,000.00	4,500.00 €		9,000.00 €	**60 €**
	Checking the inventory stock	Annual cost saving due to the decrease of the time needed to check the inventory stock	9,360.00	1,404,000.00	234,000.00 €	3,120.00	468,000.00	- €	78,000.00 €	156,000.00 €	**1,040 €**
Sales Floor	**Checking the stock on the stand**	Annual cost saving due to the time decrease of the time needed to check the stock of promotion stands	49,920.00	7,488,000.00	1,248,000.00 €	12,480.00	1,872,000.00	- €	312,000.00 €	936,000.00 €	**6,240 €**
		Indirect cost savings								**1,101,000.00 €**	**7,340 €**

Indirect benefits refer to the benefits which cannot be estimated based on the time which is needed currently for business processes compared to the time which is needed for these processes as a result of the RFID implementation. Two types of indirect benefits are considered.

The first type is the sales increase due the decrease of the time deviation between the programmed and the actual time of the launch of all the promotion events per year. The average time deviation based on the interview is 3 days per promotion event. This delay generates sales loss. It is estimated that this loss can be avoided with the RFID exploitation. The sales increase due to the time deviation decrease is estimated by the interviewee to be 700.000 Euros per year for all the stores. This amount divided by the number of the stores (150) equals to 4500 approximately Euros for each store. This benefit however, cannot be generated if other issues for this delay are not alleviated. One example is the delay of the promotion products in the store from the supplier due to an inadequate demand forecasting.

The second type of benefits refers to the cost saving per year for all the stores due to the reduction of the out-of-stock occurrences only for promotion products. RFID implementation is considered to be one of the factors which can lead to this reduction. Based on the interviewee, the cost saving by such a reduction is estimated to be approximately 3.500.000 Euros for all the stores per year. Based on our calculation, this amount can reach the 4.800.000 Euros per year which equals to the 2% of the yearly revenues coming from promotions (200.000.000 Euros). 8% is the total OOS percentage for overall annual sales for all the stores. According to the interviewee, the sales which come from promotions are 30% of the total sales. Thus, 2% (=30% of the total 8%) can be the percentage of the OOS only for promotion products. However, for the benefit estimation we keep the more pessimistic scenario of the 3.500.000 cost saving for all the stores and the respective amount of 23.000 Euros per store.

Estimated indirect benefits of the PM service

	For all the stores	**For one store**
Sales increase per year for all the stores due to the elimination of the time deviation between the programmed and the actual time of the launch of all the promotion events	700.000,00 €	4.667 €
Cost saving per year for all the stores due to the reduction of the out-of-stock occurrences for promotion products (2% of the average sales of promotions)	3.500.000,00 €	23.333 €

The following table includes all the estimated direct and indirect benefits derived from THE RFID-ENABLED SYSTEM service for promotion management.

Total estimated benefits (Direct and indirect) of the PM service

Stages	Benefits			Cost saving/Sales increase per store
			Cost saving/Sales increase per year for all the stores	
		Direct benefits		
Backroom	Orders receiving	Annual cost saving due to the decrease of time needed for the orders receiving	9,000.00 €	60 €
	Checking the inventory stock	Annual cost saving due to the decrease of the time needed to check the inventory stock	156,000.00 €	1,040 €
Sales Floor	Checking the stock and the availability on the stand	Annual cost saving due to the time decrease of the time needed to check the stock of promotion stands	936,000.00 €	6,240 €
		Indirect benefits	1,101,000.00 €	7,340 €
		Sales increase per year for all the stores due to the elimination of the time deviation between the programmed and the actual time of the launch of all the promotion events	700,000.00 €	4,667 €
		Cost saving per year for all the stores due to the reduction of the out-of-stock occurrences for promotion products (2% of the average sales of promotions)	3,500,000.00 €	23,333 €
		TOTAL (DIRECT+INDIRECT)	5,301,000.00 €	35,340 €

Hidden benefits

Hidden benefits are the benefits that can be derived through the service by selling RFID-enabled information to the suppliers. The table below includes the amount of money that a supplier could pay the retailer to gain access to RFID- enabled information as it is estimated on average by the interviewee (Head Buyer of the specific Company Supermarket). This information is categorized based on the RFID implementation stages in the backroom and the Sales Floor. Different types of information exist according to the business aim they fulfill.

Based on the first stage, a retailer could "sell" information to suppliers about the time when the orders for products on promotion arrive at a retailing store. In addition, the supplier can gain access to information regarding the inventory stock of its products on promotion. As it is estimated by the interviewee, suppliers can give per year 53.000 Euros for all the (150) stores in order to have access to the above information.

As far as the second stage is concerned, where the RFID implementation is made at the Sales floor, different kind of information suppliers can have access to. The interviewee estimates that suppliers could give approximately 60.000 Euros per year for all the (150) stores to be informed for the sales of a promotion event in a real-time basis. The same amount of money is estimated that can be given by the suppliers for getting real-time information for the stock of the promotion stands. Furthermore, it is estimated that suppliers may be willing to pay a retailer 70.000 Euros per year for all the stores to gain access to an information report which compares the sales of products on all the promotion stands inside one store. The same amount of money is estimated that can be given by a supplier to be informed in a real-time basis for a comparison among the different stores regarding the sales of all the promotion stands. The table depicts the above analysis. The right column includes the amount of money that a supplier could pay a retailer only for one store, in order to gain access to this kind of information. The total amount that the suppliers could give for all the stores per year is 313.000 Euros. This amount is decreased to 250.000 in order to exploit a pessimistic scenario.

Estimated hidden benefits of the PM service

Stage	Profit by selling the RFID information below to the suppliers (estimation of a Retailer BASED ON INTERVIEW)	Estimated amount **per year** for **all the stores**	Calculated amount **per year** for **one store**
Backroom	time of the orders receiving	3.000,00 €	20 €
	Inventory stock	50.000,00 €	333 €
	SUBTOTAL	53.000,00 €	353 €
Sales Floor	Start point of a promotion event		
	sales of a promotion event	60.000,00 €	400 €
	stock on the stand	60.000,00 €	400 €
	comparison among the sales of all the promotion stands	70.000,00 €	467 €
	comparison among the sales of all the promotion stands of all the stores	70.000,00 €	467 €
	SUBTOTAL	260.000,00 €	1.733 €
	TOTAL PROFIT	313.000,00 €	2.087 €
	ADJUSTED AMOUNT	**250.000,00 €**	1.667 €

Based on the above information and the total amount of money (250.000 Euros) that a supplier could give to the retailer per year for all the stores, the profit per year for all the stores is calculated. This time, the % of all the (80) suppliers of the specific supermarket company, that could pay for this kind of information is considered. The first two years and the respective percentages (20%-30%) of suppliers that could pay for this kind of information are the more realistic scenarios based on the estimations of the interviewee. However, we estimated how much profit could be derived if the percentage and the number of the involved suppliers are increased every year.

Estimated profit by hidden benefits for the PM service based on the percentage of the suppliers

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7
% of the 80 suppliers	20%	30%	40%	50%	60%	70%	100%
No of the suppliers	16	24	32	40	48	56	80
PROFIT for all stores	4.000.000,00 €	6.000.000,00 €	8.000.000,00 €	10.000.000,00 €	12.000.000,00 €	14.000.000,00 €	20.000.000,00 €
PROFIT for one store	26.667 €	40.000 €	53.333 €	66.667 €	80.000 €	93.333 €	133.333 €

<u>Cost Analysis</u>

This section includes the analysis of the cost that a retailer it is estimated to pay in order to implement the RFID-enabled service for the promotion management process. The assumptions of the cost analysis are the same with the ones made for the benefit analysis.

RFID deployment for the support of the Promotion Management service requires the following two main types of cost for the retailer: (a) Capital Cost and (b) Operational Cost.

The capital cost refers to the fixed cost that the retailer is required to disburse for the implementation of the RFID infrastructure (RFID readers, antennas, servers, networking equipment) and the software development.

<u>Hardware Cost:</u>

As far as the hardware is concerned, we assume that the main RFID equipment is comprised of RFID gates placed at the coldroom entrance/exit, RFID readers and antennas embedded on the promotion stands and one server to support the software components of the RFID service. In addition, we have included in the capital cost category the cost of the networking equipment (e.g. wireless networking infrastructure) and the cost of training the employees for the utilization of the RFID system. The following table contains the average prices of the RFID infrastructure.

RFID EQUIPMENT	PRICES
1 RFID GATE	8.000,00 €
1 RFID READER	2.000,00 €
1 RFID ANTENNA	200,00 €
1 LOCAL SERVER	3.000,00 €
NETWORKING EQUIPMENT PER SHELF	400,00 €
TRAINING COST PER STORE (FIXED)	300,00 €

The following table includes the estimated capital hardware and training cost for the RFID implementation categorized into 3 main scenarios.

Scenario 1 refers to the cost derived from the implementation of 2 RFID gates at the coldroom entrance/exit for the inventory management and RFID readers and antennas on all the promotion stands of one store.

Scenario 2 includes the cost coming from the implementation of 2 RFID gates at the inventory room entrance/exit and 1 RFID reader and antennas on only one promotion stand per store for ALL THE stores.

Scenario 3 depicts the full-cost of the RFID deployment. (2 RFID gates at the coldroom entrance/exit and RFID readers and antennas on all the promotion stand per one store, estimated for all the stores)

	RFID EQUIPMENT	SERVER COST	NETWORKING EQUIPMENT	TRAINING	TOTAL COST
SCENARIO 1: INVENTORY MANAGEMENT AND ALL PROMOTION STANDS IN ONE STORE	38.400,00 €	3.000,00 €	600,00 €	3.000,00 €	45.000,00 €
SCENARIO 2: INVENTORY MANAGEMENT AND ONE PROMOTION STAND IN ALL THE STORES	1.485.000,00 €	450.000,00 €	90.000,00 €	450.000,00 €	2.475.000,00 €
SCENARIO 3: INVENTORY MANAGEMENT AND ALL THE PROMOTION STANDS IN ALL THE STORES	5.950.000,00 €	450.000,00 €	90.000,00 €	450.000,00 €	6.940.000,00 €

<u>Software Cost:</u>

This type of cost refers to the amount of money that the retailer is required to pay for the RFID software deployment regarding the PM service. In other words, this cost can be considered as the revenues a business organization can gain through the exploitation of the RFID-enabled system. The SW cost is categorized into three types.

- *Site implementation analysis.* This type of cost entails all the necessary activities which deal with the evaluation of the current retailer's store architecture for the RFID deployment. Specific requirements in each store as prerequisites for the Promotion management implementation are considered at this stage. In addition, the specification of a business plan for the RFID application takes place as well and it is taken into account for the estimation of the cost.
- *SW for the Inventory management:* This category entails the software customization, installation and integration with the legacy systems dealing with the inventory management of the perishable products at the coldroom of the store. This cost stems from the SW required to monitor the product availability at the coldroom of one store.
- *SW for the Promotion management process:* This type includes the software customization and installation for the Promotion management business process. It is comprised of the SW that is needed to monitor the availability of the products on the fridge shelves and monitor the performance of the tagged on promotion products.

The following table illustrates the total SW cost for the Promotion management service. It is assumed that 5000 Euros is the month-rate for the SW development of the service. The cost is estimated for all the 150 stores of the Supermarkets chain in Greece and for each one store separately.

RFID application	**Man months**	**Cost for one store**	**Cost for all the (23) stores**
Stage 0 Site implementation analysis			
Assessment of retailer's store architecture and specification of a deployment plan			
Stage 1 Inventory management (Backroom)	4	20.000,00 €	20.000,00 €
Software customisation		- €	
Integration with legacy systems	4,00	20.000,00 €	20.000,00 €
Software installation	2,00	10.000,00 €	10.000,00 €
Stage 2 Promotion Management (Sales Floor)	0,50	2.500,00 €	375.000,00 €
Software customisation		- €	

Integration with legacy systems	4,00	20.000,00 €	20.000,00 €
Software installation	2,00	10.000,00 €	10.000,00 €
	0,50	2.500,00 €	375.000,00 €
		85.000,00 €	830.000,00 €

<u>Operational Cost:</u>

Operation cost includes the cost that the retailer is required to pay each year for the operation of the RFID-enabled promotion management service. We estimated that for the maintenance of the hardware and the software an amount of 3.000 Euros is needed per store and 450.000 Euros for all the 150 stores of Supermarket chain in Greece. In addition, the operational cost includes the license fees which are estimated to be 200 Euros per store and 30.000 Euros for all the stores per year. Please note, that the training cost is not included in this section as it is estimated as part of the capital-fixed cost. In addition, the cost of checking the RFID system for the promotion management purposes is not included in this section, as it was estimated as part of the benefit calculations (See Cost-Benefit Analysis 4.4.4.1).

The following table depicts the total operational cost for the service implementation per store and for all the stores.

RETAILER	PER STORE PER YEAR	ALL 23 THE STORES PER YEAR
HW & SW MAINTENANCE PER YEAR PER STORE	3.000,00 €	450.000,00 €
THE RFID-ENABLED SYSTEM LICENSE	200,00 €	30.000,00 €
	3.200,00 €	480.000,00 €

(c) Cost-Benefit analysis for the Dynamic Pricing service-Case Study II

This section includes the quantitative results of the cost-benefit analysis of the Dynamic Pricing (DP) service. In addition, this section encompasses the main assumptions that have been made for the Cost-Benefit analysis. The analysis has the aim to explain in a monetary basis what gains a retailer can derive from the implementation of the DP Service and what is the required cost of this service deployment.

Assumptions for the CB analysis

Several assumptions have been made for the estimation of the cost-benefit derived from the RFID-enabled service for dynamic pricing. Some of these assumptions refer either to real data gathered through the interview with one of the managers of Superquinn Supermarkets in Ireland or to "Rule of thumb" assumptions. *For example,* ***all the calculations are based*** on the real number of the examined retailing stores (23 stores). The number of the stores justifies the difference between the benefit figures estimated for the DP service and the ones for the PM service. In particular, the number of the stores taken as a basis for the Cost & Benefit estimation of the PM service is too much higher (150 stores). To alleviate this difference, the benefit figures for the DP service are calculated per store in order to be comparable to the ones stemmed from the PM service. Except for the number of the stores, we assume that the retailer has on average 4 fridge shelves approximately in each store. In addition, in order to estimate time and cost savings because of the RFID implementation, an average amount of salary had to be taken into account. In particular, the main assumption is the fact that one hour of the Sales Floor manager is charged in 15 Euros. Furthermore, it is assumed that the working days per year are 312. The table below includes the main figures based on which the cost-benefit estimations are made.

Main assumptions for the CB analysis of the DP service

Stores and fridge shelves	
Number of stores	23,00
No of Fridge shelves	92,00
On average Number of fridge shelves per store	4,00
No of orders	
Number of orders with perishable products received per month per store	6,00
Number of orders received per year per store	72,00
Number of orders received per year for all the stores	1656,00
Other variables	
Labor hourly rate	15euros

Benefit analysis

The main categories of the benefits derived from the Dynamic Pricing service implementation that can be expressed in a quantitative basis are the direct and the indirect benefits.

1. Direct benefits

The direct benefits are considered as the benefits of the RFID enabled service and come as a result of the expected cost savings. The table below depicts the main values of the key performance indicators for the direct benefit estimations. The direct benefits are divided into two stages based on the location of RFID gates/readers.

The first stage includes the RFID implementation in the coldroom and refers to two types of business processes. The first is the orders receiving. The current average time (30 mins) needed for an employee to receive an order with products on dynamic pricing is compared to the estimated time (20 mins) that an employee is expected to need due to the introduction of the RFID technology. The second type of business process is the audit of the coldroom stock. The average time (10mins) currently needed by the personnel to check the coldroom stock of products (once per day) is compared to the one estimated due to the RFID introduction. It is assumed that 5 mins on average will be needed for an employee to check the coldroom stock of the products on dynamic pricing through the RFID-enabled application on a PC. It is assumed that there will be no need of a physical check.

The second stage includes the RFID implementation at the Sales floor, where RFID readers are placed on the fridge shelves. Currently, employees consume 10 mins to check the availability of products on one fridge shelf. On the contrary, it is assumed that through the RFID technology an employee will need 20 mins to check the availability of all the fridge shelves in one store on the screen of a PC. In addition, it is assumed that there is no need of a physical check of the fridge shelves.

Key Performance Indicators for the Benefit estimation (DP service)

			AS-IS		TO-BE (RFID)	
		Measurement	As-Is value for checking physically the shelf or the cold room	Unit	To-be value for checking physically the shelf or the coldroom	To-be value for checking the PC
Reader at the coldroom	Orders receiving	Time needed for the orders receiving (per order)	30	minutes	20	0,00
		Employees involved simultaneously at the orders receiving process	2	Units	1	0,00

	Checking the coldroom stock	Time needed per checking the coldroom stock and availability of the DP products in one store (for all the fridge shelves in the store)	10,00	minutes	0,00	5,00
		Employees involved simultaneously at one coldroom checking	1,00	Units	1,00	1,00
		Frequency of checking the coldroom of products per day	1,00	Units	0,00	1,00
Reader on the fridge shelf	Checking the stock and the availability on the fridge shelf	Time needed per checking the stock and the availability of products on one fridge shelf (with RFID on all the fridge shelves)	10,00	minutes	0,00	20,00
		employees involved simultaneously during one check	1,00	Units	1,00	1,00
		Frequency of checking the stock of one stand per day	3,00	Units	0,00	2,00

Based on the above Performance Indicators and their respective values, the estimation of the cost savings is made. These cost savings are categorized into two stages. The first stage includes the RFID investment at the coldroom. Based on the calculations (see deliverable 4.1 Methodology for the CB analysis) it is estimated that the cost saving due to the decrease of the time needed for the orders receiving process is 16.560 Euros annually for all the stores (720 Euros per store). This is a result of the reduction of the time needed to validate the order documents with the actual products which are received in the store as a result of their automatic identification through RFID technology. The calculation is based on the assumption that 6 orders for perishable products are received per month (72 orders per year). The second parameter which is a part of the first stage (RFID investment in the coldroom) refers to the annual cost saving that can be derived by the RFID implementation due to the time reduction needed to check the stock at the coldroom. It is estimated to be 8.970 Euros for all the stores and 390 Euros per store.

Regarding the second stage of the RFID investment at the Sales Floor for the promotion management, it is estimated that the annual cost saving due to the time reduction needed to check the stock and the availability of the fridge shelves is 143.520 Euros for all the stores and 6240 Euros per store.

Estimated direct benefits of the DP service

		AS IS			TO BE					
Orders receiving	Benefit	**Time needed As-Is per year for checking orders/stock per year per store**	**Time needed As-Is per year for checking orders/stock per year for all the stores**	**Cost as is for all the stores per year**	**Time needed To-Be for checking orders/stocks per year per store**	**Time needed To-Be for checking orders/stocks per year for all the stores**	**cost To-Be (RFID) for checking the stands physically per year**	**Cost To-be (RFID) for checking the PC(for all the stands/all the stores/ per year)**	**COST SAVING per year for all the stores**	**COST SAVING PER STORE PER YEAR**
	Direct cost savings	**mins**	**mins**	**euros**	**mins**	**mins**	**euros**			
Checking the coldroom stock	Annual cost saving due to the decrease of time needed for the orders receiving	4.320,00	99.360,00	24.840,00 €	1.440,00	33.120,00	8.280,00 €		16.560,00 €	**720,00 €**
	Annual cost saving due to the decrease of the time needed to check the coldroom stock	3.120,00	71.760,00	17.940,00 €	1.560,00	35.880,00	- €	8.970,00 €	8.970,00 €	**390,00 €**
Checking the stock and the availability on the fridge shelf	Annual cost saving due to the time decrease of the time needed to check the stock of fridge shelves	37.440,00	861.120,00	215.280,00 €	12.480,00	287.040,00	- €	71.760,00 €	143.520,00 €	**6.240,00 €**
	TOTAL DIRECT COST SAVINGS								169.050,00 €	**7.350,00 €**

2. Indirect benefits

Indirect benefits refer to the benefits which cannot be estimated based on the time which is needed currently for business processes compared to the needed time for these processes as a result of the RFID implementation. Two types of indirect benefits are considered for the case of the DP.

- Sales increase
- Waste Reduction

The first type of the indirect benefits refers to the estimated increase of the sales regarding the perishable products where the dynamic pricing service is applied to. It is assumed that this service will drive sales to a higher point since it can work as a discount offer. In addition, the sales increase can be a result of the improved inventory management though the RFID implementation. In particular, the visibility of the stock at the coldroom and the fridge shelves is expected to be improved. As a result, the out-of stock occurrences might be minimized. The above can lead to sales increase. Based on the interviewee estimations the sales increase as a result of the DP service is expected to be 812.500 Euros for all the stores per year (35.326 for each store).

The second type of indirect benefits refers to the estimated waste reduction due to the automatic identification of the products through the RFID system. Based on the interviewee calculation it is estimated that the DP service can lead to 500.000 Euros waste reduction for all the 23 stores per year. This equals to 21.739 Euros of estimated waste reduction for each store. The following table depicts the referred figures regarding the estimated indirect benefits of the DP service.

Estimated indirect benefits of the DP service

Indirect benefits of the DP service	For all the stores	For one store
Sales increase due to the DP service	812.500,00 €	35.326,09 €
Waste reduction (due system identifying products)	500.000,00 €	21.739,13 €

The following table encompasses all the estimated direct and indirect benefits derived from the RFID-enabled service for dynamic pricing.

Total estimated benefits (Direct and indirect) of the DP service

	Benefits			Cost saving/Sales increase per store
Stages			Cost saving/Sales increase per year for all the stores	
		Direct benefits		
Coldroom	Orders receiving	Annual cost saving due to the decrease of time needed for the orders receiving	16.560,00 €	720,00 €
	Checking the coldroom stock	Annual cost saving due to the decrease of the time needed to check the coldroom stock	8.970,00 €	390,00 €
Sales Floor	Checking the stock and the availability on the fridge shelf	Annual cost saving due to the time decrease of the time needed to check the stock of fridge shelves	143.520,00 €	6.240,00 €
		Indirect benefits	169.050,00 €	7.350,00 €
		Sales increase due to the DP service	812.500,00 €	35.326,09 €
		Waste reduction (due system identifying products)	500.000,00 €	21.739,13 €
		TOTAL (DIRECT+INDIRECT)	1.312.500,00 €	57.065,22 €

<u>Cost Analysis</u>

This section includes the analysis of the cost that a retailer it is estimated to pay in order to implement the RFID-enabled service for the dynamic pricing process. The assumptions of the cost analysis are the same with the ones made for the benefit analysis.

RFID deployment for the support of the Dynamic Pricing service requires the following two main types of cost for the retailer: (a) Capital Cost and (b) Operational Cost. The capital cost refers to the fixed cost that the retailer is required to disburse for the implementation of the RFID infrastructure (RFID readers, antennas, servers, networking equipment) and the software development.

<u>Hardware Cost:</u>

As far as the hardware is concerned, we assume that the main RFID equipment is comprised of RFID gates placed at the coldroom entrance/exit, RFID readers and antennas embedded on the fridge shelves and one server to support the software components of the Dynamic Pricing service. In addition, we have included in the capital cost category the cost of the networking equipment (e.g. wireless networking infrastructure) and the cost of training the employees for the utilization of the RFID-enabled system. The following table contains the average prices of the RFID infrastructure.

RFID EQUIPMENT	PRICES
1 RFID GATE	8.000,00 €
1 RFID READER	2.000,00 €
1 RFID ANTENNA	200,00 €
1 LOCAL SERVER	3.000,00 €
NETWORKING EQUIPMENT PER SHELF	400,00 €
TRAINING COST PER STORE (FIXED)	300,00 €

The following table includes the estimated capital hardware and training cost for the RFID implementation categorized into 3 main scenarios.

Scenario 1 refers to the cost derived from the implementation of 2 RFID gates at the coldroom entrance/exit for the inventory management and RFID readers and antennas on all the fridge shelves of one store.

Scenario 2 includes the cost coming from the implementation of 2 RFID gates at the coldroom entrance/exit and 1 RFID reader and antennas on only one fridge shelf per store for ALL THE stores.

Scenario 3 depicts the full-cost of the RFID deployment. (2 RFID gates at the coldroom entrance/exit and RFID readers and antennas on all the fridge shelves per one store, estimated for all the stores)

	RFID EQUIPMENT	SERVER COST	NETWORKING EQUIPMENT	TRAINING	TOTAL COST
SCENARIO 1: INVENTORY MANAGEMENT AND ALL FRIDGE SHELVES IN ONE STORE	27.200,00 €	3.000,00 €	1.600,00 €	300,00 €	32.100,00 €
SCENARIO 2: INVENTORY MANAGEMENT AND ONE FRIDGE SHELVE IN ALL THE	432.400,00 €	69.000,00 €	9.200,00 €	6.900,00 €	517.500,00 €

STORES					
SCENARIO 3: INVENTORY MANAGEMENT AND ALL THE FRIDGE SHELVES IN ALL THE STORES	625.600,00 €	69.000,00 €	36.800,00 €	6.900,00 €	738.300,00 €

The following table includes the cost of the above 3 scenarios with one main difference. The assumption is that 2 RFID readers with the respective number of antennas (rather than only one reader) are placed at each one fridge shelf. The cost as it is expected is higher for this case.

	RFID EQUIPMENT	SERVER COST	NETWORKING EQUIPMENT	TRAINING	TOTAL COST
SCENARIO 1: INVENTORY MANAGEMENT AND ALL FRIDGE SHELVES IN ONE STORE	38.400,00 €	3.000,00 €	1.600,00 €	300,00 €	43.300,00 €
SCENARIO 2: INVENTORY MANAGEMENT AND ONE FRIDGE SHELVE IN ALL THE STORES	496.800,00 €	69.000,00 €	9.200,00 €	6.900,00 €	581.900,00 €
SCENARIO 3: INVENTORY MANAGEMENT AND ALL THE FRIDGE SHELVES IN ALL THE STORES	883.200,00 €	69.000,00 €	36.800,00 €	6.900,00 €	995.900,00 €

Software Cost:

This type of cost refers to the amount of money that the retailer is required to pay for the RFID software deployment regarding the DP service. In other words, this cost can be considered as the revenues a business organization can gain through the exploitation of the RFID-enabled system. The SW cost is categorized into three types.

Site implementation analysis. This type of cost entails all the necessary activities which deal with the evaluation of the current retailer's store architecture for the RFID deployment. Specific requirements in each store as prerequisites for the Dynamic Pricing implementation are considered at this stage. In addition, the specification of a business plan for the RFID application takes place as well and it is taken into account for the estimation of the cost.

SW for the Inventory management: This category entails the software customization, installation and integration with the legacy systems dealing with the inventory management of the perishable products at the coldroom of the store. This cost stems from the SW required to monitor the product availability at the coldroom of one store.

SW for the Dynamic Pricing process: This type includes the software customization and installation for the dynamic pricing business process. It is comprised of the SW that is needed to monitor the availability of the products on the fridge shelves and monitor the performance of the tagged perishable products.

The following table illustrates the total SW cost for the Dynamic Pricing service. It is assumed that 5000 Euros is the month-rate for the SW development of the service. The cost is estimated for all the 23 stores of the Superquinn Supermarkets and for each one store separately.

RFID application	Man months	Cost for one store	Cost for all the stores
Stage 0 Site implementation analysis			
Assessment of retailer's store architecture and specification of a deployment plan	4	20.000,00 €	20.000,00 €
Stage 1 Inventory management (Coldroom)			
Software customisation	4,00	20.000,00 €	20.000,00 €
Integration with legacy systems	2,00	10.000,00 €	10.000,00 €
Software installation	0,50	2.500,00 €	57.500,00 €
Stage 2 Dynamic Pricing (Sales Floor)			
Software customisation	4,00	20.000,00 €	20.000,00 €
Integration with legacy systems	2,00	10.000,00 €	10.000,00 €
Software installation	0,50	2.500,00 €	57.500,00 €
		85.000,00 €	195.000,00

Operational Cost

Operation cost includes the cost that the retailer is required to pay each year for the operation of the RFID enabled dynamic pricing service. We estimated that for the maintenance of the hardware and the software an amount of 3.000 euros is needed per store and 69.000 euros for all the 23 stores of Superquinn supermarkets in

Ireland. In addition, the operational cost includes the license fees which are estimated to be 200 Euros per store and 4.600 Euros for all the stores per year. Please note, that the training cost is not included in this section as it is estimated as part of the capital-fixed cost. In addition, the cost of checking the RFID system for the dynamic pricing purposes is not included in this section, as it was estimated as part of the benefit calculations (See 3.3.3).

The following table depicts the total operational cost for the DP service implementation per store and for all the stores.

RETAILER	PER STORE PER YEAR	ALL 23 THE STORES PER YEAR
HW & SW MAINTENANCE PER YEAR PER STORE	3.000,00 €	69.000,00 €
THE RFID-ENABLED SYSTEM LICENSE	200,00 €	4.600,00 €
	3.200,00 €	73.600,00

Net Present Value (NPV) Estimation for the Dynamic Pricing Service

	0	1	2	3	4	5
BENEFITS ESTIMATION						
Direct Benefits		7.350,00 €	7.350,00 €	7.350,00 €	7.350,00 €	7.350,00 €
Indirect Benefits		1.312.500, 00 €	1.312.500, 00 €	1.312.500, 00 €	1.312.500, 00 €	1.312.500, 00 €
Revenues for exploiting the service		800.000,00 €	1.200.000, 00 €	1.600.000, 00 €	2.000.000, 00 €	2.400.000, 00 €
TOTAL BENEFITS	- €	1.319.850, 00 €	1.319.850, 00 €	1.319.850, 00 €	1.319.850, 00 €	1.319.850, 00 €
TOTAL BENEFITS EXCL. EXPLOITATION	- €	1.319.850, 00 €	1.319.850, 00 €	1.319.850, 00 €	1.319.850, 00 €	1.319.850, 00 €
COSTS ESTIMATION						
Capital Expenses	933.300,00 €					
Operational Expenses		73.600,00 €	73.600,00 €	73.600,00 €	73.600,00 €	73.600,00 €
Tagging Costs	83.959,20 €	75.563,28 €	68.006,95 €	61.206,26 €	55.085,63 €	49.577,07 €
Costs Including Tagging	1.017.259,20 €	149.163,28 €	141.606,95 €	134.806,26 €	128.685,63 €	123.177,07 €
Costs Excluding Tagging	933.300,00 €	73.600,00 €	73.600,00 €	73.600,00 €	73.600,00 €	73.600,00 €
INVESTMENT APPRAISAL						
CASH FLOWS (BEFORE TAXES AND DEPRECIATION EFFECTS)	-933.300,00 €	1.246.250, 00 €	1.246.250, 00 €	1.246.250, 00 €	1.246.250, 00 €	1.246.250, 00 €
NET CASH FLOWS (PV) - INCL. INTEREST	-933.300,00 €	1.112.723, 21 €	993.502,87 €	887.056,13 €	792.014,41 €	707.155,72 €
CUMULATIVE NET CASH FLOWS (PV)	-933.300,00 €	179.423,21 €	1.172.926, 08 €	2.059.982, 22 €	2.851.996, 62 €	3.559.152, 34 €
NET PRESENT VALUE	3.559.152,34 €					

APPENDIX 5- CASE STUDY III

(a) Questionnaire distributed to the Retailing Beverage Company

Βασικές Ενότητες του ερωτηματολογίου για την αποτύπωση και αξιολόγηση της υφιστάμενης κατάστασης

Για την αποτύπωση και αξιολόγηση της υφιστάμενης κατάστασης είναι απαραίτητη η συλλογή των παρακάτω δεδομένων:

ΕΦΟΔΙΑΣΤΙΚΗ ΑΛΥΣΙΔΑ	
• Αριθμός και τοποθεσία εργοστασίων και αποθηκών	
1. Αριθμός εργοστασίων με αποθήκες	
2. Αριθμός αποθηκών (χωρίς παραγωγή)	
ΑΠΟΤΥΠΩΣΗ ΔΙΑΔΙΚΑΣΙΩΝ	
I. ΔΙΑΔΙΚΑΣΙΑ ΠΑΡΑΛΑΒΗΣ και ΑΠΟΘΗΚΕΥΣΗΣ ΠΑΛΕΤΩΝ	
Χρόνοι & Πόροι - Μέσα από τα δεδομένα αυτά θα προκύψει το εργατικό κόστος για τη διαδικασία της παραλαβής και της αποθήκευσης παλετών.	
1. Κατά μέσο όρο, πόσος χρόνος χρειάζεται για τη διαδικασία της παραλαβής και της αποθήκευσης παλετών **ανά φορτηγό;** *(η συνολική διάρκεια περιλαμβάνει το χρόνο που απαιτείται για τον έλεγχο και τη διασταύρωση του δελτίου αποστολής με τις καταχωρημένες παραγγελίες και με τα προϊόντα που πραγματικά παρελήφθησαν, το ξεφόρτωμα και το σκανάρισμα παλετών, την εκτύπωση και την επικόλληση των ετικετών, το χρόνο που καταναλώνεται για την αναζήτηση της θέσης για εναπόθεση της παλέτας στο storage location και στο picking location, τη μεταφορά παλέτας από την παραλαβή στη storage location και από το storage location στο picking location)*	
2. Αριθμός ατόμων που απασχολούνται ΤΑΥΤΟΧΡΟΝΑ με την παραλαβή και την αποθήκευση των παλετών ανά φορτηγό.	

3. Πόσος χρόνος απαιτείται κατά μέσο όρο για να παραληφθεί **<u>μια παραχθείσα παλέτα</u>** από την αντίστοιχη μονάδα παλετοποίησης μέχρι και την αποθήκευσή της; *(ο χρόνος αφορά στη διάρκεια από τη στιγμή της παραλαβής μιας παλέτας από τη μονάδα παλετοποίησης και της ταυτοποίησής της με το σύστημα μέχρι τη στιγμή της αποθήκευσής της)*	
4. Πόσος χρόνος απαιτείται κατά μέσο όρο για να παραληφθεί από τη μονάδα παλετοποίησης και να αποθηκευτεί **<u>μια παλέτα;</u>**	
5. Αριθμός ατόμων που απασχολούνται ΤΑΥΤΟΧΡΟΝΑ με την παραλαβή και την αποθήκευση μιας παραχθείσας παλέτας *(από τη μονάδα παλετοποίησης μέχρι την αποθήκευσή της).*	
<u>Ποσοστό Λαθών/ Αποκλίσεων (%)</u>- Μέσα από τα δεδομένα αυτά θα προκύψουν οι μέσοι όροι για την αποτελεσματικότητα των αντίστοιχων διαδικασιών:	
6. Πόσο συχνά παρατηρούνται διαφορές μεταξύ του Δελτίου Αποστολής και της καταχωρημένης Παραγγελίας/ εντολής διακίνησης, <u>ανά φορτηγό;</u>	
7. Πόσος χρόνος χρειάζεται κατά μέσο όρο για να εξεταστεί και να επιδιορθωθεί μια τέτοια απόκλιση;	
8. Πόσο συχνά προκύπτει λάθος κατά των scanning λόγω φθορών ετικέτας κτλ., ανά φορτηγό;	
9. Πόση ώρα χρειάζεται για να επιδιορθωθεί το λάθος?	
10. Πόσο συχνά παρατηρούνται διαφορές μεταξύ του Δελτίου Αποστολής και των προϊόντων που πραγματικά παρελήφθησαν, <u>ανά φορτηγό;</u>	
11. Πόσος χρόνος κατά μέσο όρο χρειάζεται για επιλυθεί μια τέτοια απόκλιση;	
12. Πόσο συχνά έχω λάθη στην εναπόθεση, ανά φορτηγό;	
13. Πόση ώρα χρειάζεται για να επανατοποθετεί στη σωστή θέση;	
14. Πόσο συχνά προκύπτει λάθος στην παραλαβή και αποθήκευση μιας παραχθείσας παλέτας (π.χ. μη	

επιβεβαίωση με την εντολή του συστήματος.). Στις 100 παραλαβές, πόσα λάθη;	
15. Πόσος χρόνος κατά μέσο όρο χρειάζεται για επιλυθεί μια τέτοια απόκλιση;	
II. <u>ΔΙΑΔΙΚΑΣΙΑ ΣΥΛΛΟΓΗΣ ΚΑΙ ΦΟΡΤΩΣΗΣ (ΠΡΟΣ ΑΠΟΣΤΟΛΗ) ΠΑΛΕΤΩΝ</u>	
<u>Χρόνοι & Πόροι</u> - Μέσα από τα δεδομένα αυτά θα προκύψει το εργατικό κόστος της διαδικασίας της συλλογής και της φόρτωσης προς αποστολή παλετών.	
1. Κατά μέσο όρο πόση ώρα απαιτείται για να συλλεχθεί, ελεγχθεί και να φορτωθεί προς αποστολή **<u>μια ατόφια παλέτα</u>** *(παλέτα με ένα είδος προϊόντος);* *(Η συνολική διάρκεια περιλαμβάνει το χρόνο που χρειάζεται για τον έλεγχο ενδεχόμενων διαφορών μεταξύ της Picking list και των προϊόντων που πραγματικά έχουν συλλεγεί, τη διαδικασία μέτρησης σε περίπτωση διαφορών, το φόρτωμα της ατόφιας παλέτας και την παραγωγή του δελτίου αποστολής)*	
2. Πόσα άτομα απασχολούνται κατά μέσο όρο ΤΑΥΤΟΧΡΟΝΑ με τη συλλογή, τον έλεγχο και τη φόρτωση προς αποστολή μιας ατόφιας παλέτας;	
3. Κατά μέσο όρο πόσος χρόνος απαιτείται για να συλλεχθεί, ελεγχθεί και φορτωθεί προς αποστολή **<u>μια μεικτή παλέτα</u>** *(παλέτα με διάφορα είδη προϊόντος)*; *(Η συνολική διάρκεια περιλαμβάνει το χρόνο που χρειάζεται για τον έλεγχο ενδεχόμενων διαφορών μεταξύ της Picking list και των προϊόντων που πραγματικά έχουν συλλεγεί, τη διαδικασία μέτρησης σε περίπτωση διαφορών, το φόρτωμα της μεικτής παλέτας και την παραγωγή του δελτίου αποστολής)*	
4. Πόσα άτομα απασχολούνται κατά μέσο όρο ΤΑΥΤΟΧΡΟΝΑ με τη συλλογή, τον έλεγχο και τη φόρτωση προς αποστολή μιας μεικτής παλέτας;	
5. Κατά μέσο όρο πόσος χρόνος χρειάζεται για να **<u>ελεγχθεί</u>** το περιεχόμενο **<u>ενός φορτηγού προς αποστολή;</u>**	

6. Πόσα άτομα απασχολούνται κατά μέσο όρο ΤΑΥΤΟΧΡΟΝΑ με τον έλεγχο του περιεχομένου ενός φορτηγού;	
7. Κατά μέσο όρο πόσος χρόνος απαιτείται για να **φορτωθεί ένα φορτηγό** προς αποστολή;	
8. Πόσα άτομα απασχολούνται κατά μέσο όρο ΤΑΥΤΟΧΡΟΝΑ με τη φόρτωση **ενός φορτηγού** προς αποστολή;	
Ποσοστό Λαθών/ Αποκλίσεων (%)- Μέσα από τα δεδομένα αυτά θα προκύψουν οι μέσοι όροι για την αποτελεσματικότητα της διαδικασίας:	
9. Πόσο συχνά παρατηρούνται διαφορές μεταξύ του της Picking list και των προϊόντων που πραγματικά έχουν συλλεγεί, ανά φορτηγό;	*1%-3% (Σε ένα-τρια από τα 100 φορτηγά υπάρχει λάθος)*
10. Ποιο είναι το ποσοστό αυτής της απόκλισης;	
11. Κατά μέσο όρο ο χρόνος που χρειάζεται για εξεταστεί και να επιλυθεί μια τέτοια απόκλιση.	
III. ΔΙΑΔΙΚΑΣΙΑ ΑΠΟΓΡΑΦΗΣ ΠΑΛΕΤΩΝ	
Χρόνοι & Πόροι - Μέσα από τα δεδομένα αυτά θα προκύψει το εργατικό κόστος για τη διαδικασία της απογραφής.	
1. Πόση ώρα διαρκεί η διαδικασία **ΜΙΑΣ απογραφής** σε ένα εργοστάσιο/αποθήκη; Πόσες εργατοώρες απασχολείται ο κάθε ένας υπάλληλος για την ολοκλήρωση μιας απογραφής;	
2. Συχνότητα απογραφής:	
3. Πόσα άτομα/υπάλληλοι απασχολούνται ΤΑΥΤΟΧΡΟΝΑ για κάθε μια απογραφή;	
4. Αριθμός παλετών που απογράφονται κατά μέσο όρο κατά τη διάρκεια μιας απογραφής, πανελλαδικά.	
5. Αριθμός παλετών που απογράφονται κατά μέσο όρο κατά τη διάρκεια μιας απογραφής, ανά εργοστάσιο (ανά μήνα).	
Ποσοστό Λαθών/ Αποκλίσεων (%)- Μέσα από τα δεδομένα αυτά θα προκύψουν οι μέσοι όροι για την αποτελεσματικότητα της διαδικασίας της απογραφής.	

6. Πόσο συχνά παρατηρούνται διαφορές μεταξύ του πραγματικού αποθέματος και του αποθέματος του συστήματος, ανά απογραφή;	
7. Ποιο είναι το ποσοστό αυτών των αποκλίσεων; (Στις 100 παλέτες πόσες είναι αυτές για τις οποίες εμφανίζεται απόκλιση;)	
8. Κατά μέσο όρο ο χρόνος που χρειάζεται για να εξεταστεί και να επιλυθεί μια τέτοια απόκλιση στην απογραφή.	
ΧΡΗΜΑΤΟΟΙΚΟΝΟΜΙΚΑ ΔΕΔΟΜΕΝΑ	
Οι παρακάτω ερωτήσεις εξετάζουν συγκεκριμένα χρηματοοικονομικά δεδομένα για την κοστολόγηση των παραπάνω διαδικασιών και την αξιολόγηση ενδεχόμενης επένδυσης σε νέες τεχνολογίες που υποστηρίζουν αυτές τις διαδικασίες.	
1. **Κόστος ανθρωποώρας** του εργατικού δυναμικού που απασχολείται με: την παραλαβή και αποθήκευση παλετών, τη συλλογή και αποστολή παλετών και την απογραφή.	
2. Ποσοστό του **προεξοφλητικού επιτοκίου** που χρησιμοποιείται από την εταιρεία για τον υπολογισμό ROI διαφόρων επενδύσεων.	
3. **Μεικτό περιθώριο κέρδους** (%)	
4. **Καθαρό περιθώριο κέρδους**(%)	
5. **Ποσοστό απόσβεσης** εξοπλισμού (%)	
6. **Ποσοστό φορολογίας** (%)	
7. Κατά μέσο όρο (προτεινόμενος) **χρόνος απόσβεσης** επενδύσεων:	

ΜΕΣΟΙ ΟΡΟΙ ΑΡΙΘΜΟΥ ΠΑΛΕΤΩΝ, ΦΟΡΤΗΓΩΝ που διακινούνται (στοιχεία σε excel)

(b) NPV approach for the CASE STUDY III

<u>Κόστος κεφαλαίου επένδυσης (CAPEX)</u>

<u>Κόστος εξοπλισμού (HW)</u>

Η εκτίμηση του κόστους κεφαλαίου επένδυσης βασίστηκε στις εξής παρακάτω τιμές.

RFID ΕΞΟΠΛΙΣΜΟΣ	ΤΙΜΕΣ
RFID PRINTER	4.000,00 €
LOCAL SERVER+ system SW	1.500,00 €
PC	600,00 €
NETWORKING	600,00 €
RFID GATE ΓΙΑ ΦΟΡΤΗΓΟ	8.000,00 €
RFID GATE ΓΙΑ ΠΟΡΤΑ ΑΠΟΘΗΚΗΣ	6.000,00 €

Πίνακας 1. Τιμές για τον υπολογισμό του HW

Ο παρακάτω πίνακας περιλαμβάνει το συνολικό κόστος HW για όλες τις εγκαταστάσεις και για τις τρεις διαδικασίες.

HW COST	
ΚΑΤΗΓΟΡΙΑ ΚΟΣΤΟΥΣ	ΠΟΣΟ
LOCAL SERVER+ SYSTEM SW	€ 13.500,00
NETWORKING EQUIPMENT	€ 5.400,00
PCS	€ 5.400,00
RFID PRINTER	€ 80.000,00
ΠΑΡΑΛΑΒΗ	
RFID GATE για το φορτηγό	€ 72.000,00
ΑΠΟΣΤΟΛΗ	
RFID GATE για το φορτηγό	€ 72.000,00
ΑΠΟΓΡΑΦΗ	
RFID GATE για την αποθήκη	€ 138.000,00
ΣΥΝΟΛΙΚΟ ΚΟΣΤΟΣ	€ 386.300,00

Πίνακας 2. Κόστος κεφαλαίου επένδυσης HW

Σημείωση

Για τον υπολογισμό του κόστους για τους RFID printers, έχει ληφθεί υπόψη ότι ο αριθμός των printers είναι ανάλογος του αριθμού μονάδων παλετοποίησης που περιέχει κάθε εγκατάσταση. Θεωρούμε ότι ο εκτυπωτής θα είναι σε αυτές τις μονάδες παλετοποίησης. Το κόστος έχει υπολογιστεί πολλαπλασιαστικά για όλες τις μονάδες παλετοποίησης και για όλες τις εγκαταστάσεις.

Για τον υπολογισμό του κόστους για τις απαιτούμενες RFID πύλες από τις οποίες θα περνά το φορτηγό κατά τη διάρκεια της παραλαβής και αποστολής, έχει θεωρηθεί ότι απαιτείται μια πύλη για κάθε μια από τις δύο διαδικασίες.

Για τον υπολογισμό του κόστους της απογραφής για τις απαιτούμενες RFID πύλες από τις οποίες θα περνούν οι παλέτες στην αποθήκη, έχει γίνει η υπόθεση ότι ο αριθμός των RFID πυλών θα είναι ίσος με τον αριθμό των διακριτών μονάδων αποθήκευσης που περιέχει κάθε εγκατάσταση.

<u>Κόστους Λογισμικού (SW)</u>

Το συνολικό κόστος για το λογισμικό, για όλες τις διαδικασίες και για την εφαρμογή της τεχνολογίας σε όλες τις εγκαταστάσεις είναι: 102.000,00 €. Στον παρακάτω πίνακα φαίνονται αναλυτικά οι υποκατηγορίες του κόστους.

Κόστος Ανθρωπομήνα	4.000,00 €		
RFID εφαρμογή	Ανθρωπομήνες	Κόστος για μια εγκατάσταση	Κόστος για όλες τις εγκαταστάσεις
ΚΟΙΝΟ ΚΟΣΤΟΣ ΓΙΑ ΌΛΑ ΤΑ ΕΡΓΟΣΤΑΣΙΑ & ΓΙΑ ΟΛΕΣ ΤΙΣ ΔΙΑΔΙΚΑΣΙΕΣ			
Ενοποίηση με τα υπάρχοντα συστήματα (ERP)	2,00		€ 8.000,00
Εγκατάσταση λογισμικού	1,00		€ 4.000,00
ΚΟΣΤΟΣ ΓΙΑ ΌΛΑ ΤΑ ΕΡΓΟΣΤΑΣΙΑ, ΓΙΑ ΚΆΘΕ ΔΙΑΔΙΚΑΣΙΑ ΞΕΧΩΡΙΣΤΑ (Ανάλυση απαιτήσεων και ανάπτυξη λογισμικού)			
ΠΑΡΑΛΑΒΗ s/w	3,00		€ 12.000,00
ΑΠΟΣΤΟΛΗ s/w	3,00		€ 12.000,00
ΑΠΟΓΡΑΦΗ s/w	3,00		€ 12.000,00
ΚΟΣΤΟΣ ΑΝΑ ΕΡΓΟΣΤΑΣΙΟ			
Testing- Ενοποίηση με τα υπάρχοντα συστήματα	1,00	4.000,00 €	€ 36.000,00
Εγκατάσταση	0,50	2.000,00 €	€ 18.000,00

Πίνακας 3. Κόστος SW

Λειτουργικό κόστος επένδυσης (OPEX)

Για την εφαρμογή της τεχνολογίας RF-ID στο σύνολο των καταστημάτων το λειτουργικό κόστος (OPEX) ανά έτος διαμορφώνεται σύμφωνα με τον παρακάτω πίνακα:

Παράμετρος λειτουργικού κόστους (€)	1ο έτος	2ο έτος	3ο έτος	4ο έτος	5ο έτος
Κόστος RFID Tags (0.08 Ευρώ+10% μείωση το έτος)	93.848,17	84.463,35	76.017,02	68.415,31	61.573,78
Συντήρηση HW (10% του Total HW)	38.630,00	38.630,00	38.630,00	38.630,00	38.630,00
Συντηρήσεις-Αναβαθμίσεις SW (10% του total SW)	10.200,00	10.200,00	10.200,00	10.200,00	10.200,00
Εκπαίδευση νέων στελεχών (15% του 1ου έτους η επανεκπαίδευση)	4320,00	648,00	648,00 €	648,00	648,00
Σύνολο	146.998,17	133.941,35	125.495,02	117.893,31	111.051,78

Πίνακας 4. Λειτουργικό Κόστος ανά έτος

Σημείωση

Ο υπολογισμός του κόστους των tags βασίστηκε στον αριθμό παλετών που παράγονται. Για το συγκεκριμένο οργανισμό ο αριθμός αυτών των παλετών που παρήχθησαν από όλα τα εργοστάσια ήταν 1.173.102 το έτος 2010. Το κόστος της επικόλλησης ισούται με Τον αριθμό των παλετών Χ το κόστος μιας ετικέτας. Στην προκειμένη περίπτωση το κόστους ενός tag είναι ίσο με 8 λεπτά, και μειώνεται κατά 10% κάθε χρόνο.

	ΕΤΟΣ					
	0	1	2	3	4	5
ΠΟΣΟΣΤΟ ΑΠΟΣΒΕΣΗΣ	0%	30,00%	30,00%	30,00%	10,00%	
ΑΠΟΣΒΕΣΗ (AVG)		146.490,00 €	146.490,00 €	146.490,00 €	48.830,00 €	- €

Πίνακας 5. Υπολογισμός Αποσβέσεων

Εκτίμηση οφέλους Επένδυσης στην Τεχνολογία RFID

(1) Διαδικασία παραλαβής παλετών

1.1 Υπάρχουσα διαδικασία

Συμπερασματικά θα μπορούσε να ειπωθεί ότι ο μέσος χρόνος για την παραλαβή ενός φορτηγού είναι αρκετά υψηλός (44 λεπτά). Πιο συγκεκριμένα σε ορισμένα εργοστάσια όπως αυτά της Πάτρας και της Θεσσαλονίκης ο χρόνος για την παραλαβή και αποθήκευση αντιστοιχεί σε 50 λεπτά, για το εργοστάσιο του Ηρακλείου σε 60 λεπτά ενώ στα υπόλοιπα εργοστάσια ο χρόνος κυμαίνεται από 30-44 λεπτά. Ο αριθμός των ατόμων που απασχολούνται για την συγκεκριμένη διαδικασία διαφέρει ανά εργοστάσιο και κυμαίνεται από 1 έως 4 άτομα ενώ υπάρχουν συνολικά 9 εγκαταστάσεις για να ολοκληρώσουν τη διαδικασία. Αυτό έχει αντίκτυπο στο λειτουργικό κόστος της επιχείρησης, το οποίο μπορεί να υπολογιστεί λαμβάνοντας υπόψη τη μέση διάρκεια της παραλαβής παλετών. Το κόστος της συγκεκριμένης διαδικασίας για κάθε εργοστάσιο φαίνεται στον πίνακα που ακολουθεί.

Ερώτηση	min	max	Τύπος δείκτη με τον οποίο συνδέεται η ερώτηση	Δείκτης
Διάρκεια διαδικασίας (σε λεπτά)	30	60	Ποσοτικός	Μείωση του λειτουργικού κόστους
Αριθμός υπαλλήλων για τη διαδικασία της παραλαβής	1	4		

Πίνακας 6. Δείκτες για τον υπολογισμό του AS-IS λειτουργικού κόστους για τη διαδικασία της παραλαβής

1.2 Επίδραση της τεχνολογίας

Όσον αφορά την επίδραση της τεχνολογίας RFID στη διαδικασία, εκτιμούμε ότι θα μειωθεί ο χρόνος που απαιτείται για τη διαδικασία περίπου κατά 19 λεπτά δηλαδή πλέον θα απαιτούνται μόνο 25 λεπτά προκειμένου να διεκπεραιωθεί η συγκεκριμένη διαδικασία μιας και θα αναγνωρίζονται αυτόματα όλες οι παλέτες χωρίς να απαιτείται έλεγχος πάνω σε αυτές ενώ παράλληλα ο αριθμός των ατόμων που θα δεσμεύονται στη διαδικασία θα ανέρχεται σε 2 άτομα. Ουσιαστικά, η τεχνολογία RFID θα συμβάλλει στη μείωση του χρόνου που αφορά στον έλεγχο του δελτίου παραλαβής και στο σκανάρισμα των παλετών που συνθέτουν την παραγγελία, ενώ οι διαδικασίες ξεφορτώματος και αναζήτησης θέσης θα μείνουν ως έχουν. Πλέον το κόστος της διαδικασίας «Παραλαβής και αποθήκευσης παλετών» εκτιμάται ότι θα είναι € 233.888,35 (έναντι €460.059,02 που κοστίζει τη δεδομένη χρονική στιγμή) γεγονός που σημαίνει όφελος της τάξης των € 226.170,68.

(2) Διαδικασία αποστολής παλετών

2.1 Υπάρχουσα διαδικασία

Ο μέσος χρόνος για την διαδικασία ελέγχου του φορτίου ενός φορτηγού προς αποστολή είναι 8,4 λέπτα. Πιο συγκεκριμένα σε ορισμένα εργοστάσια όπως αυτά της Πάτρας και της Θεσσαλονίκης ο χρόνος για τον έλεγχο του φορτηγού αντιστοιχεί σε 15 λεπτά, ενώ στα υπόλοιπα εργοστάσια ο χρόνος κυμαίνεται από 2-8,4 λεπτά. Ο αριθμός των ατόμων που απασχολούνται για την συγκεκριμένη διαδικασία είναι ίδιος για κάθε εργοστάσιο και αντιστοιχεί σε 1 άτομο ενώ υπάρχουν συνολικά 9 εγκαταστάσεις για να ολοκληρώσουν τη διαδικασία. Αυτό έχει αντίκτυπο στο λειτουργικό κόστος της επιχείρησης, το οποίο μπορεί να υπολογιστεί λαμβάνοντας υπόψη τη μέση διάρκεια ελέγχου του φορτηγού προς αποστολή. Το κόστος της συγκεκριμένης διαδικασίας για κάθε εργοστάσιο φαίνεται στον πίνακα που ακολουθεί:

Ερώτηση	min	max	Τύπος δείκτη με τον οποίο συνδέεται η ερώτηση	Δείκτης
Διάρκεια διαδικασίας (σε λεπτά)	2	15	Ποσοτικός	Μείωση του λειτουργικού κόστους
Αριθμός υπαλλήλων για τη διαδικασία της παραλαβής	1	1		

Πίνακας 7. Δείκτες για τον υπολογισμό του AS-IS λειτουργικού κόστους για τη διαδικασία της αποστολής

2.2 Επίδραση της τεχνολογίας

Όσον αφορά την επίδραση της τεχνολογίας RFID στη διαδικασία, εκτιμούμε ότι θα μειωθεί ο χρόνος που απαιτείται για τη διαδικασία περίπου κατά 7 λεπτά δηλαδή πλέον θα απαιτείται μόνο 1 λεπτό προκειμένου να διεκπεραιωθεί η διαδικασία ελέγχου ενός φορτηγού προς αποστολή μιας και ο έλεγχος του φορτίου θα γίνεται αυτόματα από RFID readers χωρίς να χρειάζεται επιπρόσθετο σκανάρισμα και περεταίρω έλεγχος. Ο αριθμός των ατόμων που θα απασχολούνται στη συγκεκριμένη διαδικασία παραμένει ίδιος με πριν (δηλαδή 1 άτομο) ενώ το λειτουργικό κόστος θα μειωθεί δεδομένου ότι ο έλεγχος του φορτηγού θα γίνεται όπως είπαμε και πριν αυτόματα κάνοντας χρήση της τεχνολογίας RFID. Πλέον το κόστος της διαδικασίας «Συλλογή και φόρτωση προς αποστολή παλετών» εκτιμάται ότι θα είναι € 9.460,95(έναντι € 82.409,78 που κοστίζει τη δεδομένη χρονική στιγμή) γεγονός που σημαίνει όφελος της τάξης των € 72.948,83.

(3) Διαδικασία απογραφής παλετών

3. 1 Υπάρχουσα διαδικασία

Ο μέσος χρόνος για την διαδικασία της απογραφής είναι πολύ υψηλός και ανέρχεται σε 480 λεπτά. Πιο συγκεκριμένα σε ορισμένα εργοστάσια όπως αυτό της Θεσσαλονίκης ο χρόνος για την απογραφή των παλετών στις αποθήκες αντιστοιχεί σε 600 λεπτά, στην Πάτρα ο χρόνος ανέρχεται σε 360 λεπτά, στην Αθήνα στα 480 λεπτά ενώ γενικότερα στα υπόλοιπα εργοστάσια ο χρόνος κυμαίνεται μεταξύ 360 και 480 λεπτών. Ο αριθμός των ατόμων που απασχολούνται για την συγκεκριμένη διαδικασία είναι διαφορετικός για κάθε εργοστάσιο(π.χ Ηράκλειο 12 άτομα, Αθήνα 7 άτομα) και κυμαίνεται μεταξύ 7 και 12 ατόμων, ενώ σε κάθε εργοστάσιο η διαδικασία αυτή πραγματοποιείται μια φορά το μήνα. Επιπλέον υπάρχουν συνολικά 9 εγκαταστάσεις για να ολοκληρώσουν τη διαδικασία. Αυτό έχει αντίκτυπο στο λειτουργικό κόστος της επιχείρησης, το οποίο μπορεί να υπολογιστεί λαμβάνοντας υπόψη τη μέση διάρκεια της διαδικασίας απογραφής. Το κόστος της συγκεκριμένης διαδικασίας για κάθε εργοστάσιο φαίνεται στον πίνακα που ακολουθεί:

Ερώτηση	min	max	Τύπος δείκτη με τον οποίο συνδέεται η ερώτηση	Δείκτης
Διάρκεια διαδικασίας (σε λεπτά)	360	480	Ποσοτικός	Μείωση του λειτουργικού κόστους
Αριθμός υπαλλήλων για τη διαδικασία της παραλαβής	7	12		

Πίνακας 8. Δείκτες για τον υπολογισμό του AS-IS λειτουργικού κόστους για τη διαδικασία της απογραφής

3. 2 Επίδραση της τεχνολογίας

Όσον αφορά την επίδραση της τεχνολογίας RFID στη διαδικασία, εκτιμούμε ότι το όφελος έγκειται στο γεγονός ότι η διαδικασία θα πραγματοποιείται μια φορά το χρόνο και όχι κάθε μήνα όπως συμβαίνει στην παρούσα κατάσταση. Όπως είναι λογικό κάτι τέτοιο έχει άμεσο αντίκτυπο στο κόστος που συνεπάγεται η συγκεκριμένη διαδικασία το οποίο θα μειωθεί δραματικά από €89.073,60 σε €7.422,80 γεγονός που σηματοδοτεί όφελος της τάξης €81.651,80 κάθε χρόνο.

Επιπλέον, εκτός από το ότι η διαδικασία μετά την εφαρμογή της RFID τεχνολογίας θα πραγματοποιείται μία φορά χρόνο ένας επιπλέον παράγοντας που συντελεί στην μείωση του κόστους και κατά συνέπεια στην αύξηση του οφέλους είναι η μείωση στον συνολικό αριθμό των εργατοωρών το χρόνο που απαιτούνται προκειμένου να διεκπεραιωθεί η διαδικασία της απογραφής.

Συνοπτικός πίνακας δεικτών και για τις τρεις διαδικασίες : Συνοπτικά, ο παρακάτω πίνακας, περιλαμβάνει τις βασικές μεταβλητές που μετρήθηκαν από τη συλλογή των ερωτηματολογίων για την υπάρχουσα κατάσταση των τριών διαδικασιών.

ΔΙΑΔΙΑΚΑΣΙΑ	ΔΕΙΚΤΗΣ	Τρέχουσα τιμή (Μ.Ο.)	Μονάδα Μέτρησης	RFID TO-BE Τιμή Δείκτη
ΠΑΡΑΛΑΒΗ	Μέσος Χρόνος Διεκπεραίωσης παραλαβής	44	Λεπτά	25
	Αριθμός υπαλλήλων που ασχολούνται με την παραλαβή	1-4	Άτομα	2
ΑΠΟΣΤΟΛΗ	Μέσος Χρόνος Διεκπεραίωσης αποστολής (έλεγχος περιεχομένου φορτηγού)	8,4	Λεπτά	1
	Αριθμός υπαλλήλων που ασχολούνται με την αποστολή	1	Άτομα	1
ΑΠΟΓΡΑΦΗ	Μέσος Χρόνος Διεκπεραίωσης απογραφής	480	Λεπτά	Γίνεται αυτόματα
	Αριθμός υπαλλήλων που ασχολούνται με την απογραφή	7-12	Άτομα	Γίνεται αυτόματα

Πίνακας 9. Πίνακας δεικτών μείωσης του λειτουργικού κόστους και για τις τρεις διαδικασίες

ΚΑΤΗΓΟΡΙΑ ΔΙΑΔΙΚΑΣΙΑΣ	AS IS COST PER YEAR	TO BE COST PER YEAR	COST SAVING PER YEAR
Απογραφή			
Κόστος Απογραφής	€ 89.073,60	€ 7.422,80	€ 81.650,80
Παραλαβή			

Κόστος Παραλαβής	€ 460.059,02	€ 233.888,35	€ 226.170,68
Αποστολή			
Κόστος αποστολής	€ 82.409,78	€ 9.460,95	€ 72.948,83
ΣΥΝΟΛΟ	€ 631.542,40	€ 250.772,10	€ 380.770,30

Πίνακας 10. Λειτουργικό κόστος χωρίς και με τη χρήση της τεχνολογίας RFID. Μείωση του λειτουργικού κόστους για τις τρεις διαδικασίες, για όλες τις εγκαταστάσεις

Στον παρακάνω πίνακα φαίνεται το συνολικό COST SAVING για όλες τις διαδικασίες και για όλες τις εγκαταστάσεις, έτσι όπως θα προκύψει από την επίδραση της τεχνολογίας. Για κάθε διαδικασία απεικονίζεται το υπάρχον κόστος (AS-IS) το κόστος με τη χρήση της τεχνολογίας RFID και η μείωση αυτού του κόστους.

Εκτός από τον υπολογισμό της μείωσης του λειτουργικού κόστους ως επίδραση της τεχνολογίας RFID υπάρχουν και τα παρακάτω ποιοτικά οφέλη για την εφαρμογή στις 3 αναφερόμενες επιχειρηματικές διαδικασίες.

- Πιστοποίηση καλής παράδοσης παραγγελίας
- Μείωση κλοπών
- Αποδοτικότερες μεταφορές
- Ποιοτικός έλεγχος
- Πλήρης ορατότητα της εφοδιαστικής αλυσίδας και παρακολούθηση των προϊόντων
- Δυνατότητα εισαγωγής μεγάλου όγκου πληροφορίας
- Αύξηση παραγωγικότητας (μέσω της καλύτερης διάθεσης των πόρων)
- Μείωση out-of-stock περιπτώσεων
- Αυτόματες ειδοποιήσεις για λανθασμένες παραγγελίες, για έλλειψη αποθεμάτων

Υπολογισμός συνολικού οφέλους για όλες τις διαδικασίες και εγκαταστάσεις

Για όλες τις εγκαταστάσεις τα αναμενόμενα οφέλη ποσοτικοποιούνται στον παρακάτω πίνακα.

α/α	ΟΦΕΛΟΣ	ΠΟΣΟ
1	ΟΦΕΛΟΣ ΑΠΟ ΔΙΑΔΙΚΑΣΙΑ ΠΑΡΑΛΑΒΗΣ	€ 226.170,68
2	ΟΦΕΛΟΣ ΑΠΟ ΔΙΑΔΙΚΑΣΙΑ ΑΠΟΣΤΟΛΗΣ	€ 72.948,83

3	ΟΦΕΛΟΣ ΑΠΟ ΔΙΑΔΙΚΑΣΙΑ ΑΠΟΓΡΑΦΗΣ	€ 81.650,80
ΣΥΝΟΛΙΚΟ ΟΦΕΛΟΣ		€ 380.770,30

Πίνακας 11. Πίνακας συνολικού οφέλους ανά διαδικασία

Σημείωση

Για τον υπολογισμό του υπάρχοντος λειτουργικού κόστους και του κόστους μετά την επίδραση της τεχνολογίας RFID, το COST SAVING για κάθε διαδικασία προέκυπτε από τον εξής υπολογισμό: COST SAVING= AS-IS COST (χωρίς τη χρήση της τεχνολογίας RFID) -TO BE COST (με την επίδραση της τεχνολογίας). Επίσης, για τον υπολογισμό του τωρινού λειτουργικού κόστους και αυτού μετά την επίδραση της τεχνολογίας RFID δημιουργήθηκαν συναρτήσεις οι οποίες λειτουργούσαν παραμετρικά για κάθε εγκατάσταση ξεχωριστά. Αυτές οι συναρτήσεις ήταν ξεχωριστές για κάθε διαδικασία.

Για παράδειγμα για τον υπολογισμό του AS-IS και του TO-BE λειτουργικού κόστους για τη διαδικασία της παραλαβής παλετών χρησιμοποιήθηκε η εξής συνάρτηση: Λεπτά που χρειάζονται για την παραλαβή παλετών από ένα φορτηγό X Το κόστος ενός λεπτού για έναν εργαζόμενο X Αριθμός εργαζομένων που ασχολούνται με την παραλαβή ενός φορτηγού X Αριθμός φορτηγών που παραλαμβάνονται ανά ημέρα X Αριθμός ημερών μέσα στο έτος

<u>ΑΠΟΤΕΛΕΣΜΑΤΑ ΚΑΙ ΣΥΜΠΕΡΑΣΜΑΤΑ ΑΠΟΤΙΜΗΣΗΣ ΤΗΣ ΕΠΕΝΔΥΣΗΣ</u>

Μοντέλο αξιολόγησης της επένδυσης

Για την αξιολόγηση της σκοπιμότητας της επένδυσης και τον υπολογισμών των σχετικών δεικτών υλοποιήθηκε στα πλαίσια του έργου φύλλο εργασίας (σε EXCEL).

Παράμετροι Μοντέλου Αξιολόγησης της Επένδυσης

Το μοντέλο αξιολόγησης της επένδυσης είναι πλήρως παραμετρικό. Αυτό προσδίδει τη δυνατότητα υλοποίησης αναλύσεων ευαισθησίας με σκοπό την επιλογή των παραμέτρων αυτών που βελτιστοποιούν τους δείκτες αξιολόγησης της επένδυσης.

Α. Βασικές παράμετροι του μοντέλου είναι:

- Ο αριθμός των εγκαταστάσεων που θα εφαρμοστεί η τεχνολογία
- Σενάρια RFID που θα υλοποιηθούν

Με αυτόν τον τρόπο είναι δυνατή η ανάλυση του κόστους σε:

- Κοινό κόστος (που αφορά όλες τις διαδικασίες)
- Κόστος που σχετίζεται μόνο με την εφαρμογή μιας μεμονωμένης διαδικασίας
- Επίσης ανά σενάριο αναγνωρίζονται και ποσοτικοποιούνται τα οφέλη

Β. Άλλες παράμετροι του μοντέλου:

- Το κόστος του κεφαλαίου (προεξοφλητικό επιτόκιο)
- Η μέθοδος και τα ποσοστά ετήσιας απόσβεσης εξοπλισμού
- Τα ποσοστά της ετήσιας τεχνικής υποστήριξης
- Το κόστος των RFID TAGs
- Το κόστος του ανθρωποχρόνου όπου αυτό απαιτείται για τους υπολογισμούς

Παραδοχές

Για τον υπολογισμό των δεικτών αξιολόγησης της επένδυση έχουν ληφθεί υπόψη οι παρακάτω παραδοχές:

- Παραδοχές σχετικές με την επικόλληση ετικετών στις παλέτες

Η εφαρμογή θα γίνει σε παλέτες. Tags θα τοποθετηθούν στις παλέτες.

- ➢ Χρηματοοικονομικές παραδοχές
- Το κόστος κεφαλαίου (επιτόκιο προεξόφλησης) ανέρχεται σε 12%
- Χρησιμοποιήθηκε σταθερή μέθοδος απόσβεσης
- Ως ωφέλιμη ζωή του εξοπλισμού RFID λογίζεται η πενταετία
- Το ποσοστό φορολογίας για την εταιρεία είναι 20%

- ➢ Παραδοχές σε παραμέτρους οφέλους

Έχει εκτιμηθεί η μείωση του λειτουργικού κόστους που θα προέλθει από τη μείωση του χρόνου πραγματοποίησης των υπαρχουσών διαδικασιών

Άλλες παραδοχές:

- Το κόστος των RF-ID tags βαίνει μειούμενο κατά 10% ετησίως
- Το κόστος συντήρησης του υλικού λογισμικού ανέρχεται σε 12% του συνολικού κόστους ετησίως

Ο παρακάτω πίνακας περιλαμβάνει συνολικά όλες τις βασικές παραδοχές για την ανάπτυξη του μοντέλου.

ΚΑΤΗΓΟΡΙΑ	ΠΑΡΑΔΟΧΕΣ
Παραδοχές σχετικές με τα σενάρια υλοποίησης	▪ Η εφαρμογή θα γίνει **σε 3 διαδικασίες** (παραλαβή, αποστολή και απογραφή) ▪ Όλα τα προϊόντα θα γίνονται **tagged σε επίπεδο παλετών**
Χρηματοοικονομικές παραδοχές	▪ Το κόστος κεφαλαίου (επιτόκιο προεξόφλησης) ανέρχεται σε **12%** ▪ Χρησιμοποιήθηκε **σταθερή μέθοδος απόσβεσης** (30%) ▪ Ως ωφέλιμη ζωή του εξοπλισμού RFID λογίζεται η πενταετία
Παραδοχές σε παραμέτρους οφέλους	Ως όφελος έχει υπολογιστεί η **προσδοκώμενη μείωση του λειτουργικού κόστους στις υπάρχουσες διαδικασίες** (μείωση χρόνου) μέσω της χρήσης της τεχνολογίας RFID
Άλλες παραδοχές:	▪ **Το κόστος των RF-ID tags** βαίνει **μειούμενο κατά 10% ετησίως** ▪ **Το κόστος συντήρησης** του υλικού και λογισμικού ανέρχεται σε **10% του αρχικού αντίστοιχου κόστους ετησίως**

Πίνακας 12. Παραδοχές του Χρηματοοικονομικού Μοντέλου