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MASTER OF SCIENCE (MSc) IN INTERNATIONAL SHIPPING, FINANCE & MANAGEMENT

# Investment Triggering Analysis in Dry Bulk Shipping Sector

# Based on Uncertainty & Vessel Specific Reversibility Metrics

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A Thesis submitted to the Secretariat of the MSc in International Shipping, Finance and Management of the Athens University of Economics and Business as partial fulfillment of the Requirements for the Master’s Degree

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## CERTIFICATION OF THESIS PREPARATION

“We hereby declare that this particular thesis has been written by us, in order to obtain the Master’s Degree in INTERNATIONAL SHIPPING, FINANCE & MANAGEMENT, and has not been submitted to or approved by any other postgraduate or undergraduate program in Greece or abroad. This thesis presents our personal views on the subject. All the sources we have used for the preparation of this particular thesis are mentioned explicitly with references being made either to their authors, or to the URL’s (if found on the internet).”

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## Abstract

Uncertainty is inherent to investment decisions. Therefore, it is extremely important to properly address this issue. In the field of investment decision making on maritime sector and more specifically in Dry-Bulk segment, the effect of uncertainty is rarely discussed or quantified. Theoretically, on top of the system complexity, the physical movements of shipments require synchronization from both information and financial flows to maintain its seamlessness. The reliability of the system, therefore, is heavily affected by the accumulation of uncertain factors from its components.

It is the goal of this paper to fill this gap by focusing on a particular industry, that of dry-bulk shipping. For this reason, this paper explores the negative nature of uncertainty reducing the likelihood of investment triggering in world dry bulk shipping. Moreover, this effect is more pronounced as the vessel investment irreversibility[1] increases. Reversibility is measured by two different metrics, capturing the ability to resell a vessel but also the price discount at which this sale occurs. On one hand by witnessing the ability to re-sell a secondhand 5yr vessel, we quantify the extent of liquifying a vessel in the secondhand market. On the other hand, by quantifying the impact of time to build a vessel we capture the price discount at which the sale of SH compared to a NB will occur. In other words, the higher the irreversibility of these two metrics, the more often inaction zone exists, and zero-investment triggering is present. Finally, we introduce the dummy crisis, in order to measure the overall impact on investment triggering.



Keywords: Vessel Investment, Uncertainty, Irreversibility, Investment Triggering, Inaction Zone, Dry-Bulk Sector, Shipowners, Shipping Investors


[1] An irreversible investment opportunity is analogous to a financial call option where the holder has the right, but not the obligation, within a specified time period to pay an exercise price and receive in return the underlying asset. Exercising ('killing') the option is irreversible in the sense that although the underlying asset maybe resold, the investor cannot retrieve the option.

## List of Abbreviations

| | |
|---|---|
| **NB** | *Newbuilding* |
| **SH** | *Secondhand* |
| **ROA** | *Real Option Analysis* |
| **VIX** | *Volatility Index* |
| **TC** | *Time Charter* |
| **Ret** | *Return on earnings* |
| **Igpr** | *Industrial Production for the G7 economies* |
| **Infl** | *Inflation* |
| **CPI** | *Consumer Price Index* |
| **OECD** | *Organization for Economic Co-operation and Development* |
| **LOA** | *Length Overall* |
| **IRR** | *Internal Rate of Return* |
| **NPV** | *Net Present Value* |
| **DCF** | *Discount Cash Flow* |
| **OPEX** | *Operating Expenses* |

## Introduction

Shipping industry, and to be more specific, Dry-Bulk sector, lends itself to this analysis, as it provides an outstanding example of the interaction between uncertainty and irreversibility. Shipping firms—conducting 70 percent of world seaborne trade (in tons) (UNCTAD, 2015) (Stopford, 2008) —face long lags between the order and delivery of a new vessel, while the uncertain demand for sea transport may substantially alter conditions during this wait. To illustrate this point, in 2019 the seaborne trade was estimated to be over 11,000 million tonnes (UNCTAD, 2019)

Meanwhile, many uncertain factors are affecting the performance of maritime transportation in real-world scenarios, observable in digitalization with the disruptions of bigdata, machine learning, and blockchain; in geopolitical and economical instabilities, in regulations and operational costs with the IMO 2020 sulfur cap and lastly, in demand shocks.

For instance, the recent growth of raw material imports, particularly in China, led to sustained increases in freight rates and a sevenfold climb in the new ship backlog between 2003 and 2008. The crisis of 2008 led to an idling of the existing fleet and a lot of these ships were delivered during those times. As a result, firms faced an excess supply of ships, and in turn fierce price competition and low profitability.

Many industry experts attribute industry excess capacity to the firms' inability to forecast demand correctly, due to uncertainty.

The recent global events have shown us how uncertainty affects international trade negatively. The period that started with the trade war between China and the USA later increased the uncertainty with the COVID-19 pandemic. This uncertainty significantly affected both micro-scale commercial enterprises and macro-scale country economies.

Investment timing and uncertainty are issues that call for careful consideration when committing to any investment. Managers rely extensively on the use of traditional investment valuation criteria such as the internal rate of return (IRR hereafter) and net present value (NPV hereafter). These methods, although intuitive and easy to implement, have their shortcomings as the managerial flexibility implicit in any investment opportunity, that is, the option to adapt investment decisions in response to uncertainty, is not considered, resulting in *suboptimal* investment results.

In the literature, traditional capital budgeting theory states that projects should only be accepted if the value of the NPV, is greater than or equal to 0. Furthermore, traditional Discount Cash Flows (DCF hereafter) approach assumes implicitly that the project once undertaken, will be operated until the end of its useful life which is set at the outset.

However, DCF analysis ignores important strategic concerns about future uncertainty and management's flexibility to respond to cases that differ from the expected outcome of future cash flows. It implies an unyielding management strategy which is not a reflection of real-world competitive interactions and the operating environment of most firms, especially those operating in a multicurrency environment such as shipping.

For this reason, ROA, has been developed. It incorporates both the uncertainty inherent in the operating business environment and the ability to actively manage, control or alter a project in response to changing circumstances when new information enters to the equation and thus becomes available.

This flexibility gives the manager the capability not only to minimize downside loss, but at the same time retain relatively unlimited upside potential for profit. The more capital intensive and volatile the industry, the more critical is the correct choice of the investment valuation tool. Project decisions need to be optimum not only at the time of making the decision to invest in a project but also in respect of future options available, should the business operating environment change. The ROA explicitly acknowledges the options or flexibilities and the value of these options

This paper focuses on deep-sea shipping that has recently attracted much interest also in the finance and economics literature (e.g., see (Kalouptsidi, 2014), (Papapostolou,, et al., 2014).

The key contribution of this paper is the development of a framework to shed light to the relationship of the global phenomenon of uncertainty on triggering asset investment in accordance with irreversibility.

## Literature Review

Throughout the years there have been many attempts to examine and investigate uncertainty. Nowadays, Real option theory has been important for economics and investment decisions.

Going back to 1984, (McDonald & Siegel, 1984) were among the first to introduce the "real option" value to the society. Since then, several attempts and researches have been established and presented that the static Net Present Value (NPV hereafter) rule is not the appropriate tool when assessing investment decisions. The reason will be explained later to this paper.

Studies have shown that the solution to an optimal investment problem may be characterized entirely in terms of the width of the range of inaction due to the risk factor.

Generally, risk is associated with uncertainty regarding (negative) outcomes of possible future events. The lack of knowledge regarding ambiguity can lead to decision-making based on a false sense of trust in the accuracy of the results.

Empirical studies provide rather conclusive evidence for a negative impact of uncertainty on investment (Ferderer, 1993); (Ghosal & Prakash , 2000); (Rajeev & Goel, 2001) (Carruth, et al., 2003).

Similar conclusions have been drawn by (Caballero & Pindyck, 1996). In their research on uncertainty in investment and on industry evolution. They showed the existence of irreversibility on investment and how it is being affected by uncertainty.

According to Abel, it is understood that the greater the range of uncertainty, the higher the current rate of investment can be. During his studies, he followed (Pindyck, 1982) and (Hartman, 1972) which they observed and presented totally contrasting results. To further analyze, Hartman displayed that a hiked output price in uncertainty, leads the vying firm to increase its expenditure.

On the other hand, Pindyck found that a hiked output price in uncertainty, can lead to increased investment only if the marginal adjustment cost function is convex; but, if the marginal adjustment cost function is concave, then increased uncertainty will diminish the rate of investment.

For the above arguments, we can halt that Pindyck's results contradict from Hartman's results because of a different stochastic stipulation of the price of output.

In the setting of irreversible fixed investment, higher instability with respect to the future stream of cash flows demonstrates the decision to wait, until portion of the uncertainty has resolved valuable. This is also known as Real Option Analysis (ROA) ( (McDonald & Siegel, 1984) (Pindyck, 1990) (Dixit & Pindyck, 1994)

Most investment expenditures are at least in part irreversible, i.e., are sunk costs that cannot be recovered. As a result, the cost of making an investment incorporates not only the expenditure itself, but also an opportunity cost associated with committing resources rather than waiting for new information to arrive.

It exists a wide and growing literature describing how this opportunity cost can be evaluated and demonstrated. It is highly sensitive to uncertainty over future project values. The results highlight the role of uncertainty as a determinant of investment spending and recommend policies that reduce volatility such as exchange rates, prices, or interest rates that could reduce the required cost of capital.

When investment is irreversible, theory suggests that firms will be reluctant to invest.

Pindyck (1994), as well as the earlier work of (Arrow, 1968); (Nickell, 1977) and the survey by (Caballero, 1999) illustrated that firms hesitate to invest today. This can be attributed to their wish to reclaim little if any of the undepreciated asset value into the uncertain fore coming future. Thus, this prominent motivation tends to keep the choice "alive" in order to gain more information regarding future conditions. This may evaporate investment triggering, and therefore generating the outcome that there is negative relationship between investment decision and uncertainty.

Additionally, Abel, Dixit, Eberly and Pindyck (Abel, et al., 1996) in their collective study presented that the option to invest (call option) arises from the expandability of the capital stock (as already mentioned above), while the option to disinvest (put option) arises from the reversibility of investment.

The synergy between those two options can give incentives and determine the net effect of expandability and reversibility, while on the event of uncertainty. For instance, if both options' values rise with uncertainty, and the two options have opposing effects on the stimulus to invest, the net effect of uncertainty can be enigmatic.

At this point it needs to be pointed out the Goldilocks principle: The stimulus for someone to invest can be unaffected with the proviso that the news are "too hot" or "too cold", whilst changes within the intermediate range of the distribution (where the news are "just right") influence the stimulus to invest.

Following their previous study, Abel and Eberly (Abel & Eberly, 1999) offered more into the literature. They came up with an additional strand. When investment is irreversible, firms cannot disinvest even when the marginal profitability of capital is low.

Assuming that this constraint may strap into the future, firms apply a higher user cost of capital to current investment decisions. They demonstrated that both the formidable event (inability to disinvest, totally irreversible) and the firm's reaction to it (a high user cost) are important features of capital growth. Nonetheless, which effect becomes relatively stronger depends on characteristics of the firm and its environment.

Uncertainty does not comfort the ambiguity regarding the long-run effect of irreversibility, but rather expands it. Consecutively, greater uncertainty boosts the level of the forecasted long-run capital stock under irreversibility but can increase it even more under reversibility.

Management has the ability to change a course of action after it is underway. The value of this flexibility is not captured in a traditional NPV analysis. Thus, (Bendall & Stent, 2005) to their investigation, result that ROA is a very useful tool, valuing flexibility for decision makers when the management has to adapt a project in conditions of uncertainty, also considering the fact that as time progresses, more information comes in hand. These uncertainties may resolve progressively in time, but managers should have the flexibility to exercise alter strategies when pre-determined option conditions materialize.

Thus, following their previous study, Bendall, and Stent in 2007 brought light to that, once greater the volatility of the elemental base projects, the more value the respected strategies will have. (Bendall & Stent, 2007)

Likewise, as we continue to add options to the investment decision table, the more value, will be added. For instance, standard ships with low asset specificity have more encapsulated real options as they provide management with greater flexibility to alter strategy, comparatively they move to a different trade, to charter out, to sell, etc. once uncertainty is resolved.

Recent theoretical analyses of investment under uncertainty have displayed that, investment will behave more cautiously to an accustomed demand shock, when experiences higher levels of uncertainty (due to wider verges of the inaction zone). (Bloom, et al., 2007)

This is important as management traditionally desires to react to major shocks, but the behavioral responses to any given stimulus may be much lower than normal - in periods of high uncertainty. Probabilities showed that firms subject to greater uncertainty, may place less weight on recent information ("too hot") in updating their expectations of future growth prospects.

In a nutshell, it is relatively smooth to show that uncertainty can reduce the incentive to trigger the investment. If the firm can wait without severe penalties, and if committing now engages sunk costs, then there is clearly a leverage on a postponement. However, this conclusion can be reversed as follows: When costs are not sunk (i.e., there is a put option) or when waiting implicates a penalty, as in the case of a firm being unable to respond to a future favorable shock because of some binding constraint (e.g., with respect to input supplies), then there is no possibility of delaying the trigger.

Shipping related studies using real option analysis were intitated in 2009, when (Sødal, et al., 2009) used this valuation model in freight rates. To be more specific, they examined the case of switching between different shipping segments and sub-segments. That is, from dry bulk industry and vessel to the liquid industry, on a tanker vessel. This could happen when the expected NPV is optimal from a ROA based rule. What was promised, their research came up with the following conclusion. Swapping did not pay off, pointing out how efficient the dry bulk second-hand market can be.

In the more recent years, studies incorporate different models to explain how, investment can be analyzed. Bendall and Stent used the real options approach (ROA) which showed immediately altered the traditional way of valuing strategy. ROA can distinguish the fact that management does not operate in a ceteris paribus world. Shipping lines face dynamic, fast paced, economic/competitive environment and often need to make strategic decisions under uncertainty. (Bendall & Stent, 2010)

As mentioned before, once a project is afoot often new information enters indicating that it may be more opportune to shift to a new strategy (stimulus). Management must not think of strategic choice in terms of mutually exclusive scenarios but rather as a switching option challenge task, providing that the cost of shifting is lower that the benefit from altering course.

A shipping line does not always have this luxury, i.e., to delay investments until that uncertainty is resolved. However, the flexibility to alter strategies when new information becomes available can be modelled by explicitly incorporating this flexibility or real options into the investment decision.

What's more, Drakos has conducted an investigation about how irreversible investment cause negative relationship between uncertainty and the investment extensive margin. (Drakos, 2011). He concluded that higher irreversibility display a higher tendency of dropping in the inaction zone. Apart from the effects on inactivity, the conflicts lead to a lower probability that investments move to any of the higher-order extensive margins.

Uncertainty, generates a negative effect on the extensive margin, resulting in a shrinkage of the possibility of investment triggering. This effect takes the form of both a higher probability of investment inactivity but also a lower probability of investment triggering.

In another study, (Axarloglou, et al., 2013) using ROA examined the asymmetry between potential company profits and losses under uncertainty. Specifically, managers should take into consideration the stage of the industry business cycle, the growth prospects of the industry, as well as the market volatility.

They presented evidence that during a market upturn (bull market), shipowners, tend to charter their vessels under (short) voyage contracts (spot market) as opposed to time-charter contracts (thus maintaining resource flexibility),while at the same time, charterers switch to hire vessels under (lengthy) time-charter contracts as opposed to voyage contacts (preferring thus resource commitment).

However, due to uncertainty, management cannot always forecast such periods, and thus terminate time charter contracts just to negotiate faster in spot market uprising conditions of the moment.

Drakos & Konstantinou, in their recent mutual study on oil prices, they investigated if and how an uprise or a downturn can affect the likelihood of triggering any investment decision by the management. (Drakos & Konstantinou, 2013). Their result was that oil prices and uncertainty, if both variables increase, they can subsequently significantly reduce the probability to invest. Therefore, as oil price uncertainty escalates, the inaction zone is expanding and finally, may result to postponing the triggering. However, investment decisions display solid, pure state dependence on what were the initial conditions when commencing the investment planning and are getting affected by that.

Manymore, Kyriakou, Pouliasis, Papapostolou, and Nomikos in their collective study regarding freight-related dry bulk shipping assets, they investigated the effect of uncertainty on vessel valuation and investment decision. (Kyriakou, et al., 2017)

They confirmed the existence of lead time (more than two months) that the spot rate will need to return to midpoint against the long-run level. Moreover, spot freight rates exhibit sudden shifts which are mainly associated to the inability of supply to instantly react to changes in demand due to the construction lag deep-seated in shipbuilding. These variables when come together, they inherent uncertainty which later influence negatively as shown above, the investment triggering.

In a related with Axarloglou, Visvikis, and Zarkos study, (Adland, et al., 2017) apply an assessment of the cargo type flexibility to shift between "clean" (refined) oil products and "dirty" (crude oil and heavy fuel oil) oil products, calibrating the value of the switching option. They showed that the expected value of this swift decision in operating the vessel, has flourished over time, and has surpassed the additional investment cost.

Nowadays, ROA has been proven a more effective model to apply when it comes to investment evaluation by the management. The reason that NPV is not preferred, is that ROA can explain why a decision maker might opt for a professedly sub-optimal project when NPV has been calculated.

## Industry and Data

### *Dry-bulk shipping industry*

This section describes key features of the bulk shipping industry and gives an overview of the data.

This industry lends itself to this analysis, as it provides an outstanding example of the interaction between uncertainty and adjustment costs.

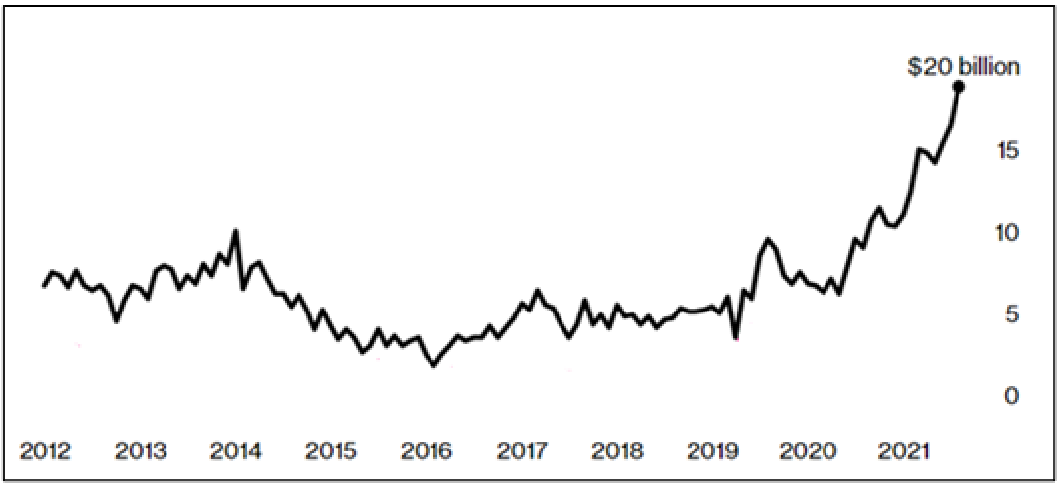
Dry-Bulk shipping concerns vessels designed to carry a homogeneous unpacked dry cargo, for individual shippers on nonscheduled routes. The entire cargo usually belongs to one shipper (owner of the cargo). Bulk carriers are acting like taxi drivers, carrying, and moving a specific cargo, to a specific destination agreed, individually in a specific ship for a certain price. Traditionally, Bulk vessels do not operate on scheduled itineraries like container ships, but only via individual contracts.

Dry bulk shipping consists mostly of raw materials, such as iron ore, steel, coal, bauxite, phosphates, but also grain, sugar, and wood chips. There are four different categories of bulk carriers based on size:

- Handysize (10,000–40,000 DWT)
- Handymax (40,000–60,000 DWT)
- Panamax (60,000–100,000 DWT)
- Capesize (larger than 100,000 DWT)

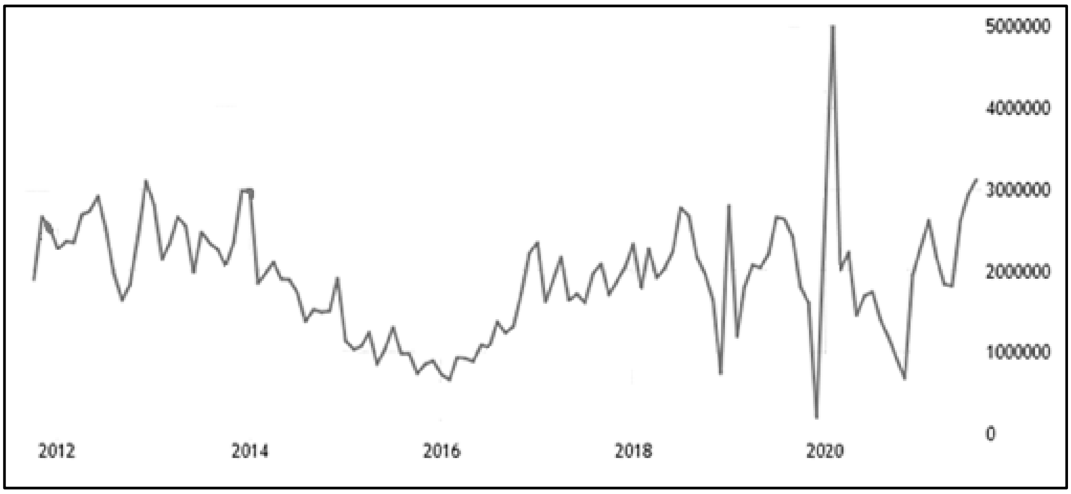
Vessels in different categories can carry different products, attain different routes, and approach different ports. Executives treat them as different markets. Each such market consists of a large number of shipowning firms. Even though there is some scope for differentiation (based on the age of the ship, the shipyard where it was built, the reputation of the shipowner, etc.) shipping services are largely perceived as homogeneous.

Demand for shipping services is driven by world seaborne trade and is, thus, subject to world economy fluctuations. In recent years, the growth and infrastructure building at several countries led to increased imports of raw materials, significantly boosting demand for bulk transport.




*Time-series 1 China's total imports of iron ore (2012-2021) Source: China's General Administration of Customs*

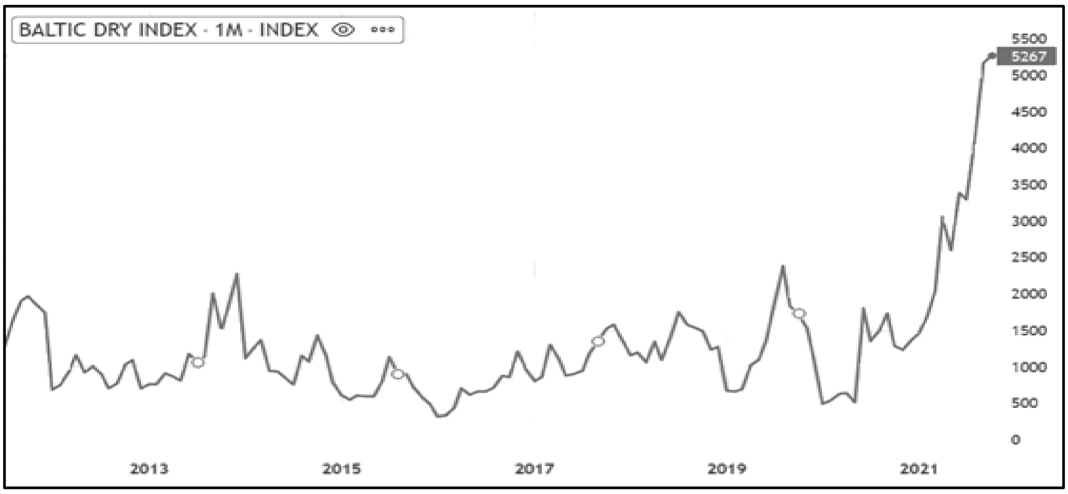
For instance, Chinese imports grew by 67 percent by year 2021 from 2012, while Asian imports represent more than 50 percent of world imports; Time-series 1 shows China's imports of iron ore and Time-series 2 of coal.




*Time-series 2 China's total imports of coal (2012-2021) in U$D Source: National Bureau of statistics in China*

As Stopford (1997) notes, "even though the physical capacity of ships is fixed at a point in time, the available transportation capacity is flexible," as shipowners can adjust the ton-miles, they offer by adjusting their speed of sail. Thus, in the short-term, the supply of shipping services is decisive by the number of voyages carried out by shipowners.

It is rather inelastic as voyage costs such as: fuel, port/canal dues, agencies and cargo handling are bulging in speed. Additionally, these costs are subject to increases due to the ship's age, as its fuel efficiency and overall operation deteriorates over time. The fluctuating shipping demand combined with the inelastic supply leads to volatile shipping prices, shown in Time Series 3.

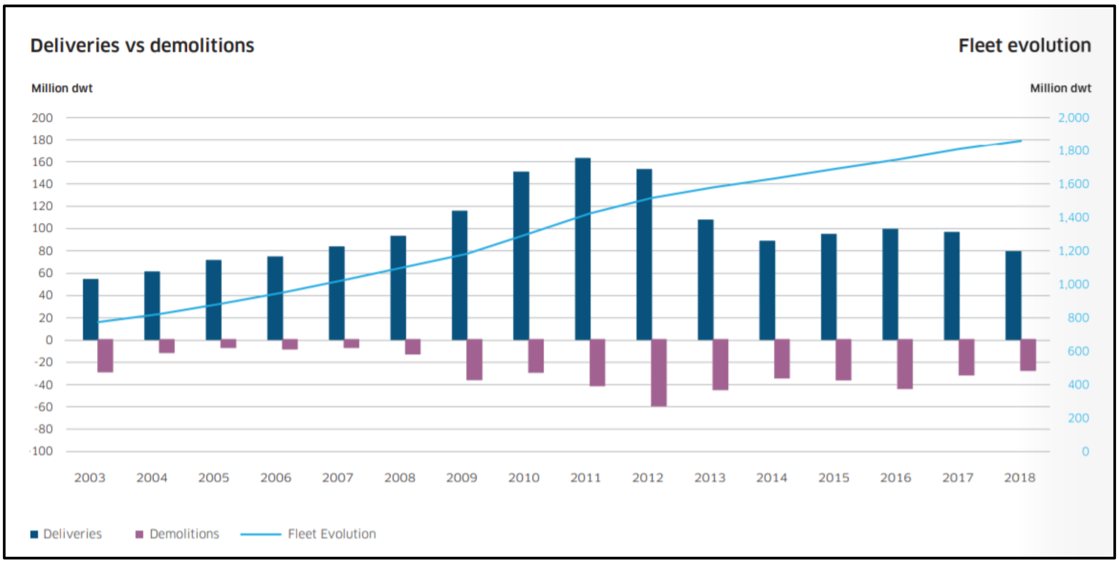



*Time-series 3 The Baltic Dry Index (2012-2021) Source Unctad 2021*

On the other hand, when analyzing the long run, the supply of cargo transportation adjusts, through the construction and scrapping of vessels.

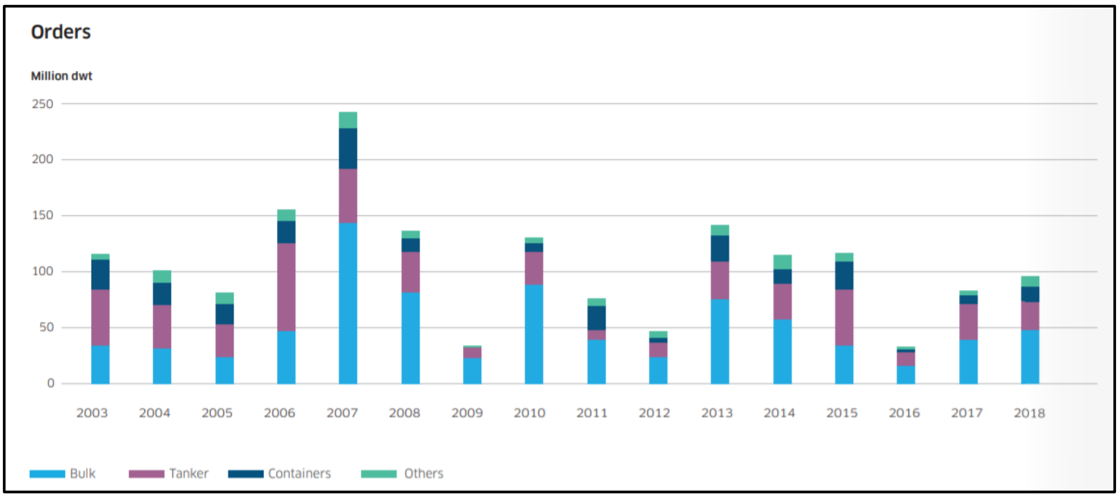
When shipbuilding process takes place, then we can call it as "entry in the industry". This occurs when shipowners buy new ships from world shipyards. The building of new ships is characterized by significant construction lags. In addition to the actual construction time, shipyards often face binding capacity constraints due to their limited number of assembly docks. In that case, queues of ship orders increase the time to build.

In the opposite case, during the scrapping procedure, the interior, and the exterior of the ship (machinery, furniture, technological equipment, spares, oils, etc.) is removed from the vessel and sold. The ship is then taken to a scrapyard, where it is dismantled, and its steel hull is recycled.




*Time-series 4 Deliveries Vs Demolitions on Global Fleet (2003-2018) Source: OECD*

In the above graph we can observe how during 2008-2018 decade, there was a surge of dismantling of old and acquiring of new vessels worldwide. This is an example of how the shipowners and operators want to refresh their fleet from time to time.




*Time-series 5 Orders by Vessel type (2003-2018) Source: OECD*

Furthermore, we can observe how during 2007-2008, just before the global economic fall, shipowners had already made many orders for new vessels (Time series 5), which they could not cancel later (irreversible investment).

It is important to note that canceling a shipyard order is difficult; even during the 2008–2009 crisis, only about 10 percent of the entire orderbook (in all ship types) was canceled (UNCTAD 2009).

The dry bulk cargo shipping market is a major component of the international shipping market. It is characterized by high risk and volatility because of the uncertainty caused by factors such as the volume and pattern of world trade, the global economy and government policy. In this highly competitive market, the fierce volatility of freight rates makes the trend unpredictable and has brought great risks as well as opportunities to the operators.

## Data, Variables, Econometric model & Results

We examine a panel dataset of 1,220 vessel-month observations, whose cross-section ($i$) comprises of four (4) different dry bulk vessel sizes: Capesize, Panamax, Handymax, Handysize.

The time series dimension covers the period from January 1996 to May 2021 (305 monthly observations).

For each vessel size we obtain the following monthly time-series from Clarkson's Shipping Intelligence Network (SIN):

1. *New contracting* $(NBC_{i,t})$, which measures new investments i.e., the number of agreed deals for newbuilding contracts
2. *Existing fleet* $(F_{i,t})$, i.e. The number of the existing vessels in the global fleet
3. Sales of vessels $(S_{i,t})$, i.e. The number of vessels that change hands
4. Newbuilding vessel prices $(NB\ price_{i,t})$, i.e. The average price for a newbuilding vessel in million dollars
5. Second-hand 5-years old vessel prices $(SH\ price_{i,t})$, the average price of a second-hand 5-years old vessel in million dollars
6. Average long run historical earnings for a voyage charter agreement

Average long run historical earnings for a 1-year time charter agreement.
We refer to vessels' earnings as *"freight rates[2]",* instead of focusing on the *"nominal"* freight rates earned by the shipowner from the employment of the vessel.

[2] This is adopted to orthogonalize freight rates to possible changes on bunker fuel and operating costs that can potentially affect the nominal freight rate the ship earns.

## *Variables' Explanation & measurement*

The model consists of one (1) dependent variable (*Y*), the firm's new investment rate and ten (10) control variables.

<u>Dependent Variables</u>

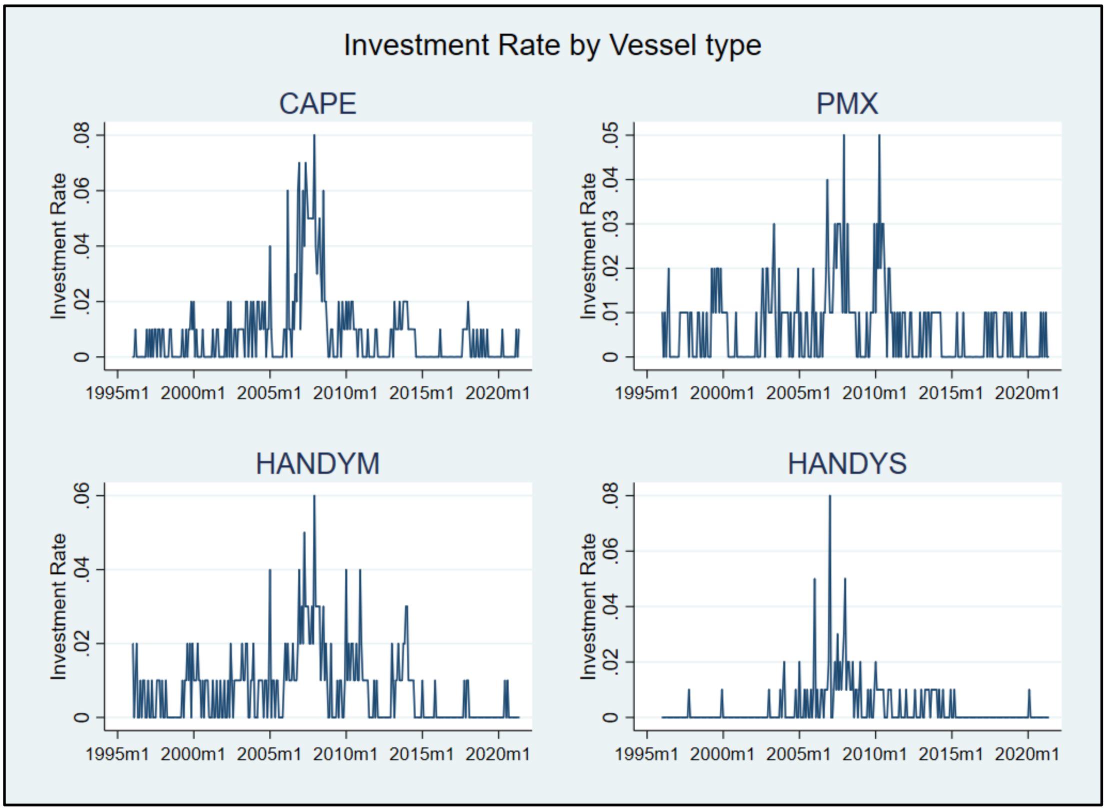
***Investment Rate***

We define the new investment rate as the ratio between the number of agreed deals for newbuilding contracts and the number of the existing vessels in the global fleet:

$$I_{i,t} = \frac{NBC_{i,t}}{F_{i,t}}$$

Whereas:

- $I_{i,t}$ = Investment rate
- $NBC_{i,t}$ = The number of newbuilding contracts agreed
- $F_{i,t}$ = The global fleet at that moment




*Time-series 6 Investment Rate by vessel type (1996-2021) Source: Clarksons*

As detected from the above time-series (Time-series 6), new investments have been minimized or even zero-out on multiple cases and across vessel types. Nonetheless, during the golden era of the shipping markets, which is the period 2003 to early 2008 they rose up to all time high . Later, there was a sudden drop after the default of Lehman

Brothers in 15/09/2008 and the global financial crisis from late December 2007 until late December 2012.

The observation of multiple zeroes in new investment leads us to calculate the zero-investment episodes in total and by vessel type, which we show in Figures below.

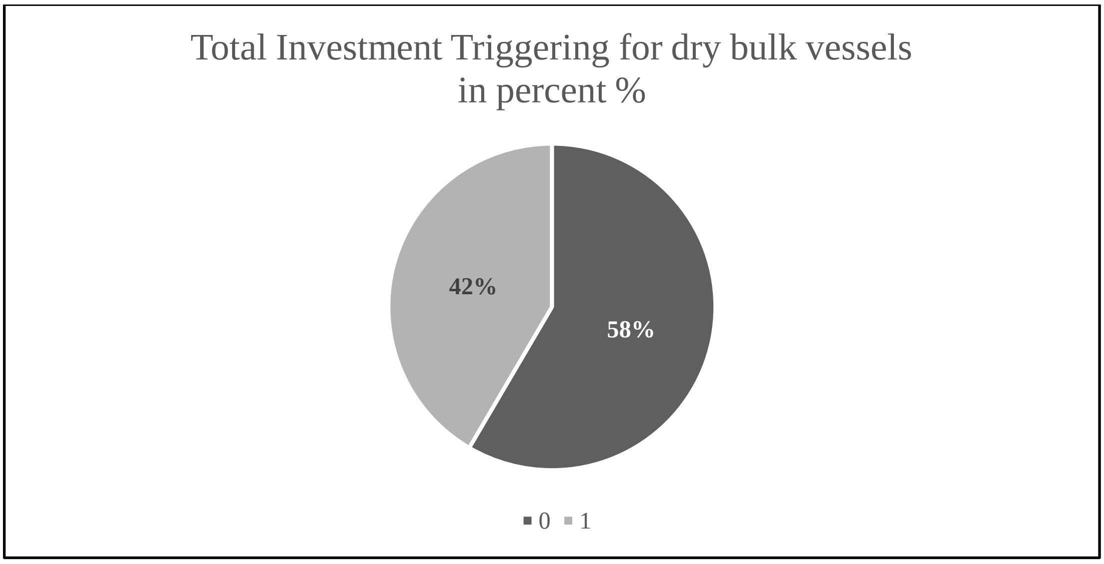



*Figure 1 Total Investment Triggering for dry bulk vessels*

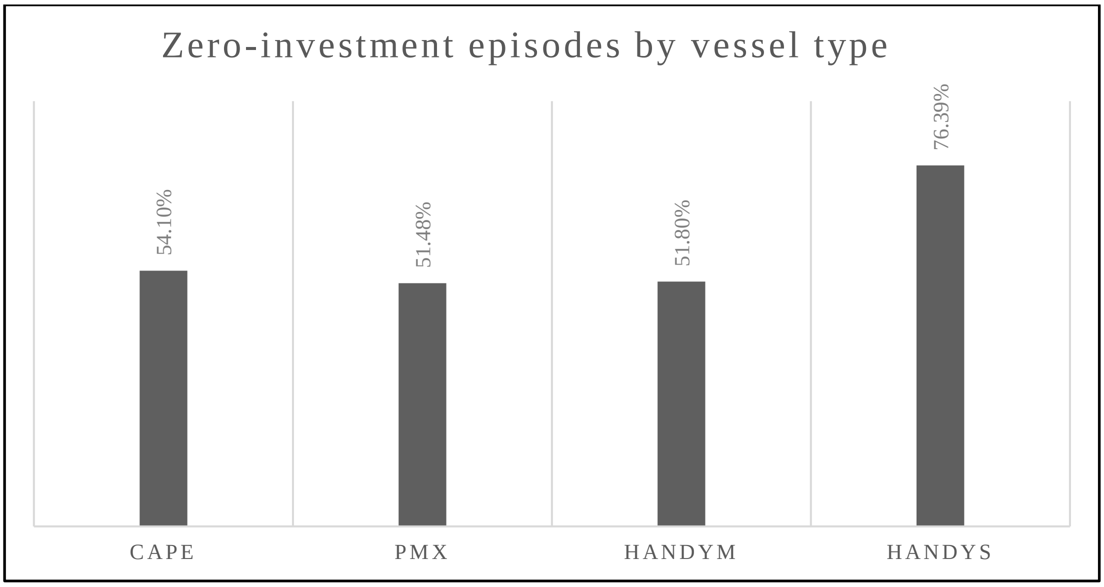
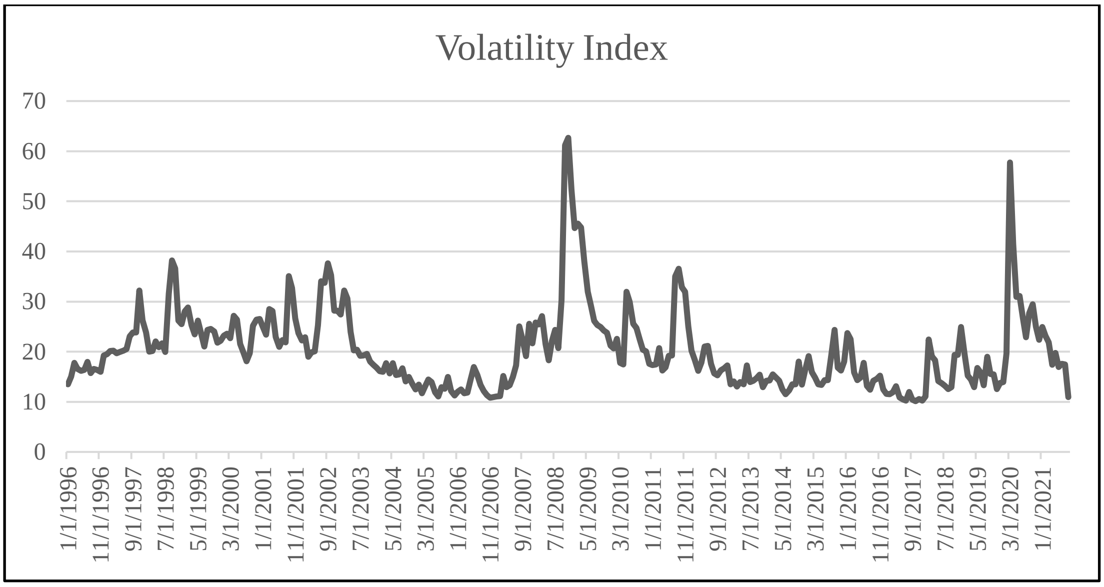



*Figure 2 Zero-Investment episodes by vessel type*

Uncertainty and Reversibility

***Volatility Index***




*Time-series 7 Volatility Index (VIX)*

As observed, the volatility index exhibits large spikes during the Great Recession period which includes the global financial crisis during the years 2007-2012 and 2007-2010 respectively.

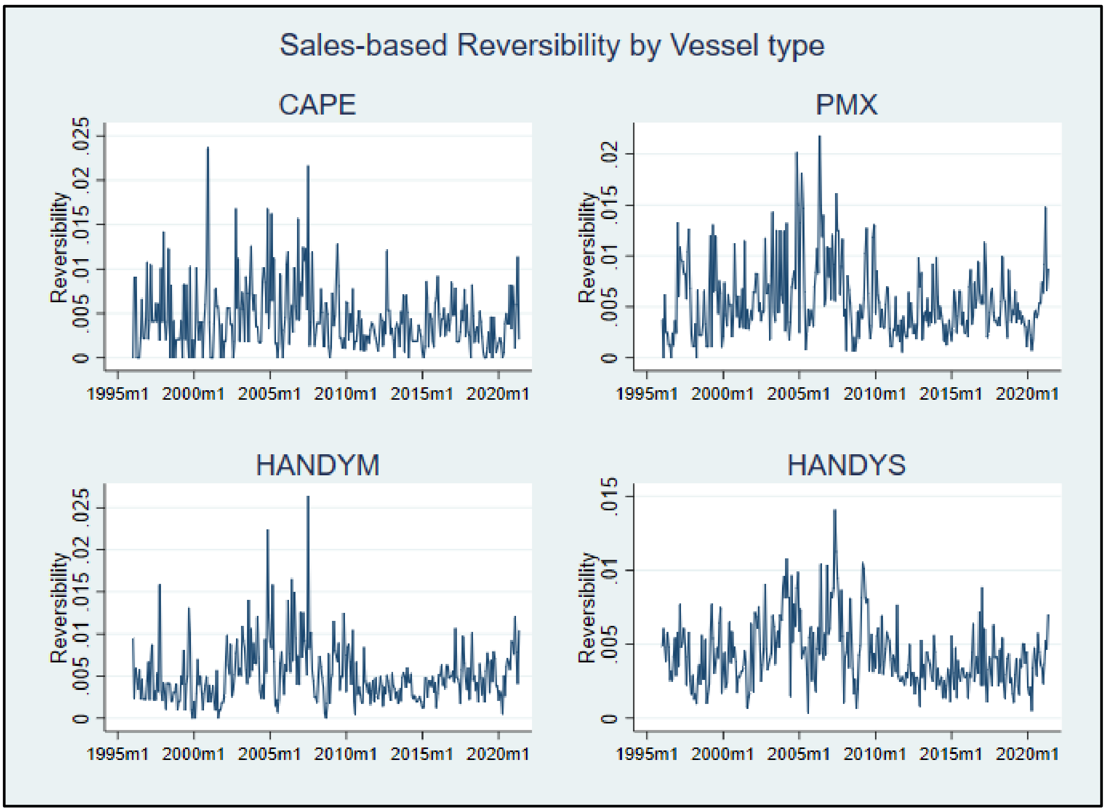
VIX is a widely used measure of the level of investor's fear in the stock market and has been found to influence US stock market returns in a number of empirical studies (see, e.g., (Kavussanos & Tsouknidis, 2014) (Gounopoulos & Paltalidis, 2018); (Michail & Melas, 2020) (Badshah, 2013); ( Li, et al., 2012); (Mayhew, et al., 2006); (Ostdiek, et al., 1995); (Hammoudeh, et al., 2014); (Melike , et al., 2019)

To measure reversibility of investments such as the high-valued ocean dry bulk vessels two measures are employed:

***Sales-based reversibility***

This measure is defined as number of vessels sold (sales) over existing number of fleet. The main purpose is to capture the liquidity in the second-hand vessel market, which then provides an indication of how easy is to sell the vessel.

The next figures, (Time series 8 & Table 1) depict the trajectories & descriptive statistics respectively, of sales-based reversibility by type of vessel.




*Time-series 8 Sales-Based Reversibility by Vessel type Source: Clarksons*

| Sales based reversibility across four types of dry bulk vessels | | | | | | | |
|---|---|---|---|---|---|---|---|
| Vessel Name | Mean | Median | Min | Max | Standard deviation | Skewness | Kurtosis |
| Capesize | 0.0034 | 0,004 | 0,00 | 0.02 | 0.00514 | 1.099 | 3.084 |
| Panamax | 0.0047 | 0,005 | 0,00 | 0,02 | 0.00532 | 0.412 | 1.868 |
| Handymax | 0.0042 | 0,004 | 0,00 | 0.03 | 0.00539 | 0.86 | 3.392 |
| Handysize | 0.003 | 0,004 | 0,00 | 0.01 | 0.00462 | 0.83 | 1.69 |

*Table 1 Sales-Based reversibility descriptive statistic results by type of vessel*

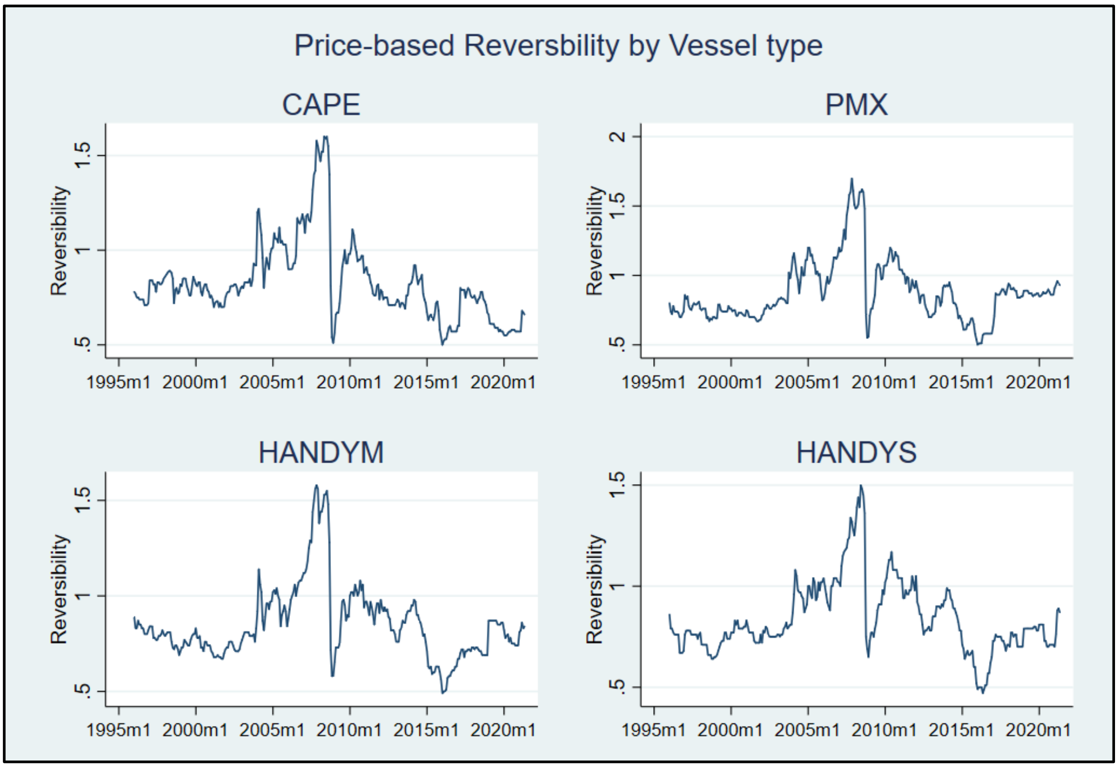
As observed from the time series and the table above, the mean values are generally low and do not exhibit any specific relationship with vessel size. However, the standard deviations are higher than the average, indicating the considerable variation of the Sales-based reversibility measure over time.

***Price-based reversibility***

This measure is defined as the second-hand 5yr old price of a vessel over its NB price. It points out if the current price for a second-hand vessel to be sold is close to the NB one. The logical to assume would be that the second-hand price of a vessel is smaller than its NB one.

In shipping, it is often that the prevailing freight rates can climb so high, and thus, drive the second-hand price of a 5-year-old vessel higher rather than its NB price ("skyrocketing freight rates"). That occurs because a NB vessel is subject to a significant time-lag of construction of around 18-36 months. (Kalouptsidi, 2014). (Kyriakou , et al., 2017)

Next figures (Time-series 9 & Table 2) show the trajectories & the descriptive statistics respectively, of price-based reversibility over time and by type of vessel.




*Time-series 9 Price-based Reversibility by Vessel type Source: Clarksons*

As observed in the above time series there is a considerable increase of the second-hand price when compared to the newbuilding price across all vessel types examined during the period of very high freight rates in the shipping markets, i.e., the period 2003-2008.

During this period, investors were willing to pay more for a second-hand vessel rather than the corresponding NB one, as the latter requires a significant time-lag of construction.

| Price based reversibility across four types of dry bulk vessels | | | | | | | |
|---|---|---|---|---|---|---|---|
| Vessel Name | Mean | Median | Min | Max | Standard deviation | Skewness | Kurtosis |
| Capesize | 0.8297 | 0,806 | 0,500 | 1.6 | 0.2122 | 1.495 | 5.88 |
| Panamax | 0.8808 | 0,778 | 0,505 | 1.7 | 0.2191 | 1.393 | 5.4375 |
| Handymax | 0.8509 | 0,798 | 0,495 | 1.58 | 0.194 | 1.587 | 6.414 |
| Handysize | 0.8417 | 0,738 | 0,450 | 1.5 | 0.1783 | 1.11 | 4.796 |

*Table 2 Price-Based reversibility descriptive statistic results by type of vessel*

The Table above is depicting the descriptive statistics for the price-based reversibility measure per vessel type.

As observed, the mean values lay down to the range between 0.82 to 0.88. This indicates, that on average, the SH price of a 5-year-old vessel can accomplish/reach -in value- from 82% to 88%, the price of the corresponding newbuilding. The standard deviations are modest, indicating relatively low variation of the price-based reversibility measure over time. In all cases, standard deviations are considerably less rather than the standard deviations of the sales-based reversibility measure presented in Table 3.

The following conclusions can be draught from the above:

<u>By sales-based reversible perspective:</u>

a) For the investors that owe and a potential investor that choose a SH 5yr old vessel, desire to capture the level of difficulty to re-sell the vessel

<u>By price-based reversible perspective:</u>

a) For the owner of a SH 5yr old vessel during bull market, an investor who wants to do a new investments, avoid a NB construction due to the construction time-lag, thus the capital invested 5 years ago on the todays SH vessels is reversible and price discount is lees or eliminated by trading (Axarloglou, et al., 2013)

b) When global demand for vessels is satisfied, and thus there is neither bull market nor bear market, construction lag does not affect investors and they may freely choose to invest in a NB.

   The -unfavored- side is the investors which already own SH 5yr vessels and experience substantial price discount. Thus, the capital they have put into, is less reversible (irreversible).

   The worst scenario for a 5yr SH is the bear market as there is a high possibility that the ship will be laid up, if OPEX are not covered, and the option to resell it compared to NB construction will lead to a much higher price discount, if not to the scrab value price discount.

Control Variables

Using the variables discussed earlier to this paper, we now calculate *two vessel-specific control variables:*

*The spread of freight rates* ***(Spread)***

Defined as the difference between 1yr Time charter rate [3](TC hereafter) minus the spot (voyage) freight rate, over the spot rate (voyage freight rate).

Spreads in general are negative, indicating the corresponding safety that a TC contract provides, in comparison to the spot one. This can be explained as follows: TC contracts ‘‘lock” the revenues of the ship for a specific period of time and in this way, owners are protected against the uncertainty of seeking new contracts and routes to hire the vessel again at the end of the voyage (spot) contract.

It must be noted that in general, the spread is time-varying and depends on the volatility of the freight markets (Cullinane & Adland, 2005).

Apart from being negative, the spread can also adopt positive sign, when the freight market is strong, and therefore, short-term freight contracts (spot) are selected over long-term ones.

For instance, when a shipowner enters to a TC agreement his vulnerability to volatile spot freight rates is wiped out, but his inefficiency to terminate or to sell the agreement creates liquidity risk (irreversible decision).

However, the charterer he may be enticed to default or re-negotiate the terms and details of the agreement if the spot market moves towards him.

Moreover, a small negative or even positive value of the spread corresponds to the TC rate being close or even above the spot rate, which generally indicates an optimistic expectation for the long-term spot market in the future but can also indicate a pessimistic expectation for the short-term spot market if the prevailing freight rate level is high. (Kavussanos & Tsouknidis, 2016). Thus, makes our stasis in this case as indifferent.

The above can be shorted out to the following table:

*Table 3 Spread possible cases and alternatives*

| SPREAD | PREVAILING FREIGHT RATE | SHORT TERM | LONG TERM |
|---|---|---|---|
| NEGATIVE (TC>SPOT) | LOW | Low Expectation | High Expectation |
| POSITIVE (TC<SPOT) | HIGH | High Expectations | Low Expectations |
| INDIFFERENT (-1…0.5) | LOW | Optimistic | Pessimistic |
| INDIFFERENT (-1…0.5) | HIGH | Pessimistic | Optimistic |

[3] Both the 1yr TC and spot rates are expressed in $/day. The constituent routes of these average earnings figures are listed in Annex 4 (b) of the Clarkson’s’ (2015) SIN SIW report.

*Returns of Earnings* ***(Ret)***

The first logarithmic differences of spot voyage earnings (*Ret*), which captures the current state of the dry-bulk shipping market.

Following, we obtain data for five (5) macroeconomic control variables:

*The 3-Month London Interbank Offered Rate* ***(Libor)***

*Libor*, based on U.S. Dollar, can be defined as the average interest rate at which banks borrow sizeable funds from other banks in the London market and is used to capture the ease of finance for shipping investors. (Hin & , 2014); (Duru, et al., 2010); (Atari, et al., 2019).

*The Industrial Production for the G7 economies* ***(Igpr)***

*Igpr,* measures the output of the industry sector of the G7 (Canada, Italy, Japan, UK, US, Germany France) and captures to a large extent the demand for sea transportation. The industrial production index is highly sensitive to interest rates and consumer demand. The shipping transportation demand is a derived, products demand from consumers.

Also, inflation is created by the industrial production because high level of industrial production led to uncontrolled level of consumptions and that to rapid inflation.

*The Consumer Price Index* ***(Infl)***

*CPI* captures changes at the level of the prices over time.

As expected, it has negative sign, and affects the investment triggering at any point in time by reducing purchasing power. For instance, the higher the inflation rate, the more interest rates are likely to rise. This occurs because lenders will demand higher interest rates as compensation for the decrease in purchasing power of the money they are paid in the future. As a result, investors who desire to invest in shipping, have to go through this crucial decision or fall into the inaction zone.

*Exchange Rate of China* ***(Exch.China)***

The exchange rate of China Yuan (¥)/$ indicates the appreciation or depreciation of Yuan to the US dollar. In addition, illustrates the purchase power of China in comparison to other countries that trade in US dollars ($).

In shipping the trading currency is the US dollar ($).

The CNY/USD exchange rate[4], in addition to being an indicator of relative economic strength, has a direct impact on each nation’s economy by affecting the value of imports and exports.

[4] In general, a stronger exchange rate makes a country’s exports more expensive, which can reduce demand for them. But a stronger exchange rate makes imports, in particular energy products, cheaper.

The variables *Libor* and *CPI* are from the website of the Federal Reserve Bank of St. Louis, while *Igpr* is from the website of OECD Data.
Exchange rate of China data index is from the database of Datastream.

***Crisis***

Crisis is referring to the period 31/12/2007-31/12/2012 and is working as a dummy to capture the negative effect of the great recession(including the financial crisis).

$$Crisis_{i,t} = \begin{cases} 1 & crisis\ occurs \\ 0 & crisis\ does\ not\ occur \end{cases}$$

Table 4, below, reports the descriptive statistics for the control variables included in the estimations discussed later in the paper.

| Control Variables Name | Mean | Median | Min | Max | Standard deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| Spread | 17,793 | 11,697 | 4,275 | 161,500 | 19,310 | 4.10297 | 24.79427 |
| Ret | 0.0026 | 0.00697 | -2.206 | 1.969 | 0.268 | -0.5255 | 18.309 |
| Libor | 2.517 | 1.82 | 0.13 | 6.86 | 2.176 | 0.52 | 1.711 |
| Ipgr | 95.899 | 96.3 | 77.03 | 112.06 | 7.612 | -0.337 | 2.977 |
| Inflation | 209.44 | 213.15 | 154.7 | 268.55 | 32.3 | -0.0892 | 1.7303 |
| Exchange Rate China (¥/$) | 7 | 7.04 | 6.05 | 8 | 0.842 | -0.02 | 1.292 |
| Crisis | -0.0236 | -0.00606 | -0.9117 | 0.4845 | 0.1559 | -0.87085 | 6.1077 |

*Table 4 Descriptive statistics for the control variables*

Whereas:

- *Ipgr* is in index units
- *Inflation*: CPI (index units)
- *Ret*: Log returns of vessel earnings

The mean value of the 3-month *Libor* interest rate and the *exchange rate of China* is equal to 2.51% and 7.34% with a standard deviation of 2.18% and 0.842% respectively. The spread of freight rates, i.e., the difference of the 1-year TC freight rate minus the spot freight rate, over the spot freight rate, has a positive average value of 17.793 with a much higher standard deviation around 19.310. Larger positive values of the freight rate spread, signal lower prospects for the freight market of the shipping industry during the next year.

Finally, returns of earnings is generally low but the standard deviation is considerably high, indicating that the current state of the freight market is exposed to volatility.

potentially increasing demand in the longer run and helping to hold down domestic inflation in the near term. A stronger yuan against the US dollar would have the opposite effect.

## *Econometric Methodology*

The unit of analysis is (*i*) which identifies our four vessel types. In the context of the modern investment theory one can break down the investment decision into two sequential processes, as follows:

$$INV_{i,t} = \begin{cases} 1 & if\ positive\ investment\ is\ triggered \\ 0 & if\ no\ investment\ is\ triggered \end{cases}$$

Where, when $INV_{i,t} = 0$, there is not investment triggering, while *1* denotes that positive investment in a vessel type is observed, i.e., investment has cleared the zero threshold.

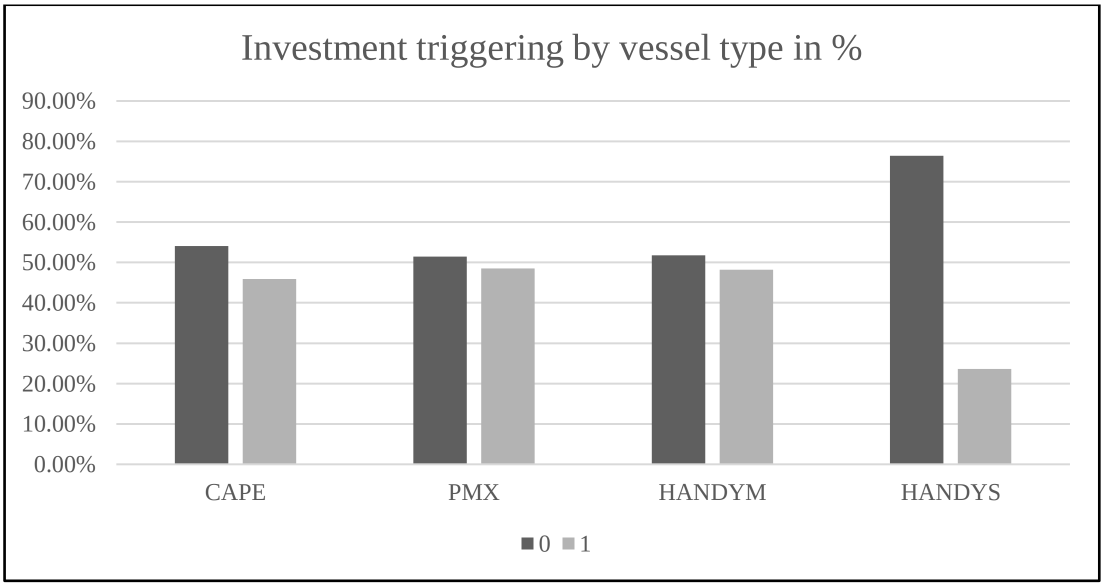



*Figure 3 Investment triggering by vessel type*

We examine investment triggering for all vessel types, by using a Random-effects probit model as our dependent variables is constructed as a dummy and a usual OLS model could not capture this behavior. The Probit-model has the ability to "force" the predicted variables of our dependent variable between zero and one.

By default, or when re is specified, xtprobit fits via maximum likelihood the random-effects model

$$Prob(y_{i,t} \neq 0 | x_{i,t}) = \Phi(x_{i,t}\beta + \nu_i)$$

Whereas:

- $i$ = 1,2.3 . . . n panels
- $t$ = 1,2,3 . . . $n_i, \nu_i$ are i.i.d., $N(0, \quad \sigma_\nu^2)$ and Φ is the standard normal cumulative distribution function.

Underlying this model is the variance components model:

$$y_{i,t} \neq 0 \leftrightarrow x_{i,t}\beta + \nu_i + \varepsilon_{i,t} > 0$$

Where $\in_{i,t}$ are i.i.d. Gaussian distributed with mean zero and variance $\sigma_{\in}^2 = 1$, independently of $\nu_i$.
The modern investment theory has evidence that the choice of inaction and actions is driven by the level of uncertainty and the compounding effect on uncertainty caused by the irreversibility degree of the asset. (Drakos, 2011) (Kyriakou , et al., 2017)

The choice between inaction and action is driven by the level of uncertainty $(U_t)$ and the compounding effect on uncertainty due to the degree of irreversibility. Our analysis will consider one possible source of uncertainty: VIX $(U_{v,t})$

As discussed earlier, following the literature, we have deployed two metrics for the degree of reversibility of investment $(REV_{i,t})$; the first captures the intensity of the second-hand market, defined as the ratio of Sales to the total Fleet $\left(\frac{S_{i,t}}{F_{i,t}}\right)$, and the second captures the price differential between second-hand and new capital, defined as the ratio of the selling price to the new buying price $\left(\frac{SH\ price_{i,t}}{NB\ price_{i,t}}\right)$. The reversibility's compounding effect will be captured by its interaction effect with uncertainty $U_t X REV_{i,t}$

A set of control variables X is expressed from the following function:

$$f\ (X_{i,t})$$

Whereas:

- *i* = 1,2.3 … 13, including interaction terms & lag investment

Thus, the primary setup we use consists of the following equation**,** that models the probability of positive investment triggering:

$$Prob(INV_{i,t} = 1|x_{i,t}) = b_0 + b_1 * U_{v,t} + b_2(U_{v,t} * REV_{i,t}) + e_{i,t}$$

Based on the economic theory and previous empirical evidence on uncertainty and the compounding effect of reversibility:

- Higher uncertainty tends to reduce (*increase*) the probability of investment triggering (*inaction*), that is we expect that $b_1 < 0$, and
- For a given level of uncertainty, the probability of investment triggering (*inaction*) is lower (*higher*) as irreversibility (*reversibility*) increases, and therefore we expect that $b_2 < 0$

<u>Panel A</u>

Panel A is constituted by three models with the following variables:

a) M1: uncertainty captured by the volatility index and reversibility is only sales-based
b) M2: uncertainty captured by the volatility index and reversibility is only price based

c) M3: uncertainty captured by the volatility index and reversibility is based on both reversibility dimensions (sales & price based)

$$Prob(INV_{i,t} = 1|x_{i,t}) = b_0 + b_1 * U_{v,t} + b_2(U_{v,t} * REV_{i,t}) + e_{i,t}$$

<u>Panel B</u>

Panel B is constituted by three models with the following variables:

a) M4: uncertainty captured by the volatility index and reversibility is only sales-based +control variables
b) M5: uncertainty captured by the volatility index and reversibility is only price-based +control variables
c) M6: uncertainty captured by the volatility index and both reversibility dimensions (sales & price based) +control variables

$$Prob(INV_{i,t} = 1|x_{i,t}) = b_0 + b_1 * U_{v,t} + b_2(U_{v,t} * REV_{i,t}) + f\ (X_{i,t}) + e_{i,t}$$

<u>Panel C</u>

For every type of vessel, the regression (M6) is performed.

a) Capesize - M7
b) Panamax- M8
c) Handymax - M9
d) Handysize - M10

<u>Panel D</u>

The dummy crisis is introduced and tested:

a) M11: uncertainty captured by the volatility index, volatility index is interacted with crisis and reversibility is based on both reversibility dimensions (sales & price based) interacted with volatility index +control variables
b) M12: uncertainty captured by the volatility index, sales-based reversibility is interacted with crisis and reversibility is based on both reversibility dimensions (sales & price based) interacted with volatility index +control variables
c) M13: uncertainty captured by the volatility index, price-based interacted with crisis and reversibility is based on both reversibility dimensions (sales & price based) interacted with volatility index +control variables
d) M14: uncertainty captured by the volatility index, volatility index is interacted with crisis, sales-based reversibility is interacted with crisis and reversibility is based on both reversibility dimensions (sales & price based) interacted with volatility index +control variables
e) M15: uncertainty captured by the volatility index, volatility index is interacted with crisis, price-based reversibility is interacted with crisis and reversibility is

based on both reversibility dimensions (sales & price based) interacted with volatility index +control variables

f) M16: uncertainty captured by the volatility index, volatility index is interacted with crisis, both reversibility dimensions (sales & price based) interacted with volatility index and crisis +control variables

$$Prob\left(INV_{i,t} = 1 | x_{i,t}\right) =$$
$$= b_0 + b_1 * U_{v,t} + b_2\left(U_{v,t} * REV_{i,t}\right) + b_3\left(crisis * REV_{i,t}\right) + b_4\left(crisis * U_{v,t}\right) + f\left(X_{i,t}\right) + e_{i,t}$$

## Empirical Results

The overall volatile and uncertain environment of the dry-bulk shipping sector is proved via the following investment triggering investigation.

To begin with we perform sixteen (16) regressions to investigate the impact of *uncertainty*, captured by the volatility index (VIX), and *irreversibility effect*. That will affect high valued tangible real assets such as ocean-going vessels.

We managed to shed light to whether is easier to resell (or not) and to what extent the price discount of the sale would be implemented. Furthermore, in what magnitude these factors would later alter the decision of an investor to trigger the investment decision in a dry bulk vessel or to stall further.

The first three models, *M1*, *M2*, *M3*, illustrated in Panel A below, are the primary indication that for all cases, it is more likely uncertainty to impact investment triggering *negatively* in the dry bulk shipping sector.

**Table 5 Random-effects probit model for investment triggering under uncertainty and reversibility's**

| | **M1:** volatility Index & price-based reversibility * vix | **M2:** volatility Index &sale-based reversibility*vix | **M3:** volatility Index &both reversibility* vix |
|---|---|---|---|
| **Panel A Investment triggering under uncertainty and reversibility** | | | |
| Volatility index | **-0.0437574**$^{***}$ | **-0.004936**$^{***}$ | **-0.044036** $^{***}$ |
| | (0.00362) | (0.00362) | (0.00358) |
| Sales-based reversibility * vix | - | **0.000956**$^{***}$ | **0.0032786**$^{*}$ |
| | | (0.000045) | (0.0018097) |
| Price-based reversibility * vix | **0.0005796**$^{***}$ | - | **0.0005675**$^{***}$ |
| | (0.000125) | | (0.0000125) |
| Constant | **-0.53192**$^{***}$ | -0.153499 | **-0.5497904**$^{***}$ |
| | (0.219824) | (0.20029) | (-0.1968521) |
| **Diagnostics and Hypotheses Tests** | | | |
| Observations (vessel-months) | 1,220 | 1,220 | 1,220 |
| Wald test overall significance | 167.85$^{***}$ | 16.71$^{***}$ | 171.76$^{***}$ |

Notes: Standard errors are reported in the parentheses below the estimated coefficients. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

*Table 5 Random-effects probit model for investment triggering under uncertainty and reversibility's*

Moreover, both price and sales-based reversibility are significantly dampening the negative effect of uncertainty on new investment triggering, but it is remarkable how the sales-based reversibility is adopting a less statistic significant level to the overall mix.

We hope this is a point for future consideration and research on how the sales-based reversibility can eventually affect investment triggering.

Furthermore, the next three models M4, M5, M6 in Panel B, include additional control variables to illustrate if there is any change in the behavior to our main importance variables.

As illustrated in the Table 6, there is higher likelihood that investment triggering is directly negative impacted by uncertainty in all cases but statistically significant only in Model 4 and Model 6.

It is imperative to notice that it is more likely that the indirect effect of the sales-based reversibility metric does not play a significant role and thus it does not mitigate the negative effect of uncertainty anymore. Also, we can witness that in the Model 6, except of the price-based reversibility metric, control variables such as the inflation, exchange rate of China, spread and the lagged investment are statistically significant at 1% level and the industrial production of G7 at 10% level.

**Table 6 Random-effects probit model for investment triggering under uncertainty and reversibility's**

| | **M4:** Volatility index & Price-based reversibility * vix | **M5:** Volatility index & Sale-based reversibility*vix | **M6:** Volatility index & Both reversibility* vix |
|---|---|---|---|
| **Panel B Investment triggering under uncertainty and reversibility + control variables** | | | |
| Volatility index | -0.02377*** | -0.00211 | -0.02426$^{***}$ |
| | (-0.0043) | (-0.00) | (0.0043) |
| Sales-based reversibility * vix | - | 0.002429 | 0.0019163 |
| | | (-0.0011) | (0.001845) |
| Price-based reversibility * vix | 0.0003179$^{***}$ | - | 0.0003137$^{***}$ |
| | (-0.0000) | | (0.0000) |
| Lagged investment rate | 0.1090128$^{***}$ | 0.12664$^{***}$ | 0.1083157$^{***}$ |
| | (-0.0166) | (-0.0165) | (0.0166) |
| Libor | -0.0039875 | -0.001657 | -0.0032826 |
| | (-0.0089) | (-0.0090) | (0.0089) |
| Spread | 6.12E-06$^{***}$ | 0.000012$^{***}$ | 6.01e-06$^{***}$ |
| | (-0.0000) | (1.37e-06) | (0.0000) |
| Ipgr | 0.004183$^{*}$ | 0.0026129 | 0.0042719$^{*}$ |
| | (-0.0023) | (0.0024) | (0.0023) |
| Infl | -0.0090299$^{***}$ | -0.0098637$^{***}$ | -0.0091276$^{***}$ |
| | (-0.0022) | (0.0022) | (0.0022) |
| Exch.china | -0.0127052$^{***}$ | -0.015430$^{***}$ | -0.0130275$^{***}$ |
| | (-0.0035) | (0.0035) | (0.0035) |
| Ret | 0.0164255 | -0.00024 | -0.0058033 |
| | (-0.0485) | (0.0482) | (0.0490) |
| Constant | -0.6841004$^{**}$ | -0.717184$^{***}$ | -0.70576$^{**}$ |
| | (-0.2840) | (0.2692) | (0.2844) |
| **Diagnostics and Hypotheses Test** | | | |
| Observations (vessel-months) | 1216 | 1216 | 1216 |
| Wald test overall significance | 224.73*** | 217.22*** | 229.11*** |

Notes: Standard errors are reported in the parentheses below the estimated coefficients. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively

*Table 6 Random-effects probit model for investment triggering under uncertainty and reversibility's Panel B*

In addition, the overall significance Wald test, 229.11*** (Model 6 higher than the other two models), is verifying a statistically significant Model at 1% level. Thus, our optimal choice will be Model 6, whose outstanding variables will below be explained.

The following observations can be made regarding the control variables:

**Lagged investment rate:** It is found as statistically significant, implies that the investment that will occur today is affected by the investment happened past.

**Spread**: It is found slightly below 0, and thus we can infer that if the prevailing market is high, the short-term spot freight market is pessimistic and in the long-term spot freight market, prospects are optimistic. However, if the prevailing market is low, then the opposite stands.

Regarding Industrial production for G7 (**Ipgr**): It is found less significant than the other control variables, but still affects positively the investment triggering.

In addition, we assume that 10% level resulted, because shipping transportation demand is derived from consumers and thus there is a time-lag between inquiries and actual execution of those.

Inflation (**Infl**): As expected, it has negative sign, and affects the investment triggering at any point in time by reducing purchasing power. Therefore, an investor who desires to invest in shipping, has to go through this crucial decision or fall into the inaction zone.

The exchange rate (**Exch.China**) between the Chinese Yuan (CNY) and the US dollar (USD), is the value of one currency against the other.

In China’s case, a lower yuan exchange rate figure actually indicates a stronger Chinese currency as it means it takes fewer yuan to purchase one US dollar. However, when Yuan is depreciated, the purchasing power is decreased. Thus, the weaker Yuan against the US dollar would generally make Chinese goods exported to the US cheaper, increasing demand, while making US exports to China more expensive, reducing demand.

Taking this into account, when sea transportation is affected, the purchasing power (exchange rate) affects the decision to invest in NB, to satisfy the derived demand.

Observing the negative sign on the table above, investors are transformed into “risk averse” and are more willing to wait for the right time to come. In other words, the threshold triggering investment is extended.

Further analysis conducted in Panel C is vessel type specific. We based our analysis on Model 6 to investigate to what extent each type of vessel the previous outcomes are valid and whether the magnitude of the negative effect of uncertainty and the dampening effect of the reversibility metrics are altered.

**Table 7 Random-effects probit model- Investment triggering by vessel type**

| | **M7:** Volatility index & both reversibility's* vix ***Capesize*** | **M8:** Volatility index & both reversibility's* vix ***Panamax*** | **M9:** Volatility index &both reversibility* vix ***Handymax*** | **M10:** Volatility index &both reversibility* vix ***Handysize*** |
|---|---|---|---|---|
| **Panel C Investment triggering under uncertainty and reversibility + control variables** | | | | |
| Volatility index | **-0.0202562**** | **-0.024034**** | **-0.0359799***** | -0.01367 |
| | (-0.4931) | (0.72089 | (1.6690) | (0.02338) |
| Sales-based reversibility * vix | 0.002063 | 0.0007157 | 0.0034703 | 0.003067 |
| | (0.10477) | (0.022014) | (0.16102) | (0.007545) |
| Price-based reversibility * vix | **0.0002701*** | **0.0003217**** | **0.0004701***** | 0.000142 |
| | (0.00411) | (0.0097446) | (0.0213) | (0.0002456) |
| Lagged investment rate | **0.142683***** | **0.1389003***** | **0.121187***** | 0.002297 |
| | (2.1726) | (4.1942) | (5.621) | (0.0269) |
| Libor | -0.004570 | 0.009078 | -0.0189499 | 0.002255 |
| | (0.0721) | (0.2643) | (0.87921) | (0.0157) |
| Spread | 4.32e-06 | 6.80E-06 | 2.47E-06 | **0.0000211***** |
| | (0.0000658) | (2.00E-04) | (0.000114) | (0.00004) |
| Ipgr | -0.00046 | 0.0067922 | **0.0095867**** | 0.001610 |
| | (0.0085) | (0.2051) | (0.4447) | (0.00506) |
| Infl | -0.00335 | **-0.0111946**** | **-0.0152513***** | -0.006649 |
| | (0.05134) | (0.3406) | -0.6624 | (0.0100) |
| Exch.china | -0.007940 | **-0.0158912**** | **-0.0142707*** | **-0.0152817**** |
| | (0.12113) | (0.4798) | (0.6619) | (0.0233) |
| Ret | 0.01951 | 0.0833234 | -0.152618 | -0.171781 |
| | (0.30292) | (0.13168) | (8.2969) | (0.0050) |
| Constant | -0.733357 | -0.78790 | -0.14924 | **-1.758***** |
| | (0.5722) | (0.5417) | (0.5585) | (0.6056) |
| **Diagnostics and Hypotheses Test** | | | | |
| Observations (vessel-months) | 304 | 304 | 304 | 304 |
| Wald test overall significance | 53.71*** | 53.82*** | 74.09*** | 57.92*** |

Notes: Standard errors are reported in the parentheses below the estimated coefficients. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively

*Table 7 Random-effects probit model- Investment triggering by vessel type Panel C*

To begin with, it is obvious that there is higher probability that the volatility index impacts negatively all four vessel types. Nonetheless, statistically significant negative impact, experience only three out of four vessel types. Capesize and Panamax prove to be at a level of 5% statistically significant in comparison to the Handymax, which is at a 1% level significant.

At this point and forward we have already become a witness of a pattern for three out of four vessel types, for which uncertainty is more likely to play a significant role.

As mentioned above in the introduction, the metric to calculate the size of a vessel is the DWT. It is more possible that the investment triggering on Capesize, Panamax, which are considered as large vessels, will be decreased by -2.02%, -2.40% and Handymax, characterized as medium vessel, by -3.59% respectively, when uncertainty is increased by 1 unit.

Based on the above, it can be observed that there is a higher probability that the size and the magnitude of the direct negative impact of uncertainty is following a monotonic negative relationship. In other words, the larger the vessel the smaller the negative effect of uncertainty exerts on investment triggering.

As time flies, the global demand for sea transportation is increasing, causing new requirements in constructing larger ships. Thus, the decision to defer from investing into a larger vessel is possibly less impacted by uncertainty as far as the global demand for it is present.

In the contrary the smallest type of vessel, Handysize, is less likely to receive an impact.

In lateral thinking, it is reasonable to assume that smaller vessels such as a Handysize are less likely to be negatively impacted by uncertainty. In the table above is illustrated as -1.36, which confirms this hypothesis, and this is why it is not statistically significant.

Factors such as "re-employment" – let's say - are not a strangle for the investor/shipowner as the usage of this kind of vessel has been very diversified. For example: Due to a wider variety of cargo types, such as steel products, grain, metal ores, phosphate, cement, logs, woodchips, and other types of so-called 'break bulk cargo" they need cargo holds for diversified storage on-deck cranes. This special equipment and their length overall (LOA) play an important role in satisfying transportation needs and global demand at all times.

In relation to the price-based reversibility, the panel follows the same pattern as the volatility index. The larger the vessel the more pronounced is the dampening effect of the price-based reversibility to uncertainty.

The following statistically significant observations can be made divided by vessel size regarding the control variables:

- <u>Capesize</u>

**Lagged investment rate**: It is found as statistically significant, implies that the investment that will occur today is affected by the investment happened past.

- <u>Panamax</u>

**Lagged investment rate**: It is found as statistically significant, implies that the investment that will occur today is affected by the investment happened past.

Inflation (**Infl**): As expected, it has negative sign, and affects the investment triggering at any point in time by reducing purchasing power. Therefore, an investor who desires to invest in shipping, has to go through this crucial decision or fall into the inaction zone.

Exchange rate of china (**Exch.China**): Observing the negative sign on the table above, investors are transformed into “risk averse” and are more willing to wait for the right time to come. In other words, the threshold triggering investment is extended

- <u>Handymax</u>

**Lagged investment rate:** It is found as statistically significant, implies that the investment that will occur today is affected by the investment happened past.

Regarding Industrial production for G7 (**Ipgr**): It is found less significant than the other control variables, but still affects positively the investment triggering.

In addition, we assume that 5% level resulted, because shipping transportation demand is derived from consumers and thus there is a time-lag between inquiries and actual execution of those.

Inflation (**Infl**): As expected, it has negative sign, and affects the investment triggering at any point in time by reducing purchasing power. Therefore, an investor who desires to invest in shipping, has to go through this crucial decision or fall into the inaction zone.

The exchange rate (**Exch.China**): Observing the negative sign on the table above, investors are transformed into “risk averse” and are more willing to wait for the right time to come. In other words, the threshold triggering investment is extended

- <u>Handysize</u>

**Spread**: It is found slightly below 0, and thus we can infer that if the prevailing market is high, the short-term spot freight market is pessimistic and in the long-term spot freight market, prospects are optimistic. However, if the prevailing market is low, then the opposite stands.

The exchange rate (**Exch.China**): Observing the negative sign on the table above, investors are transformed into “risk averse” and are more willing to wait for the right time to come. In other words, the threshold triggering investment is extended

Based on the overall Wald test significance the model M9 of the Handymax vessel, with $74.09^{***}$ is the one for which the econometric approach is the most suitable.

As a last step to our empirical analysis, in Table 8 from Panel D, the model M6 is enhanced by the interaction term of the dummy variable "*crisis*" in combination to our main in concern variables (uncertainty and reversibility metrics).

| Table 8 Random-effects probit regression- Investment triggering | |
|---|---|
| | **M16:**<br>M11 + (both reversibility's *crisis) |
| **From Panel D Investment triggering under uncertainty & reversibility & control variables & crisis** | |
| Volatility index | **-0.0318781*****<br>(0.0057) |
| Sales-based reversibility * vix | 0.0030303<br>(0.0019) |
| Price-based reversibility * vix | **0.0003841*****<br>(0.0000) |
| Vix*crisis | **0.0097489*****<br>(0.0035) |
| Sales-based reversibility * crisis | **-0.4009876***<br>(0.1377) |
| Price-based reversibility * crisis | -0.0014455<br>(0.0016) |
| Lagged investment rate | **0.100246*****<br>(0.0165) |
| Libor | -0.00516<br>(0.0090) |
| Spread | **4.56e-06****<br>(1.92e-06) |
| Ipgr | 0.0037576<br>(0.0024) |
| Infl | **-0.0089229*****<br>(0.0022) |
| Exch.china | **-0.0130751*****<br>(0.0036) |
| Ret | 0.0315556<br>(0.0499) |
| Constant | -0.54457<br>(0.3287) |
| **Diagnostics Tests** | |
| Observations (vessel-months) | 1,216 |
| Wald test overall significance | 238.21*** |

Notes: Standard errors are reported in the parentheses below the estimated coefficients. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively

*Table 8 Random-effects probit regression- Investment triggering from Panel D*

The main point was to witness whether the timeframe of 31/12/2007-31/12/2012 of the Great Recession is significantly interrelated with uncertainty and the reversibility metrics and to what extent it is more likely to affect the decision to trigger new investment.

In Appendix the full Panel D is provided to observe one by one the Models and the introduction of the interaction term *vix*crisis, sales-based reversibility* crisis* and *price-based reversibility* crisis*.

In Model 14-15 the interaction term *vix* crisis* is taken as granted and there is higher probability to be statistically significant in both cases at 5% level. In those two models the price and sales-based reversibility metrics are alternatively tested as indirect effects again to crisis. In both cases they are at 5% and 1% level statistically significant tested respectively.

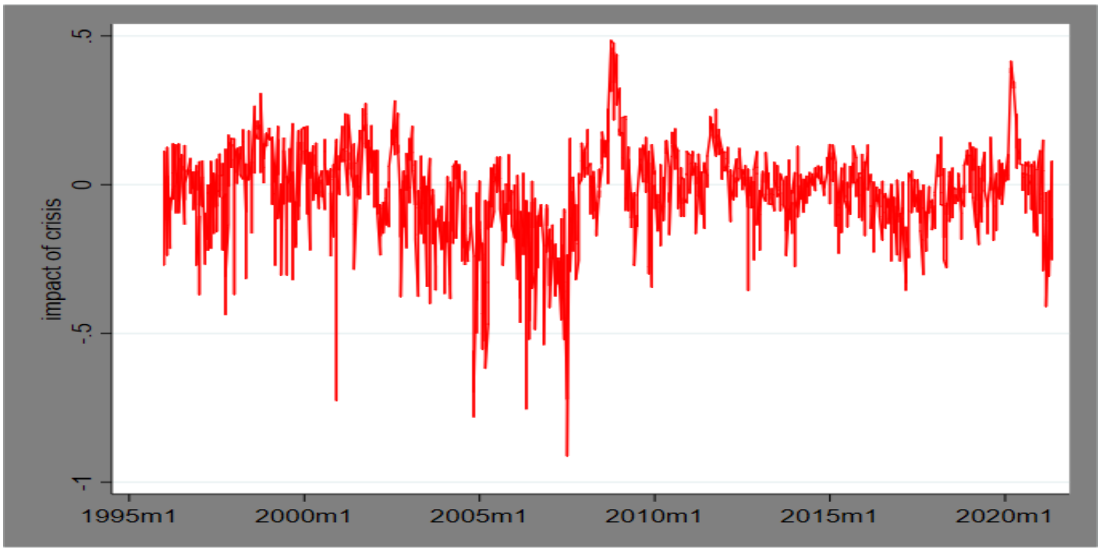
Surprisingly enough, in Model 14, there is a higher probability that sales-based reversibility interacted with the volatility index, will be statistically significant at 10% level and thus it dampens the uncertainty effect by capturing the level of difficulty to resell the vessel. However, in all other models in panel D, this is not the case. The positive effect of this reversibility metric does not apply.

In respect of Model 16, all factors are included from our basic Model 6 and all interaction terms of our dummy variable crisis. As illustrated in Table 7 there is higher probability that the direct effect of uncertainty is impacting negative the decision to invest in a dry bulk shipping sector and that impact is, as before, dampened by only the price-based reversibility metric at 1% statistically significant level.

The interesting part here is to calculate the derivative of the interacted terms with crisis to see the magnitude of the negative or positive effect caused by the dummy crisis.

As we can observe only two out of three interaction terms with crisis are more likely to be statistically significant and that is vix*crisis (*0.0083487*$^{**)}$ at a 5% level and sales-based reversibility*crisis (*-0.4009876*$^{***)}$ at a 1% level. As we can observe in the following graph, the magnitude of the impact of crisis, in our case with the characteristics of the Great Recession, will be affected from the extent of the uncertainty and reversibility in the prevailing market.

In other words, to what extent the crisis is impacting our model is more likely to be more or less severe considering the uncertainty and reversibility at each time of point.




*Time-series 10 Impact of crisis in investment triggering via uncertainty and sales-reversibility*

Based on the descriptive statistics on *Table 4*, the impact of crisis will be -0.023. Meaning that it is more likely that investment triggering will decrease at -2,3%, when crisis, which is interacted with volatility and sales-based reversibility, is 1 (as a dummy) or will increase by one unit.

The following statistically significant observations can be made regarding the control variables:

**Spread**: It is found slightly below 0, and thus we can infer that if the prevailing market is high, the short-term spot freight market is pessimistic and in the long-term spot freight market, prospects are optimistic. However, if the prevailing market is low, then the opposite stands.

Inflation (**Infl**): As expected, it has negative sign, and affects the investment triggering at any point in time by reducing purchasing power. Therefore, an investor who desires to invest in shipping, has to go through this crucial decision or fall into the inaction zone.

The exchange rate (**Exch.China**): Observing the negative sign on the table above, investors are transformed into "risk averse" and are more willing to wait for the right time to come. In other words, the threshold triggering investment is extended

Based on the overall Wald test significance the model M16 at $238.21^{***}$ is the one for which the econometric approach is the most suitable and statistically significant at 1%.

## *Empirical Conclusions*

<u>Panel A, M1-M3</u>

Uncertainty and reversibility metrics are implemented:

a) Higher probability evidence that there is statistically significant negative direct impact of uncertainty on investment triggering for all the models
b) In all cases both reversibility dimensions exert an indirect impact on investment triggering by lowering uncertainty's effect (vix)

<u>Panel B, M4-M6</u>

Uncertainty, reversibility metrics and control variables are implemented:

a) Uncertainty does impact investment triggering negatively but the negative effect of it, is only dampened by the price-based reversibility metric, thus the model with only the sales-based metric shows that the direct effect of uncertainty is not statistically significant
b) Choosing model 6, based on the overall significance level, from that point forward, the interaction term, sales-based reversibility metric multiplied with volatility, does not play a statistically significant role and thus the dampened indirect effect on uncertainty is not feasible

<u>Panel C, M7-M10:</u>

Vessel type specific following the econometric equation by Model 6:

a) The negative effect of uncertainty is statistically significant for three out of four models. The existing pattern is that it is more likely the size and magnitude of the direct effect of uncertainty to impact investment triggering, following a monotonic negative relationship
b) Smaller vessels, such as Handysize, are not statistically significant to be impacted by uncertainty
c) For the price-based reversibility metric the same pattern as by uncertainty is followed (bullet C). Meaning that the metric for the larger vessels, not Handysize, is only dampening the negative effect of uncertainty on investment triggering and the bigger the vessel as lesser the impact.

<u>Panel D, Model 11- Model 16</u>

All the characteristics from panel A & B, plus, the interaction terms with crisis (vix*crisis, price & sales-based*crisis):

a) In model M11-M16 it is more likely that the direct effect of uncertainty impacts investment triggering
b) In all models, but Model 14, the indirect effect of interaction term sales-based reversibility multiplied with the volatility index, does not mitigate the negative effect that uncertainty exerts on investment triggering. Only, the price-based metric does

c) Regarding the interaction terms of crisis, only *vix*crisis and sales-based reversibility*crisis* are statistically significant. Taking the derivative for crisis we conclude that the magnitude of the impact of crisis on investment triggering, in our case with the characteristics of the Great Recession, will be affected from the extent of uncertainty and sales-based reversibility in the prevailing market

## Conclusion

The world dry bulk shipping market is divided into four segments: Capesize, Panamax, Handymax and Handysize shipping. These markets have become more complex in recent years, in these highly competitive markets, the fierce volatility of freight rates makes the trend unpredictable and has brought great risks as well as opportunities to the operators.

To sum up, the main findings of this paper are as below:

Higher uncertainty reduces the likelihood of investment triggering, once it is triggered which comes in line with the following literature: (Abel & Eberly, 1994) ; (Ferderer, 1993); (Ghosal & Prakash , 2000); (Rajeev & Goel, 2001) (Carruth, et al., 2003) ; (Bloom, et al., 2007); (Bendall & Stent, 2010); (Axarloglou, et al., 2013); (Kyriakou, et al., 2017). However, in M5 & M10 we experienced that uncertainty is impacting in a negative way the investment triggering, but it is not statistically significant. Regarding M5, we assume that due to the non-statistically significant result of sales-based reversibility, uncertainty is affected. About M10, we assume that the non-statistically significant result of uncertainty (in Handysize type) is because of the size and characteristics being adopted.

The impact of uncertainty is lower (higher) when reversibility is higher (lower), which comes in line with the following literature: (Caballero & Pindyck, 1996); (McDonald & Siegel, 1984) (Pindyck, 1990) (Dixit & Pindyck, 1994); (Arrow, 1968); (Nickell, 1977); (Abel & Eberly, 1999); (Drakos, 2011) (Drakos & Konstantinou, 2013). In our case, only one dimension for all models of reversibility affects investment decisions, that is price-based.

In contrast to the above, in M2 & M3, where control variables are not yet introduced, sales-based reversibility is adopting a 1% & 10% statistically significance level, respectively, to the overall mix. We assume that this huge decline in statistically significance is because the sales-based reversibility metric in the prevailing market is irreversible.

Furthermore, in M14, where the interaction term vix*crisis and sales-based*crisis is introduced, sales-based reversibility multiplied by volatility index has also adopted statistically significance level of 10%. We assume, that when crisis happens, there is also liquidity stress. Shipowners are pushed to trade in the prevailing market, satisfying at least their OPEX, in many cases there can be no satisfaction neither. At this point investors are the key bone to solve the case. They put on hold their NB projects and rush to investigate and later to acquire SH vessels in very low prices.

From an investor’s point of view, crisis periods, is the best time to penetrate a market.

Acquiring vessels in very low fares when their owners are in distressed economic position, can be very beneficial. Not only because they funnel money into a lucrative industry, but also because in after crisis periods, they may sell those assets at very high prices, creating huge spreads and thus profits.

The above contrary dynamics (shipowner - investor), satisfy our sales-based metric at 10% , which renders it “less irreversible”, due to the capital interactions on both parties.

We hope this is a point for future consideration and research on how the sales-based reversibility can eventually affect investment triggering.

Finally, it is more likely that the magnitude of the impact of the crisis on investment triggering, caused by the interaction terms (*vix*crisis and sales-based reversibility*crisis)*, which will affect investment triggering negatively, in a statistically significant way, to the extent of the uncertainty and sales-based reversibility in the prevailing market. (Min, et al., 2009) (Gary van Vuuren & Claudio , 2013)

## Recommendations

Further to this paper we recommend the academic community to take advantage of this paper as a hint for future consideration and expand this research on the industry as a whole, both for dry bulk and liquid as well.

Furthermore, it is a prominent step to shed light on how the sales-based reversibility would affect industry across all segments and later the investment triggering.

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## List of time series

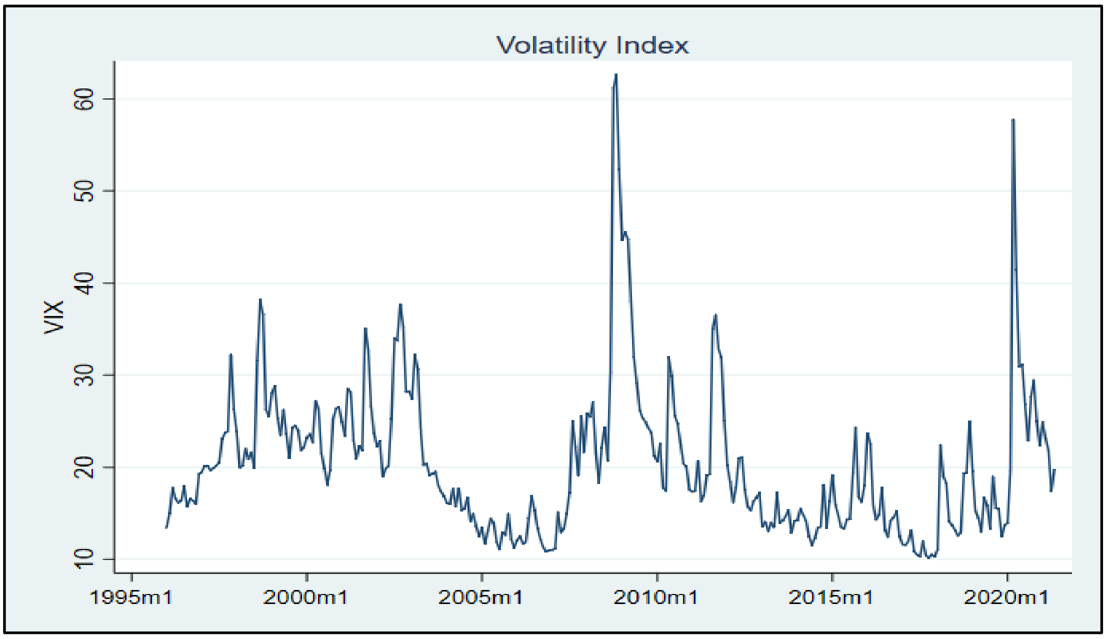


## List Of Tables



## List Of Figures

# Appendix




*Time-series 11 Volatily Index*

| Table 9 Random-effects probit regression- Investment triggering | | | | | | |
|---|---|---|---|---|---|---|
| | **M11:** M6 + (vix*crisis) | **M12:** M6 + (sale-based reversibility*crisis) | **M13:** M6 + (price-based reversibility*crisis) | **M14:** M11 + (crisis* sale-based reversibility) | **M15:** M11+ (crisis*price-based reversibility) | **M16:** M11 + (both reversibility's *crisis) |
| **Panel D Investment triggering under uncertainty & reversibility & control variables & crisis** | | | | | | |
| Volatility index | **-0.02681*****<br>(0.0053) | **-0.02248*****<br>(0.0044) | **-0.02350*****<br>(0.0044) | **-0.030461*****<br>(0.0054) | **-0.03196*****<br>(0.00579) | **-0.031878*****<br>(0.005712) |
| Sales-based reversibility * vix | 0.001680<br>(0.008)2 | 0.002814<br>(0.0194) | 0.00207<br>(0.00186) | **0.003339***<br>(0.0019) | 0.0016913<br>(0.00184) | 0.0030303<br>(0.00197) |
| Price-based reversibility * vix | **0.0003313*****<br>(0.0000) | **0.000299*****<br>(0.00005) | **0.000313*****<br>(0.00005) | **0.0003602*****<br>(0.00006) | **0.0003908*****<br>(0.0006) | **0.0003841*****<br>0.0000643 |
| Vix*crisis | 0.00177<br>(0.0021) | - | - | **0.007547****<br>0.0025 | **0.008215****<br>(0.0035) | **0.0097489*****<br>(0.003504) |
| Sales-based reversibility * crisis | - | -0.18060<br>(0.1241) | - | **-0.48134*****<br>(0.1732) | - | **-0.37780***<br>(0.00360) |
| Price-based reversibility * crisis | - | - | -0.00059<br>(0.0009) | - | **-0.003309*****<br>(0.0013) | -0.0017780<br>(0.003609) |
| Lagged investment rate | **0.10735*****<br>(0.0167) | **0.107654*****<br>(0.0165) | **0.10847*****<br>(0.0165) | **0.102116*****<br>(0.01656) | **0.104077*****<br>(0.0165) | **0.100246*****<br>0.0165187 |
| Libor | -0.00474<br>(0.0091) | -0.0018<br>(0.0089) | -0.00228<br>(0.0090) | -0.005614<br>(0.0091) | -0.00419<br>(0.0091) | -0.005165<br>(0.00905479 |
| Spread | **5.232e-06*****<br>(2E-06) | **6.56E-06*****<br>(1.74e-06) | **6.23E-06*****<br>(1.81e-06) | **4.72e-06*****<br>(1.94e-06) | **4.78e-06*****<br>(1.93e-06) | **456e-06****<br>(1.92e-06) |
| Ipgr | 0.004470<br>(0.0024) | 0.003667<br>(0.0024003) | **0.00413***<br>(0.00240) | 0.0034922<br>(0.0024) | **0.00445***<br>(0.00249 | 0.0037576<br>(0.0024113) |
| Infl | **-0.00931*****<br>0.0022 | **-0.008909*****<br>(0.0022) | **-0.0093325*****<br>(0.0022) | **-0.008641*****<br>(0.0022) | **-0.00910*****<br>(0.0022) | **0.0087121*****<br>(0.0022357) |
| Exch.china | **-0.01252*****<br>0.0037 | **-0.01368*****<br>(0.0035) | **-0.01350*****<br>(0.0035) | **-0.01186*****<br>(0.0036) | **0.01237*****<br>(0.00369) | **0.0119167*****<br>(0.0036323) |
| Ret | 0.0110<br>(0.0500) | 0.0086<br>(0.0496) | -0.0047<br>(0.04911) | 0.03501<br>(0.0504) | 0.02459<br>(0.0504) | 0.0372754<br>(0.050557) |
| Constant | **-0.5829***<br>(0.3233) | **-0.8077*****<br>(0.290) | **-0.7731*****<br>(0.3029) | -0.44922<br>(0.3286) | -0.52589<br>(0.3255) | -0.4457<br>(0.3287) |
| **Diagnostics and Hypotheses Test** | | | | | | |
| Observations (vessel-months) | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 |
| *Wald test overall significance* | ***225.45**** | ***229.68**** | ***228.70**** | ***233.27**** | ***238.45**** | ***238.21**** |

*Table 9 Random-effects probit regression- Investment triggering*