ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

Department of Economics

Essays on Immigration and Crime

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Contents

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Chapter 1: Introduction

1. Introduction

The immigration-crime nexus has been long in the core of the political agenda and has been thoroughly studied by several social sciences such as sociology, criminology and psychology. The economics of crime literature, initiated by the seminal paper of Becker (1968), placed criminal behavior in a market setting of a benefit-cost analysis. This came in contrast to the established view of the other social sciences that criminal behavior was caused by mental illness and social oppressions. Economics of crime view crime as a rational choice of the individual after comparing the expected net benefit from her legal and illegal labor market opportunities. These opportunities depend on a number of individual, sectoral, regional and country level characteristics and can be altered by various exogenous shocks such as an immigration influx, changes in the labor market policies, the economic conditions, the deterrence/incapacitation policies and more.

This thesis contributes to the literature both theoretically and empirically focusing on the case of Greece. While facing the worst economic recession in recent memory, Greece has also lately become the main entry and transit for hundreds of thousands of immigrants from neighboring countries. These events have had a tremendous effect on all the major socio-economic and demographic factors that, according to the economic theory, may have a causal effect on crime rates. The country reveals a unique pattern in property crime rates in south Europe[1], with two peaks during the debt crisis. All the above, along with the country's special characteristics that affect labor market opportunities, such as its geographical position and the large size of its informal sector, make Greece interesting to study. To my knowledge, this is the first study using panel regional data in the country.

Briefly, the structure of the thesis is as follows. In chapter 2, I analyze the socioeconomic and demographic determinants of property crime in Greece provinces during the period 2004-

[1] See Figure 1.

2016. I assemble a dataset based on reported crime rates from the Greek Police and on residence permits data from the Greek Ministry of Interior. Using a dynamic economic model of crime, I employ a GMM (Generalized Method of Moments) estimation methodology to address the potential endogeneity issues. In line with the literature, I find that higher clear up rate, which proxies the police effectiveness, leads to lower property crime rates. Furthermore, I study the effect of the lack of trust in the banking system on the property crime rates. Many Greeks have decided to withdraw (part of) their deposits and store in safe deposits or even at home[2]. I show that criminals have responded (rationally) to these new opportunities, thus increasing the property crime rate, as well as all its subcategories. Next, I study the effect of a decongestion law[3] and find that a decrease in the prison population increases property crime through the incapacitation effect[4]. Finally, I find that there is a significant positive effect of own-lagged crime rate. After controlling for endogeneity, immigration still has an impact on the overall property crime rates and all its subcategories (but the magnitude of the coefficient significantly falls).

After having established a significant positive impact of immigration on the overall property crime rates, chapter 3 focuses on further examining the immigration-crime nexus across Greek regions during the period 2008-2016. Nevertheless, there could be several reasons why the size of the immigrant population is systematically correlated with crime rate, some of which may not be adequately captured by control variables. In line with the literature, I construct three instruments based on the supply/push approach and compare the results. First, following the approach pioneered by Card (2001), I construct an outcome-based measure of supply-push factors using total migration flows by nationality toward Greece; variation of the instrument results from differences in the beginning-of-period composition by nationality of the immigrant population across different areas within Greece (see, for instance, Ottaviano and Peri, 2011; Cortes, 2008; Card, 2009). I therefore construct the instrument by weighting each nationality η in region i with the growth rate of total permits in Greece, for immigrants of nationality η and

[2] Naturally, some of the money withdrawn went abroad. See Chapter 2 for more.

[3] L. 4322/2015.

[4] The incapacitation effect of imprisoning a person is the fact that she cannot commit a crime, as she is incapacitated. This is different from the deterrence effect when one does not commit a crime out of fear of being caught and punished, i.e. is deterred to do it.

summing up across all nationalities. However, the growth rate of total permits used in the above instrument will be the weighted growth rate of all regions, thus it will still be correlated with pull factors in a given region. Thus, I also construct a second instrument where I weight each nationality η in region i with the growth rate of total permits in Greece excluding the permits of region i, for immigrants of nationality η and summing up across all nationalities.

However, both of the aforementioned instruments will still perform poorly if there are common pull factors across all Greek regions. In order to overcome this problem, I follow Bianchi et al. (2012) and construct a third instrument based on bilateral migration flows toward other destination countries as these are much less likely to be correlated with pull factors by Greek regions or Greece as a whole. The within estimator gives a positive and significant coefficient which drops when I use the IV estimator and I instrument the endogenous variable with the first instrumental variable, but is still significant. The coefficient drops further when I use the second instrumental variable, but it still is positive and significant. When I use the third instrumental variable, the coefficient becomes negative and insignificant.

Lastly, in chapter 4, I employ a search and matching model with two sectors, a formal and an informal, and undocumented immigration. The two sectors differ in several aspects, e.g., only firms that operate in the formal sector pay a payroll tax and severance payments; similarly, only workers employed in the formal sector pay an income tax and social security contributions. I study the effects of various labor market and immigration policies and calibrate the model to obtain quantitative estimates regarding the effects of these policies for the period 2000-2007 in Greece.

I find that an increase in the auditing rate, or the penalty rate, reduces the size of the informal sector. Out of the two deterrence policies, I find that an increase of the inspection rate is more effective. A reduction of the workers' income tax is the most effective incentive policy. This is also the only incentive policy reducing the unemployment rate in the informal sector and the one reducing the most the unemployment in the informal sector, as well as the overall unemployment. Another policy that is effective in reducing the relative size of the informal sector is an immigration amnesty. The opposite is true for an influx of the (undocumented) immigrant population. Finally, I find that the best option is to impose a policy mix. A

combination of a reduction of the workers' income tax and an increase in the auditing rate provides the best results in the reduction of the relative size of the informal sector.

The remaining of this section serves as an introductory note and presents an overview of the main study subjects of this thesis; crime, immigration and crime, and informality. Each section offers a brief review of the related economic literature and a related data analysis for Greece. Finally, I present a non-technical review of the data, methodology and the structure of the thesis.

1.2. Crime

Crime is a complex phenomenon of considerable importance and high academic interest, as it affects all members of society in one way or another. Either someone is a potential victim or an offender, or even just a taxpayer paying for the various expenditures on law enforcement, prisons, and the legal system.

The literature of the economics of crime, starting from Becker's (1968) seminal paper, further enriched by Ehrlich (1973) and others, view criminal decisions in the same way decisions interact in a market setting. This model of criminal choice uses a cost-benefit framework to conceive criminal behavior. Criminal decision is an economic choice made by rational agents, who compare the costs and benefits of illegal activities taking in account the probability of being arrested and punished, i.e., expected costs vs. expected benefits of crime. Becker's analysis assumes that a person commits an offence if the expected utility to him exceeds the utility he could get by using his time and other resources at other activities. Some persons become 'criminals', therefore, not because their basic motivation differs from that of other persons, but because their benefits and costs differ.

The economics of crime are based on three major microeconomic principles: rationality, equilibrium, and efficiency (Laing, 2011). Rationality assures that crime is viewed as a rational act that responds to (positive or negative) incentives. These can be either provided by the legitimate (e.g. wage) and illegitimate earnings opportunities (such as the loot from a property crime or gains from tax evasion), or via the criminal justice system (through the severity of sanctions, such as fines, incarceration, and other deterrence policies). The equilibrium principle

is referred to the fact that criminal activity is a part of the overall economic system; its level will be jointly determined as an equilibrium outcome that depends also on other socio- economic and demographic variables. The equilibrium principle should not be overlooked when designing crime reducing policies or they will not be efficient. Finally, economic efficiency permits the comparison and assessment of the effectiveness of alternative crime reducing policies.

As mentioned above, individuals maximize their utility, which is a function of various characteristics capturing their legal and illegal labor market opportunities. The economic theory can be tested empirically as these characteristics can be proxied by several variables, such as unemployment, income level, inequality level, GDP, percentage of immigration in the population, police effectiveness and more (See Buoannano 2003 for a survey of the empirical literature).

The existence of a relationship between crime and unemployment is ambiguous, both in its nature and in its robustness. In most empirical studies, it is found that unemployment rates are less important determinants of crime rates than income levels and distribution (see for example Freeman 1994). In fact, as showed by several studies (eg. Imrohoroglu et al., 2000) the majority of criminals are employed. It is therefore important to distinguish between labour market opportunities and employment.

Freeman (1994) and Lochner (1999) show that education may raise skills and abilities leading to an improvement of the wage level and work opportunities, but at the same time it can have a "civilization" effect, which tends to reduce the incidence of criminal activity. However, there have been studies finding a positive and significant effect of education on property crime. This can be attributed to several reasons, such as that education may be associated with a raise of the marginal product of labor in the crime industry relative to the legitimate economic pursuits, or with a decrease of the under-reporting of crimes and more (Ehrlich 1975, p.33).

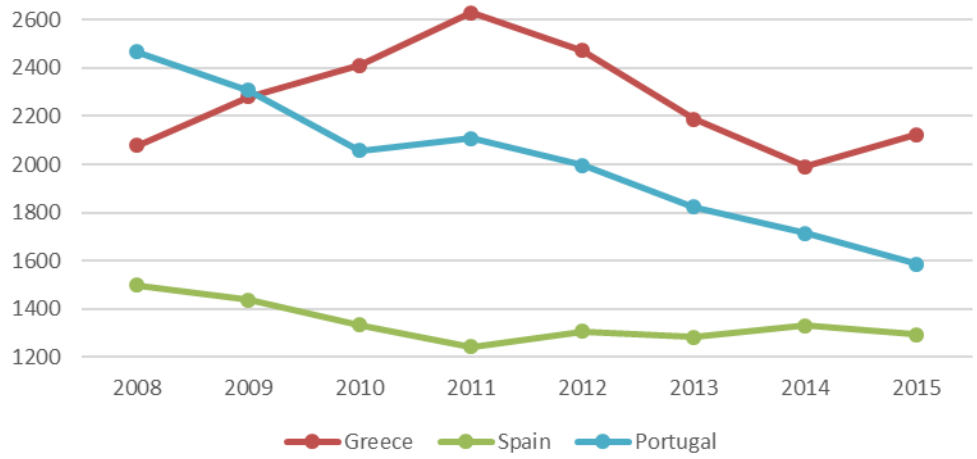
According to the economics of crime, individuals consider both the possibility to get caught and the severity of the expected punishment. The empirical evidence from the United States confirmed that both factors have a negative effect on crime rates (Buoananno 2003). A distinction is often made between the 'deterrence' effects of policing and convictions and the 'incapacitation' effect of locking-up criminals who may have a tendency to rejoin the crime

industry once they are released (see Winter, 2008). Ehrlich (1981) shows that the effectiveness of rehabilitation and incapacitation depends on the rate of recidivism of offenders, and on their responsiveness to economic incentives.

Income and wealth inequality is likely to be one of the major causes of crime. It is important to distinguish carefully the effects of inequality from those of poverty. Kelly (2000) states that areas of high inequality place poor individuals who have low returns from market activity next to high-income individuals who have goods worth taking, thereby increasing the returns to time allocated to criminal activity.

Finally, social factors, social interactions and social networks appear to be strongly correlated with propensity to crime (see Calvó-Armengol and Zenou, 2004). Neighborhood poverty may also affect the actual or perceived returns to schooling and work by affecting access to quality schools, which may depress the opportunity cost of crime. In others words, individuals are affected in taking their decisions by peer group components and by their socioeconomic background.

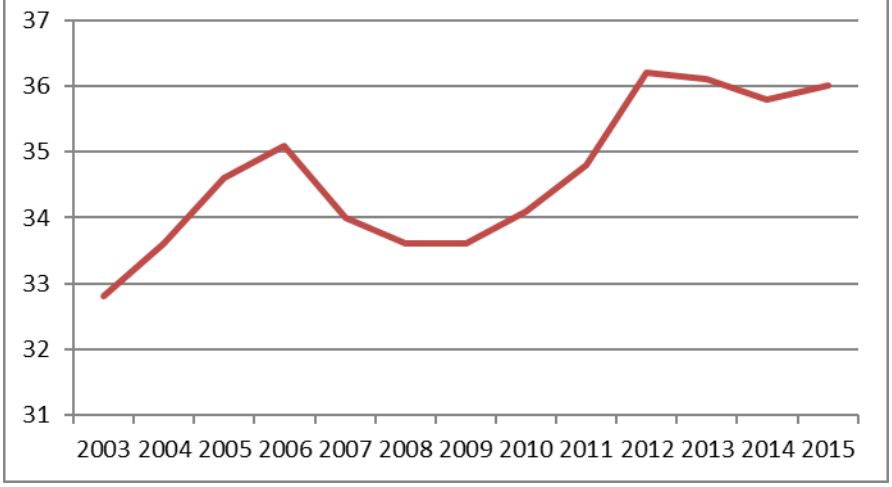
Figure 1: Property crimes per 100,000 inhabitants



Source: Eurostat

As mentioned earlier, this thesis focuses empirically on the case of Greece. Figure 1 shows the property crime rates in three periphery countries, namely Greece, Spain and Portugal[5]. Although a cross country crime rate comparison is generally not advised, due to differences in reporting levels and definitions, one can compare the across time variation of similarly defined crime types. One can observe that property crime rates (including robberies, burglaries, car thefts and thefts) have peaked during the first years of the debt crisis in Greece, while the same pattern cannot be detected in the other two countries[6]. This fact raises questions on why this pattern is revealed solely in Greece. According to the Greek Police, 172,572 crime incidents[7] were recorded in 2016. The vast majority of these incidents were property crimes (robbery, burglary, motor vehicle theft, and theft), reaching the 121,865 recorded cases.

Figure 2: GINI Coefficient



Source: World Bank

The case of Greece is also of special interest as it is a country severely affected by the global economic and humanitarian crisis. It is true that most factors, which according to the literature, may have a causal effect on crime rates have changed dramatically in absolute terms, as well as in comparison to the rest European countries. To begin with, Figure 2 shows the value of the GINI coefficient over time in Greece. The GINI coefficient measures inequality of income

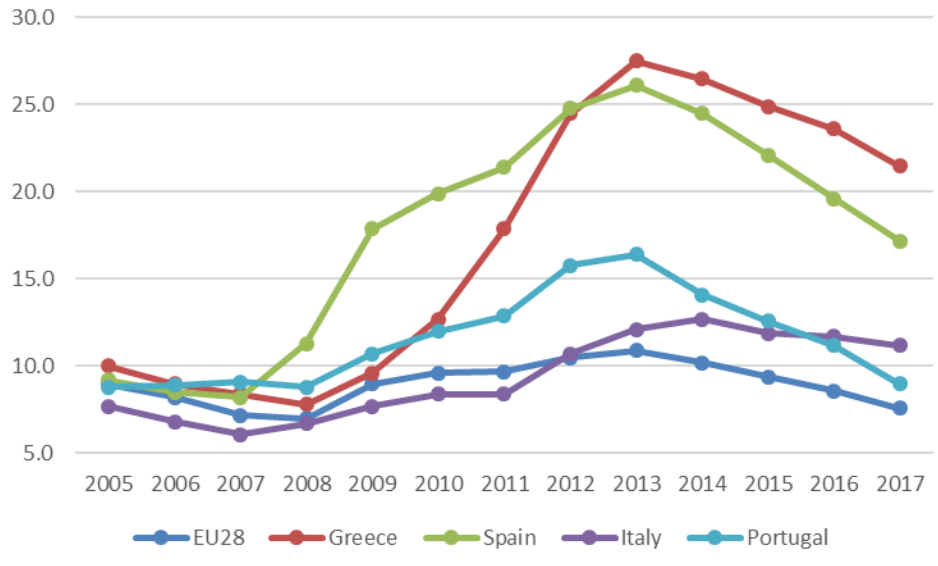
[5] Italy is not included in the graph as it differs in the definition of burglaries, thus making data not comparable.

[6] Unfortunately, Eurostat only reports comparable data on crime rates since 2008 and thus we cannot observe the pre- crisis behavior of the rates.

[7] Offences of the Penal Code, felonies and misdemeanors, table 17, Epetirida 2016 p. 34

(or wealth) with a 100 value representing perfect inequality. Inequality has seen a downward trajectory since 2006, but started increasing in the beginning of the debt crisis. Since 2012, it has been roughly stabilized in a higher level than before the debt crisis.

Figure 3: Unemployment

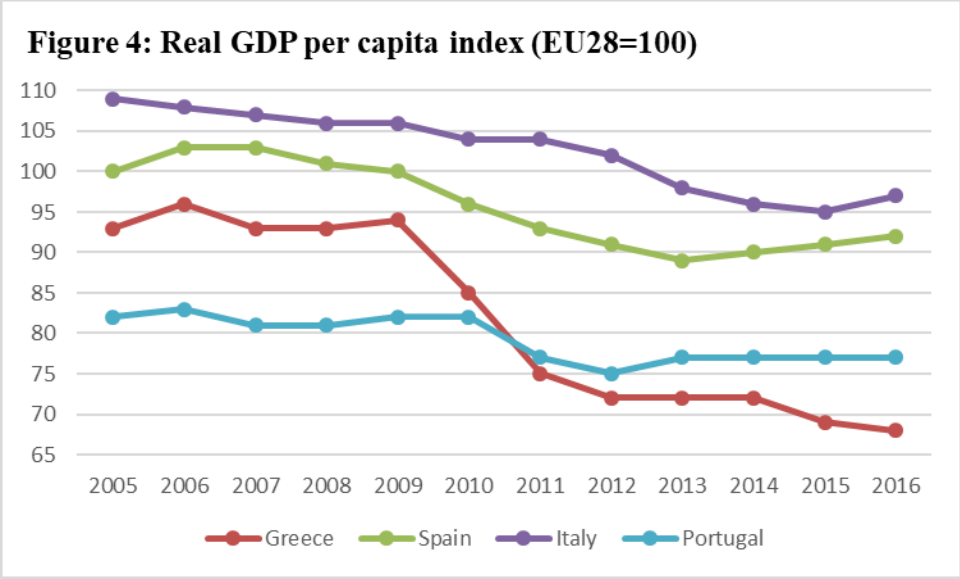


Source: Eurostat

Figure 3 shows the unemployment rate in Greece, compared to the EU28[8] and the other Southern economics, namely Spain, Italy and Portugal. Greece has had the biggest rise in the unemployment rate, specifically 19.7 percent points during 2008-2013 followed by Spain, which saw a rise of 14.8 percentage points during the same period. This is a big rise compared to the EU28 average that only saw an increase by 3.9 percentage points.

Following, Figure 4 shows how the real GDP per capita changes in comparison to the EU28. All periphery countries have fallen under the EU28 average after crisis but Greece has had the sharpest decrease among them.

[8] EU28 contains: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.



Source: Eurostat

During these past years of the economic recession, Greeks have lost their trust in the banking system and this has been recorded in the large reduction of their deposit levels. Trust and reliability in the banking system have the typical characteristics of inventory variables, i.e. time and investment are required so they can be restored if lost. Deposit levels are the same; they are very much connected to the aforementioned variables.

The downturn of the deposit levels in the Greek banks has two main points; the first one is that they returned to the last semester of 2003 level (from September 2009 until June 2018 there has been a 108.39 billion fall in the deposits, equal to 45.6%) and the second one is that this reduction has not been monotonic. The second point allows us to divide this whole period into four sub- periods, based on the turning points[9]; period 1 (- 87.24 billion euros) from September 2009 until June 2012, period 2 (+14.16 billion euros) from June 2012 until September 2014, period 3 (-43.92 billion euros) from September 2014 until July 2015 and period 4 (+8.6 billion euros) from July 2015 until June 2018.

[9] For more see: Gogos S., (2016), «7 ημέρες οικονομία», Eurobank Research, Vol: 180, 04/10/2016, ISSN: 2241-4878, p.p. 1, 3,4. (In Greek)

During the first period, the deposits of private households have reduced by 36.68%. This can be mainly attributed to the uncertainty and instability prevailing in the economic environment leading to a lack of trust in the banking system. The second period is characterized by relative stability and a slight increase of the deposits' level (+ 9%). The third period is characterized by a sharp decrease of the deposits of private households and firms. Specifically, the reduction recorded was equal to -26.66%. The early elections along with the prolonged negotiations have contributed to a prevailing state of political and economic uncertainly and instability. This has peaked with the announcement and conduction of a referendum and the imposition of capital controls. Finally, the fourth period saw an increase of 7.12% of the deposits, equal to 8.6 billion euros.

This large withdrawn of money from the Greek banks resulted in the creation of new opportunities in the crime sector; Greeks would withdraw money from the banks and frequently store them in safe boxes or even at home. There are numerous media and police reports indicating that this has cause an increase in property crime incidents.

Another factor that might affect the crime level is the severity of the expected punishment, usually proxied by the prison population. Greek prisons have been always operating above their capacity, resulting in various warnings and penalties on violation of human rights imposed by the European Court after their respective inspections. The various prison decongestion laws imposed since 2005 did not seem to sufficiently solve the issue. The first relevant law that has effectively reduced prison population in Greece is L.4322/2015. The law did not come without criticism, as many have claimed that those released according to L.4322/2015 are dangerous for the society and have indeed raised the crime rate. It was initially announced that the law would be effective for one year, starting from the April of 2015, but its implementation has been extended until the August of 2018. The special characteristics of the law are discussed in detail in chapter 2.

1.3. Immigration and Crime

Immigration is in the core of the political agenda in all Western countries. According to the Eurobarometer, the immigration of people from outside the EU evokes a positive feeling for just above a third of Europeans and a negative feeling for 56% of them. The percentage is strikingly high in Greece, with 78% of people reporting a negative feeling. Despite the fact that there is no empirical work supporting a negative impact of immigration in Greece, xenophobia and right wing extremism are in a rise[10], leading to the weakening of the social web, which is frequently translated to the appearance of hate crime incidents.

Journalists, public figures and opinion makers flood the media with different views on the subject. Often this appears related to the commonly expressed concern that immigrants harm the labor market prospects of natives. This issue has received substantial, and sometimes controversial, attention in the academic labor economics literature (see, inter alia, Borjas, 1999, or Card, 2009). However, it also reflects a wider concern over the impact of large immigration flows on other aspects of society. Issues of relevance here cover competition for education and health services, congestion, housing demand, cultural identity and crime. Although casual empiricism hints at a link between immigration and criminal activity, the empirical evidence is by no means unambiguous.

On theoretical grounds, there are a priori reasons to believe that immigration may affect crime rates. Nevertheless, the economic theory of crime offers little guidance as to the size, or even the sign of the effect. On the one hand, theory predicts that, else equal, individuals with lower outside options commit more crime. Low levels of education, low wages, higher levels of unemployment, and difficulties assimilating have all been documented for immigrants and can reasonably be associated with poorer outside options—at least if one regards legal labor market employment as the relevant margin. Furthermore, immigrants are disproportionately male and between the ages of 15 and 35. Existing research has shown these groups to be especially likely to be involved in criminal activity (Freeman, 1999).

[10] In Greece, the Racist Violence Recording Network, developed by the United Nations High Commissioner for Refugees (UNHCR) and other civil society organizations, documented 166 racist crimes in 2013, 143 of which were committed against migrants or refugees.

On the other hand, the expected costs of committing a crime are likely higher for immigrants. Not only do they face the same set of punishments as natives, but they are also subject to deportation, which may be an important deterrent. Moreover, immigrants might be positively selected on various unobservable dimensions, and may thus have an inherently lower propensity to commit crime than natives may.

Another channel through which immigration may affect crime is the presence of spillover effects. Even if immigrants themselves commit fewer crimes than observationally similar natives do, immigration could cause an increase in crime if it reduces natives' labor market opportunities inducing them to substitute toward criminal activity. At the same time, immigration may be associated with positive spillover effects. For instance, immigrants might move into and improve transitional neighborhoods by bringing social capital that is otherwise lacking.

At the aggregate level, Butcher and Piehl (1998a) look at a sample of U.S. metropolitan areas over the 1980s and conclude that new immigrants' inflows had no significant impact on crime rates. Finally, Borjas et al. (2010) argue that recent immigrants have contributed to the criminal activity of native black males by displacing them from the labor market.

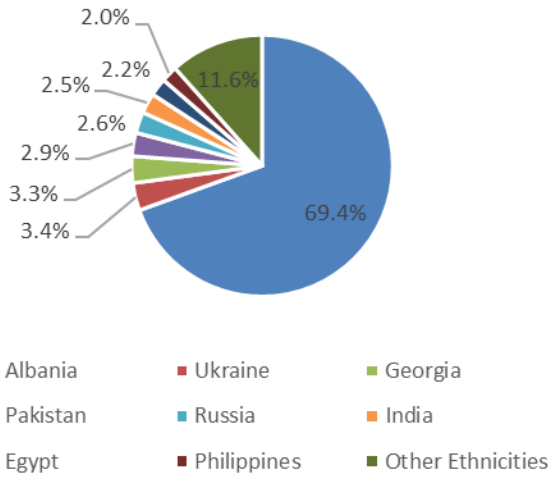
After taking into account the endogeneity of immigration, Bianchi et al (2012) find that the effect on total or property crime is not significantly different from zero. When they examine different types of property crime, they only find an effect on robberies. These are a very small fraction of crimes and thus, they do not find an effect on total crime rates.

Alonso-Borrego et al. (2012), show that there is a significant relationship between crime and immigration in Spain during the period 1999 to 2009. However, the explanation is found in the specific characteristics of the different immigrant groups, particularly in the amount and type of human capital, which result is largely in tune with the previous studies on U.S. immigration and crime.

After gaining ground spectacularly, immigration is now seen as the most important issue facing the EU, overtaking the economic themes that have led the hierarchy of main concerns. The most important issue for Europeans overall, immigration is in first position in 20 Member States. Concerns over terrorism have also increased sharply. Meanwhile, concern about economic themes has continued its downward trend.

Greece has lately become the main entry and transit for hundreds of thousands of immigrants from neighboring countries. Throughout this period, apart from facing perhaps the worst economic recession in recent memory, EU has been the main destination for hundreds of thousands of immigrants from Africa, Asia and the Middle East. Figure 6 shows the composition of the (documented) immigrant population in 2016, with Albanians representing the 69.4% of immigrants in the country.

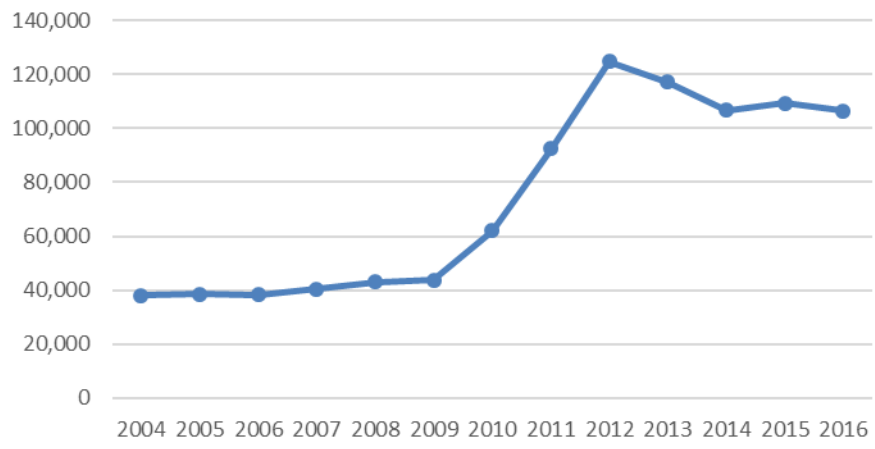
Figure 5: Composition of Immigration in 2016



Source: Data on residence permits data from the Greek Ministry of Interior

In the past three decades, Greece turned from an emigration to an immigration country (Figure 5). According to ELIAMEP (2016 p.30), the total number of emigrants for the period 2008- 2013 equals 427,000 people. Among them university graduates are over-represented and age cohorts include both younger and middle aged persons with families. Migrant flows to other OECD countries grew by 160% between 2010 and 2012, while 2013 data show a small decline. More than two thirds of these went to Germany. More than 27,000 recent Greek emigrants had at least a university degree, representing 60% of all recent emigrants from Greece.

Figure 6: Emigration in Greece



Source: Eurostat

Today the country is faced with an unprecedented economic and humanitarian crisis with the arrival of close to 950,000 people between January 2015 and February 2016 (OECD, 2016). Greece serves as a transit country to most people, with less than 1% of them having requested asylum in Greece. Meanwhile, labor migration flows slowed down with the crisis, but they did not stop. In 2012, 23,200 new residence permits were issued to non-EU citizens, compared with 43,000 in 2008.

Figure 7: Crimes of arrested foreigners

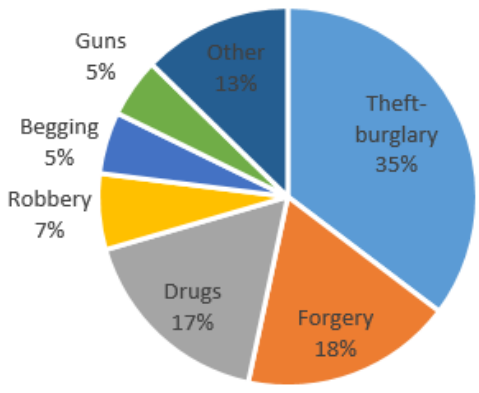
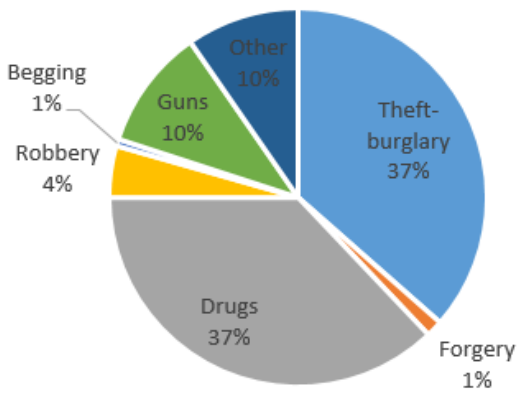


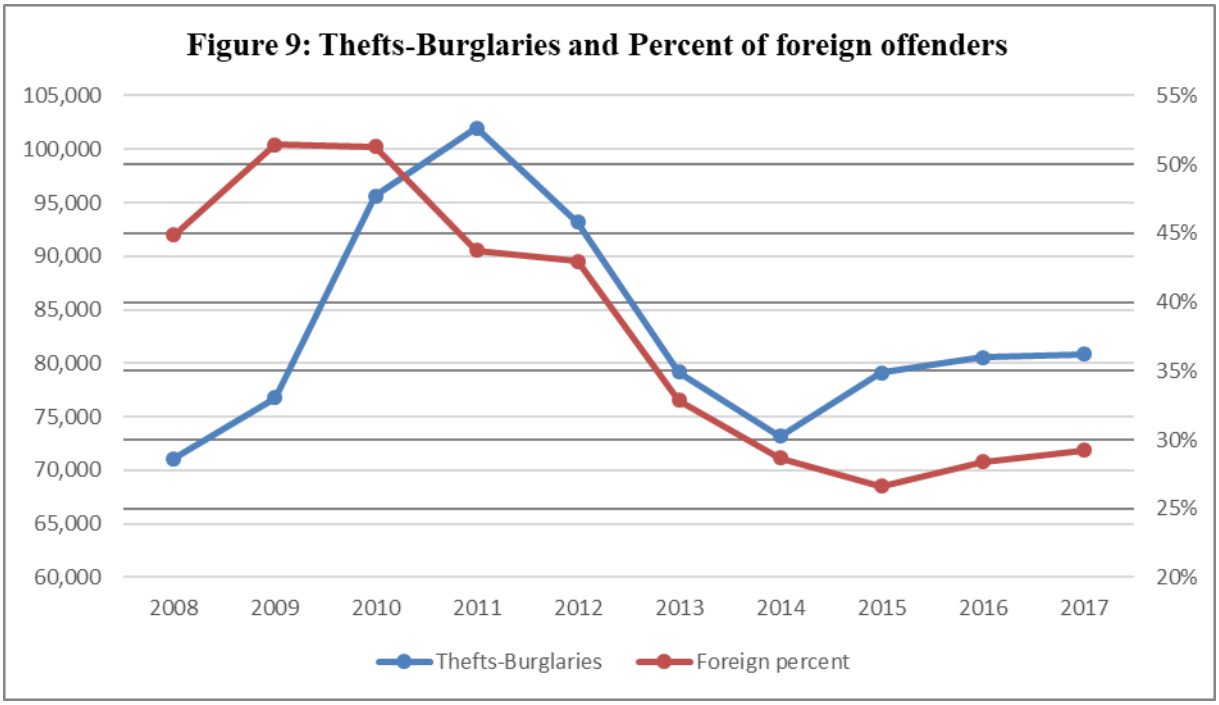
Figure 8: Crimes of arrested natives

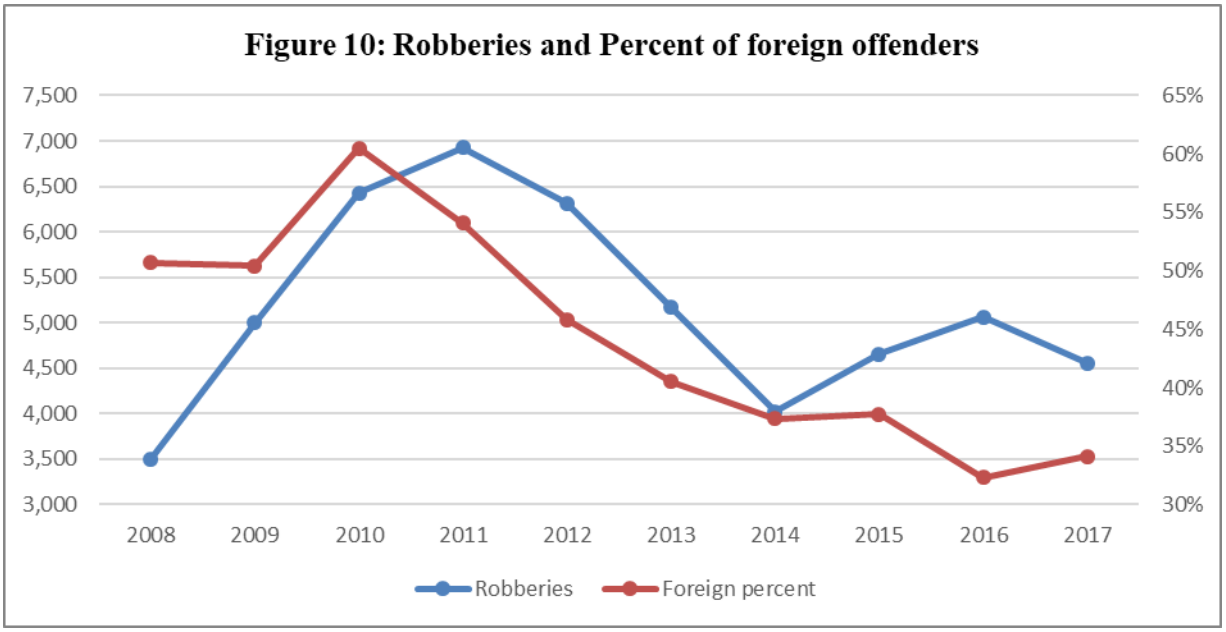


Source: Hellenic Police

The economic crisis has had a profound effect the labor market opportunities and immigrants. As reported by OECD (2016). The unemployment rate of natives raised by 17 percentage points, while for immigrants it has increased by 26 percentage points between 2008 and 2015 reaching 33%. Despite some decline in the past 2 years, possibly reflecting return migration or re-emigration to other destinations, the level of unemployment among migrants is the highest in the OECD. Moreover, it is eight percentage points higher than the unemployment rate of Greek natives.

These changes in labor force mobility and various major macroeconomic factors have had an impact in the legal -and illegal- labor market opportunities of the natives, as well as the immigrants. It is interesting to note the different opportunities in the illegal sector by looking at data that disaggregate arrests by nationality and crime type. Figures 7 and 8 show the crime sectors of expertise of natives and foreigners in Greece in 2011. On the left axis, I scale the crime incidents in absolute numbers. On the right axis, I scale the percentage of foreign offenders arrested as responsible for this crime type. Thefts and burglaries represent most arrests between foreigners (35%). Following is forgery (18%), drugs (17%), robbery (7%), begging (5%), guns (5%) and 18% includes all other recorded criminal offences. Natives also have a big percentage of arrests attributed to theft and burglary (34%), but they have an equal percentage attributed to drugs. Following is guns (10%), vehicle theft (6%) and robbery (4%), while the remaining 12% represents all other recorded criminal incidents.





Note: Total offences for each crime is on the left axis and percentage of foreign individuals in total arrests is on the right axis
Source: Hellenic Police

Figures 9 and 10 show how the percentage of foreign people arrested for robberies and burglaries varies over time. However, one has to be cautious when interpreting data on arrests between natives and immigrants. On the one hand, it is claimed that non-natives are less easy to

be tracked, as natives usually have a known address, relatives that can also be located easily etc. On the other hand, non-natives have more chances to be arrested due to racial profiling. Despite that, and assuming the aforementioned factors have not changed during the period studied, it is interesting to follow these percentages across time. I observe a co-movement of the percentage of foreign people arrested for a property crime and the absolute number of property crime incidents. This can be attributed to different reasons, such as changes in the native/immigrant population, changes in the composition of the population, changes in the opportunities in the various sectors of legal (and illegal) labor markets and more. As much as these graphs raise questions about the immigration-crime nexus, it does not point to a causal effect and needs to be examined econometrically.

1.4. Informality

Shadow economy is of great interest in most world economies. It significantly affects macroeconomic factors, such as wages and unemployment while tax evasion constitutes a key controversy between politicians. Informal sector includes all economic activities that would generally be taxable were they reported to the tax authorities. There are various definitions suggested in the literature. One commonly used definition is: all economic activities that contribute to the officially calculated (or observed) gross national product but are currently unregistered. (See for example, Schneider (1994a), Frey et al. (1984), and Lubell (1991)). Others defines it as "market based production of goods and services, whether legal or illegal, that escapes detection in the official estimates of GDP." (see Smith (1994, p. 18).

Informal activities can be related to other illegal activities such as drugs, human trafficking, guns and more. Furthermore, tax evasion is considered to be a criminal act[11] and is punished by law.

[11] In Greece L. 4337/2015 Article 8 regulates tax evasion crimes.

Table 1: Activities of the Informal Sector				
	Monetary Transactions		**Nonmonetary Transactions**	
Illegal Activities	Trade in stolen goods; drug dealing and manufacturing; prostitution; gambling; smuggling and fraud.		Barter: drugs, stolen goods, smuggling, etc. Produce or growing drugs for own use. Theft for own use.	
	Tax Evasion	**Tax Avoidance**	**Tax Evasion**	**Tax Avoidance**
Legal Activities	Unreported income from self-employment; Wages, salaries and assets from unreported work related to legal services and goods	Employee discounts, fringe benefits	Barter of legal services and goods	All do-it-yourself work and neighbor help
Source: Scneider and Enste (2000)				

Schneider (2013) suggests that tax and social contribution burdens, the intensity of regulations, public sector services and situation of the official economy can all affect the decision of an individual to search for a job in the informal sector. Tax and social security contribution burdens are proxied by using the share of direct taxes, the size of government (government expenditures) and the fiscal freedom (Heritage Foundation's economic freedom index).

Regulations include labor market regulations, such as minimum wages and dismissal protections, trade barriers, such as import quotas and labor market restrictions for foreigners, such as restrictions regarding the free movement of foreign workers. The intensity of regulations is proxied by business freedom (a component of Heritage Foundation's economic freedom index that measures business activity).

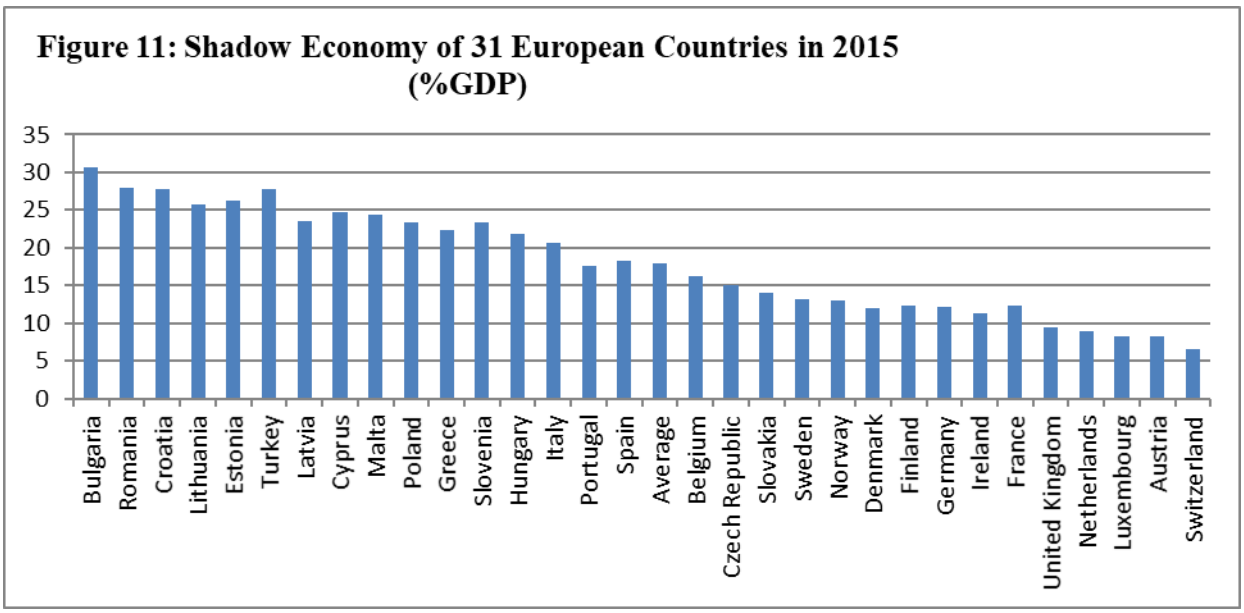
Shadow economy growth can lead to reduced state revenues, which can lead to an increase in the tax rate for firms and individuals in the official sector. This can also be combined with a deterioration in the quality of the public goods and the administration, resulting in even

stronger incentives to participate in the shadow economy. This effect is proxied by the Government Effectiveness from the World Bank´s Worldwide Governance Indicators. This variable captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Finally, the situation of the official economy can also affect the individual's decision to enter the shadow economy. In a booming official economy, there are plenty of labor market opportunities in the official sector, while in an economy facing a recession more people try to compensate their income losses through additional shadow economy activities. The variables used to proxy this effect are GDP per capita (PPP) and unemployment rate.

There is a rich literature studying the size of the informal sector, the reasons of its existence and how it emerges. For example, Bosh and Pretel (2012) use data from Brazil and suggest that policies reducing the cost of entry in the formal sector or increase the cost of informality increase the size of the formal sector. Fugazza et al (2004) find that it is better to increase incentives to participate in the formal sector, rather than employ deterrence policies. Zenou (2008) finds a clear positive effect on the employment in the formal sector, when a policy of wage subsidy or hiring subsidy is incorporated.

Figure 11 shows Schneiders' estimates of the size of shadow economy in 2015. Greece's estimated size of the informal sector reaches the 24% of GDP. Dellas et al. (2017) estimate that this percentage has increased to 40% during the crisis.



Source: Schneider (2015)

By default, undocumented immigrants can only be employed in the informal sector. It is therefore interesting to examine different policies that can affect the labor market opportunities of those who have access in both sectors as well as those who only have access in the shadow economy. Based on the aforementioned discussion, Greece constitutes an interesting case, as a country with high undocumented immigration and a large informal sector.

2. Data and Methodology

2.1. Methodology

In line with the related literature, I use a linear model to analyze the relation between the determinants of crime and the potential relation with immigration with the crime rate. In the absence of individual-level data, I have to rely on aggregate data by regions. In view of the economic theory of crime, which implies a probability of committing a crime for each individual based on some observable or unobservable characteristics, the above approach is justified under the assumption that the conditional probability of committing a crime follows a linear probability model.

Since the unobservable characteristics of each region can be a decisive factor for the crime rates of a region directly or indirectly by affecting other observable characteristics, the standard approach in the literature to determine how each observable characteristic affects the crime rates is to exploit the time variability of each characteristic and observe how the crime rates responds to these changes within each region, instead of doing comparisons between the regions for each time period. Accordingly, I use the fixed effects (within) estimator to obtain my baseline results (Chapter 1 and 2). Naturally, a limitation of this approach is that it requires a sufficient variation of the explanatory variables in time, which may not always true for certain variables such as the population density of a region.

An issue that is usually present when trying to estimate the parameters of an economic crime model is the potential endogeneity of the explanatory variables, which makes it not safe to attribute any observed correlation to the existence of a causal relationship between those variables with the crime rates. For example, endogeneity could appear when an explanatory variable is affected by an unobserved time-varying characteristic that also directly influences the explained variable. Ignoring the presence of endogeneity when estimating the model generally results in biased estimates.

In order to address endogeneity issues in my variables, I employ an instrumental variables approach, which makes use of variables (instruments) that affect the explained variable indirectly by influencing the explanatory variables that are considered to be endogenous. That is, an instrument is a variable that does not itself belong in the explanatory equation but is correlated with the endogenous explanatory variables.

Finding such variables is not a trivial matter in general, but when analyzing the determinants of crime (Chapter 2) the standard approach in the literature (see e.g. Buonanno and Montolio, 2008) is to specify a dynamic model[12] and exploit its dynamic properties to generate instruments. This works by using appropriately lagged values of the endogenous variables, as these are not expected to be correlated with the errors in the current time period. I employ a GMM-system approach following Arellano and Bover (1995) considering all the explanatory variables to be potentially endogenous.

[12] i.e. the model includes the lagged dependent variable as an explanatory variable.

When examining specifically the effect of immigrant population on crime I use a static model (Chapter 3) following Bianchi et al. (2012) where the focus is on the variable of the immigration controlling for the effect of the other variables. I construct an instrument for the potentially endogenous migration based on the approach pioneered by Card (2001) who uses composition by nationality of immigrants in each region during the previous period and migration flows to the country (Greece in my case) by nationality to predict total migration in a given region. The predictive power of the instrument exploits the fact that new immigrants of a given nationality tend to settle into the same areas as previous immigrants from the same country (see e.g. Mushi (2003)).

The core of this thesis lies on individual's decision to engage in unlawful acts. According to the economic theory, this decision consists a rational choice based on the expected benefits and costs in the legal and the illegal sector. The different labor market opportunities offered in each sector depend on a number of individual, sectoral, regional and country specific characteristics and can also be affected by various other factors, such as a change in the size of the undocumented immigration, changes in labor market policies, changes in deterrence/incapacitation policies and more.

In Chapter 4 I construct a search and matching model with two sectors, a formal and an informal. Firms operating in the formal sector, are entitled to a subsidy for maintaining a position, but are obliged to pay a payroll tax and face a firing cost, which includes a severance payment, as well as some administrative costs. Workers can be either natives or irregular immigrants. The former have access in both sectors, whereas the latter can only be employed in the informal sector. Native workers can choose where to work, but if they get a formal job they have to pay an income tax and are entitled to unemployment benefits and a severance payment. On the other hand, workers and firms in the informal sector do not have to pay taxes or a firing cost, but face the probability to get audited and have to pay a penalty. I calibrate the model for Greece for the period 2000-2007 and experiment with several deterrence, incentive and immigration policies.

2.2. Data

Reported crime data are available through the Greek Police. They publish data on a NUTS2 regional level[13], which include 13 provinces (peripheries), for the period 2008-2017. The data are disaggregated in different crime types but in this thesis, I focus on property crimes, namely vehicle thefts, burglaries and robberies. There is a number of reasons on why we focus on property crime. First, property crime can be viewed as a rational choice between legitimate and illegitimate opportunities and can be thus explained well in the context of the economics of crime. Other types of crime may not be characterized solely by rationality, such as rape and homicides. Second, as it constitutes an economic activity, it will be jointly determined with the other economic variables, such as income inequality, unemployment and more (see Freeman, 1999). Third, property crime accounts for the vast majority of the criminal activity. In 2016 in Greece, property crime accounted for 92% of all crime types[14].

Greek Police also constructs an annual statistical book[15] (epetirida) on a Police Force Area (PFA) level. There are 66 PFA levels, which we assigned to the NUTS3 regional level to match the 46 counties as defined by Eurostat, in order to be able to combine all variables for the econometric analysis. The annual statistical books contain annual and monthly information on different crime types, as well as crime data for regions of different urbanization level and regional data on the nationality (native or foreign), age and gender of arrested perpetrators. Unfortunately, there are no individual level data on reported crimes in Greece.

Turning to police effectiveness, there are data on the cleared and non-cleared crime incidences for felonies (kakourgimata) and misdemeanors (plimelimata)[16], but not for other crimes types. Furthermore, the disaggregation of crime types is not the same in the two datasets (NUTS2 and NUTS3). For example, burglaries, car thefts and thefts are reported separately in the NUTS2 dataset, while they are reported together as theft in the NUTS3. As a result, one should be very careful when combining information from the two datasets[17]. Finally, the

[13] As defined by Eurostat.

[14] Author's calculation from Eurostat data.

[15] Epetirida statistical yearbooks are published only since 2004. We have applied and acquired the yearbooks since 2004.

[16] According to the Greek Penal Code, kakourgima is a criminal act punishable with at least 5 years of imprisonment, while plimmelima is a criminal act punishable with less than 5 years.

[17] We have used data on some types of property crime from both datasets. Details on this can be found in Chapter 2.

epetirida does not contain information on prison population and number of police officers or workers in the judicial system. Such data are available at a national level from Eurostat.

Since there are no reliable annual regional data for the undocumented immigration, I follow the common practice of the literature (see for example Bianchi et al. 2012) and proxy total immigration with the annual valid residence permits. I have data on the residence permits from 2006-2017[18] from the Greek Ministry of Interior, Ministry of Immigration. The data are given on a regional level of 55 service stations (ipiresies). I have assigned them to match the 46 NUTS3 regions and the 13 NUTS2 regions so I can use them in the econometric analysis. This dataset includes regional data on the year and the month that the immigrants have acquired the residence permits, the country of origin, the gender and the number of immigrants. Unfortunately, there are no individual level data on the residence permits available.

Turning to the estimates if the size of the informal sector, I follow Schneider (2013) and use a "definition of the shadow economy so as not to deal with typical underground, classical economic crime activities, which are all illegal actions that fit the characteristics of crimes like burglary, robbery, drug dealing, etc.". Shadow economy cannot be directly measured and therefore it needs to be proxied by several indicators that best capture and reflect the characteristics of informal activities (Schneider 2013). These include money indicators, labor market indicators and indicators for the state of the official economy. Money indicators capture the effort of people to avoid leaving traces of their transactions, hence using cash. To achieve that, the ratio of M0 over M1 is used. M0 corresponds to the currency outside the banks and for M1, the usual definition is M0 plus deposits. Labor market indicators include the labor force participation rate and the growth rate of the total labor force. The state of the official economy is measured by the annual growth rate of the GDP per capita.

I use the estimates given by Schneider (2013), based in the aforementioned analysis. It is important to stress that these estimates of shadow economy include all market-based legal production of goods and services that are deliberately concealed from public authorities (to avoid payment of income, value added or other taxes and social security contributions, having to meet certain legal labor market standards and complying with certain administrative procedures).

[18] Epetirida is not published for the whole period studied. The data became available upon request.

3. Structure of the Thesis

In Chapter 2, I examine the determinants of property crime in Greek regions, during 2004-2016. In line with the literature, I find evidence of serial correlation and confirm the deterrence hypothesis for crime against property (i.e. higher clear-up rates reduce crime against property). In addition, I find a significant negative effect of the GDP on property crime and a significant positive effect of immigration on the overall property crime rates (which drops in magnitude after I control for endogeneity). Furthermore, I find that the sharp decrease in the growth rate of the deposits has created new opportunities for the criminals, thus increasing all property crime categories. Lastly, I find that the big reduction of the prison population in 2015 increased the property crime rate. This chapter is based on the related work co- authored by Dr. Alexandros Louka.

In Chapter 3, I focus on immigration as a variable of interest. I examine the possible endogeneity by constructing three different instruments. The approach I follow is to use the supply-push component of migration by nationality, as an instrument for shifts in the immigrant population across regions. These factors are events in origin/host countries that increase the propensity to emigrate. Since these are both important in determining immigration decisions and are independent of regional differences within the host country, they have often been used as a source of exogenous variation in the distribution of the immigrant population. After controlling for the endogeneity, I find that there is no impact of immigration on the property crime rates. This chapter is based on the related work co- authored by Dr. Alexandros Louka.

In Chapter 4, I employ a search and matching model with two sectors, a formal and an informal and undocumented immigration. When I empirically test the model in period 2000-2007 in Greece, I find that an immigration amnesty reduces the size of the informal sector. In addition, I find that increasing the auditing rate in the informal sector is the most effective deterrence property in reducing informality. Respectively, the most effective incentive policy is a reduction of the worker's income tax. Lastly, the best strategy is a combination of a deterrence and an incentive policy, namely a reduction of the income tax and an increase of the inspection

probability. This chapter is based on the related work co- authored by Professor Theodore Palivos and Professor Xiangbo Liu.

Chapter 2: Crime Rates during the Greek Debt Crisis

1. Introduction

The literature of economics of crime has its starting point in the late 1960s, stimulated by the seminal paper of Gary Becker (1968), which studied criminal behavior through the view of the general theory of rational behavior under uncertainty. Individuals compare the expected benefit to the expected cost from engaging in a criminal activity. The former is given by the expected gain from crime, while the latter is given by the expected punishment and the probability to get caught. The model predicts how changes in the severity of punishment, the probability to get caught and various other socio-economic and demographic variables may affect criminal decisions.

Ehrlich (1973) has further extended Becker's work by suggesting a time allocation model. Given the fixed leisure time assumption, the remaining time must be allocated between legal and illegal activities. Predictions of this model can be tested by studying variables that can affect the quantity and quality of legal and illegal labor market opportunities. These variables may be socio-economic (e.g. educational attainment, wage inequality, income, unemployment), demographic (e.g. population density, urbanization) and proxies of the expected cost (e.g. police effectiveness, severity of punishment).

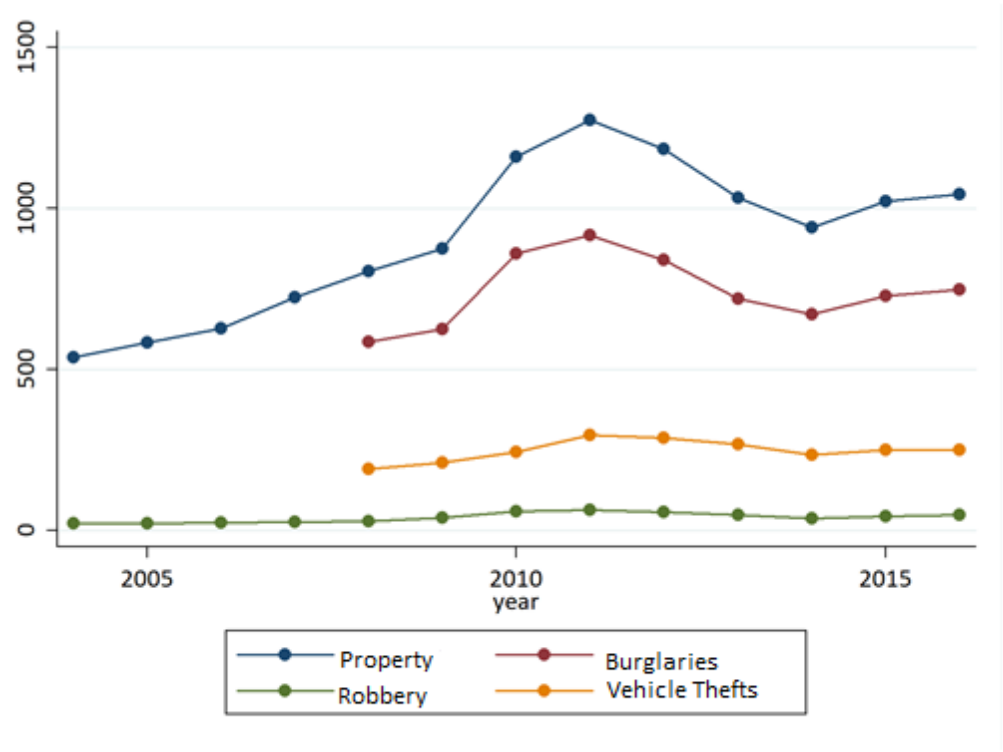
Over these past decades, there has been several studies devoted to determining the socio-economic and demographic determinants that drive criminal behavior (Eide, 1994, 1997). Despite the fact that the interest in the subject diminished in the 1980's, since the mid-1990's the literature has been thriving again (see Freeman, 1999 and Buonanno, 2003 for excellent literature surveys). One reason behind this interest is the dramatic changes in various variables that may determine crime, such as unemployment, immigration, income inequality and more.

Despite the fact that most of the literature focuses on the United States (see Lochner & Moretti, 2004, Grogger, 1995, 1998) and the United Kingdom (Machin & Meghir, 2004, Han, Bandyopadhyay and Bhattacharya 2010), there is a number of studies analyzing the determinants

of crime for European countries such as Germany (Entorf & Spengler, 2000), Italy (Buonanno, 2006; Marselli & Vannini, 1997) and Spain (Buonanno and Montolio 2008).

This paper analyzes the socio-economic determinants of property crime in Greece. The case of Greece is of high interest as it is a country deeply affected by the debt and the immigration crisis. Thus, there has been great changes in most factors known to determine the level of the property crime, a type of crime primarily based on economic incentives. I have assembled a dataset based on reported crime data from the Greek Police, for 13 provinces (NUTS2) level, during 2004-2016.

Figure 1: Property crimes and its components

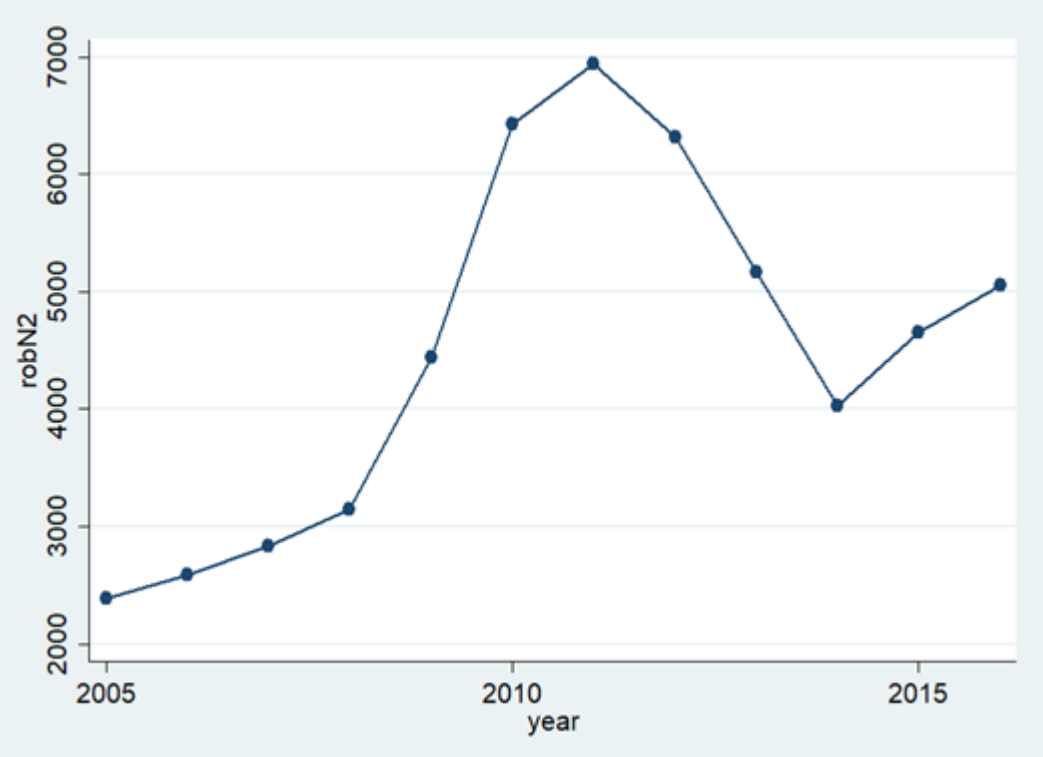


Note: Offences per 100,000 inhabitants
Source: Hellenic Police

Figure 1 shows the property crime incidents per 100,000 inhabitants in Greece from 2004 to 2016. It also shows the crime incidents per 100,000 inhabitants for three different crime subcategories; burglaries, robberies and vehicle thefts. Robberies are available from 2004 until

2016 but burglaries and vehicle thefts are reported as a separate category only since 2008 (from 2004 until 2007 they are reported together as thefts). Since 2004, property crime was following an upward trend until 2009 where one can observe the first sharp increase on property crime and peaks on 2011, where it starts dropping again. On 2014 there is a second increase which carries on also in the next year.

Figure 2: Robberies

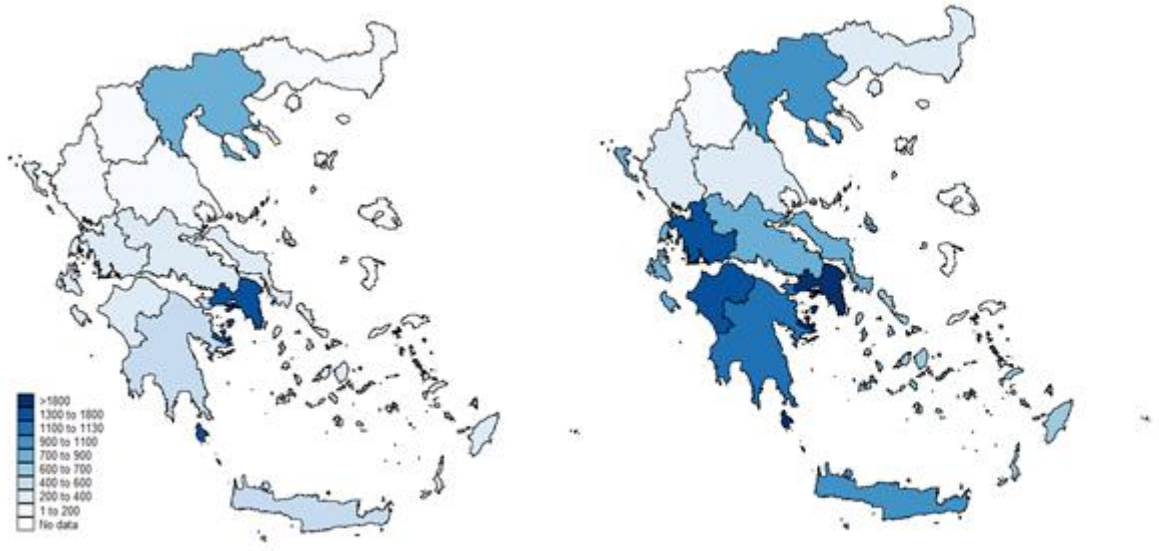


Note: Robberies per 100,000 inhabitants
Source: Hellenic Police

This pattern has been revealed for all subcategories of property crime, namely robberies, burglaries and car thefts[19]. As robberies are relatively lower in numbers, they seem flattened in Figure 2; but if one looks at Figure 3, where they are appropriately rescaled, it is obvious that robberies also follow the aforementioned pattern.

[19] See the appendix for a long description and definition of the different crime types.

Figure 3: Property Crime across NUTS2 regions



Left Map: Property Crime rate per 100,000 inhabitants in 2008
Right Map: Property Crime rate per 100,000 inhabitants in 2011

I contribute to the literature in several ways. Firstly, I construct and use two unique datasets. A reported crime dataset from the Greek Police and a dataset of residence permits from the Greek Ministry of Interior. Secondly, I conduct the first panel data analysis of crime in Greece. Greece is of special interest as it is a country deeply hurt by the recent global debt crisis. All socioeconomic and demographic factors known to determine crime, have gone through dramatic changes during the period studied. Thirdly, Greece has been deeply affected by the recent immigration crisis. I look at the effect of immigration on property crime and account for the possible endogeneity. Fourthly, previous papers in the literature study pre-crisis years and go up to 2008. My dataset runs from 2004 to 2016. Fifthly, I study the impact of the lack of trust in the banking system to the property crime rates. There have been numerous police and media reports that the money withdrawn and stored in private houses have increased property crime rate. That is, criminals have been rationally responding to new crime opportunities. Sixthly, I include the prison population to study the effect of a major prison decongestion law that was implemented in 2015 in all Greek prisons on property crime rate. Lastly, I disaggregate property crime in robberies, vehicle thefts and burglaries and examine them separately. This is important

as all these crimes have mainly economic incentives and account for 92% of the overall crime activity in the country[20]. This approach allows us to avoid aggregation bias. Cherry and List (2002) stress that "it is inappropriate to pool crime types into a single decision model … much of the existing empirical estimates suffer from aggregation bias" (p. 81)

I first employ a fixed effect estimator to account for possible unobserved province fixed effects. Following, I employ a GMM estimator, as property crime is expected to be highly correlated with business cycles and likely to be affected by recidivism, both of which could explain the significant own-lagged coefficient (Buonanno 2008).

Figure 4: Criminal Activity in Periphery

Source: Eurostat

Figure 4 shows the overall crime activity[21] as reported by Eurostat in four southern European countries, namely Greece, Spain, Italy and Portugal[22]. I see that the property crime[23] accounts for the vast amount of the criminal activity, which is 92%, 88%, 94% and 91% respectively.

[20] Own calculations using Eurostat data.

[21]This includes Intentional Homicide, Assault, Kidnapping, Sexual Assault, Robbery, Burglary of Private Residential Premises, Theft, Theft of Motorized Land Vehicle, Unlawful Acts Involving Controlled drugs or Precursors.

[22] One has to be very careful with cross country comparisons of crime rates. Differences in definitions. Legislation frame and reporting level can lead to fault results. I use data from Eurostat for all countries to ensure the maximum compatibility in crime definitions. I use only crime categories which are reported in Eurostat by all four countries.

2. Data

I construct a dataset based on reported crime from the Greek police. I study different property crime types, *prop*, namely burg, *burg*, robberies, *rob*, and vehicle thefts, *ctheft*. In order to account for the effects of immigration, I have also constructed a dataset of residence permits from the Greek ministry of Interior. I draw data from Eurostat for the rest of the socio-economic and demographic determinants, for the period 2004-2016, in a NUTS2 level (province level).

Table 1: Summary statistics, including before and after the crisis means

Variable	Description	Mean	Std. Dev.	Min	Max	Obs.	2004-2008 (mean)	2009-2016 (mean)
Burg100	Burglaries per 100,000 inhabitants	438.2	347.8	45.7	1496.1	N=117	272	458.9
Rob100	Vehicle Thefts per 100,000 inhabitants	154.5	100.9	15.0	513.0	N=117	118.4	159
Ctheft100	Robberies per 100,000 inhabitants	16.1	22.9	0.5	132.3	N=169	9.1	20.5
Prop100	Property Crime Incidents per 100,000 inhabitants	524.3	434.1	54.9	2141.3	N=169	341.8	638.3
foreign	Foreign Population (Resident Permits)	4.8	1.3	1.95	7.3	N=169	4.6	4.9
unemp	Unemployment Rate	15.6	7.3	4.7	31.6	N=182	9.7	20.1
gdp	Real Gross Domestic Product	17.2	4.3	11.1	31.3	N=182	19.6	15.4

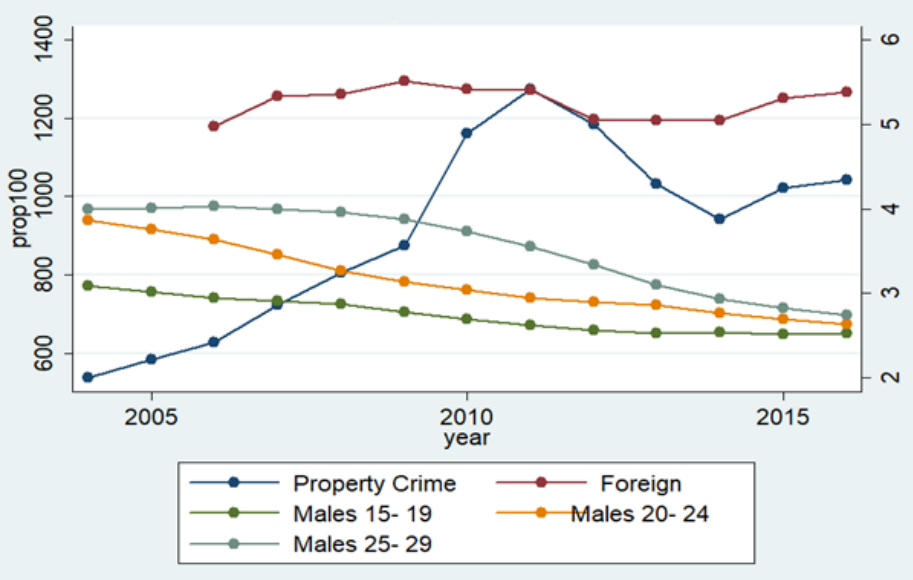
[23] Here I add all property categories reported in Eurostat by all four countries, namely Robbery, Burglary of private residential premises, theft, motorized land vehicle theft. Even if I add those who are not reported by all four countries, meaning Attempted Intentional Homicide, Sexual Violence and Rape the property crime will be still accounting for over 88% in all countries.

	(2015 Prices)							
popdensity	Population Density	131.3	261.3	28.9	1049	N=182	131.6	131.2
males1519	Percentage of male population aged between 15-19	2.8	0.3	2.3	3.9	N=182	3	2.7
males2024	Percentage of male population aged between 20-24	3.1	0.48	2.1	4.3	N=182	3.4	2.9
males2529	Percentage of male population aged between 25-29	3.5	0.5	2.2	4.5	N=182	3.8	3.2
clearup_burg	Clear up rate of Burglaries	37.1	18.5	8.7	84.9	N=117	36.7	37.2
clearup_cthefft	Clear up rate of Vehicle Thefts	44.1	14.2	21.5	100	N=117	45.7	43.6
clearup_rob	Clear up rate of Robberies	55.6	20.2	22.9	111.1	N=169	51.9	59.1
clearup_prop	Clear up rate of Property Crime	38.8	12.9	13	68.4	N=169	39.3	38.4
Deposits	Real Deposits (2015 prices) in million euros	137405.9	257992	18547.9	139780 8	N=182	147623.1	129742.9

Demographic factors: It has been indicated in many studies (Fajnzylber et al. 2002) that young males are more prone to engage in criminal activities. I therefore use three different groups of young males, namely males aged between 15 and 19, males1519, males aged between 20 and 24, males1924, and males between 25 and 29, males2529. I also account for the population density, popdensity, which is constructed as the ratio of the population of the area of each province (in squared km). It is well documented that there is more crime in urban areas than in small cities or rural areas (Glaeser & Sacerdote, 1999). In particular, returns from crime may be higher and the probability of arrest may be lower in urban areas (Buonanno 2008).

In figure 5, I scale the property crime incidents per 100,000 inhabitants on the left axis, and the percentage of male population aged between 15 and 19 years old, the percentage of male population aged between 20 and 24 years old, the percentage of male population aged between 25 and 29 years old and the percentage of the foreign residents over the total population on the right axis.

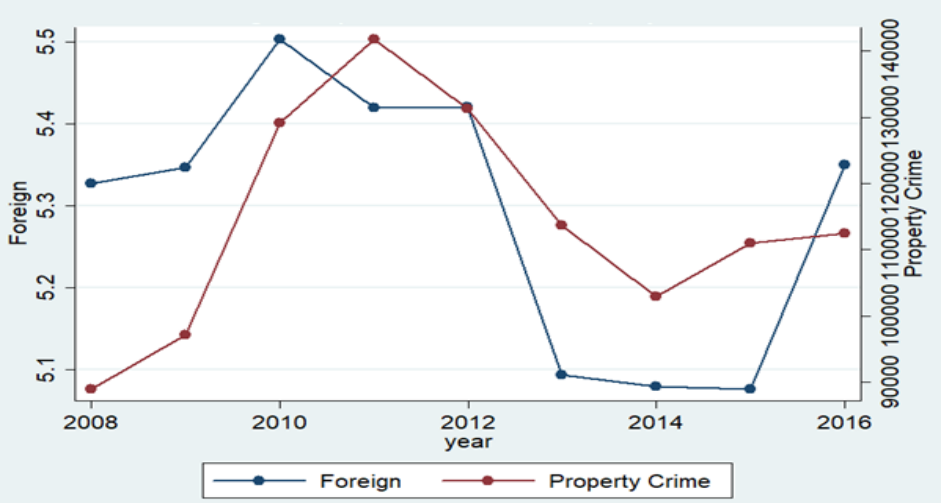
Figure 5: Demographic Variables



Source: Hellenic Police, Eurostat

Lastly, I account for immigrant presence, by including the ratio of residence permits over population, foreign. Unfortunately, there are no annual data for undocumented immigrants in a province level in Greece. Due to the aforementioned reason, it is a common practice to proxy total immigration by the stock of valid issued residence permits (Bianchi, 2012). I have constructed the dataset of the residence permits using the valid issued permits from the Greek Ministry of Interior. There is a number of different reasons for someone to obtain a residence permits, such as work/professional permits, humanitarian permits, family reunion permits and more (see Appendix D). In figure 6 the percentage of foreign population is scaled on the left axis, and the property crime incidents per hundred thousand inhabitants on the right axis.

Figure 6: Foreign Population and Property Crime

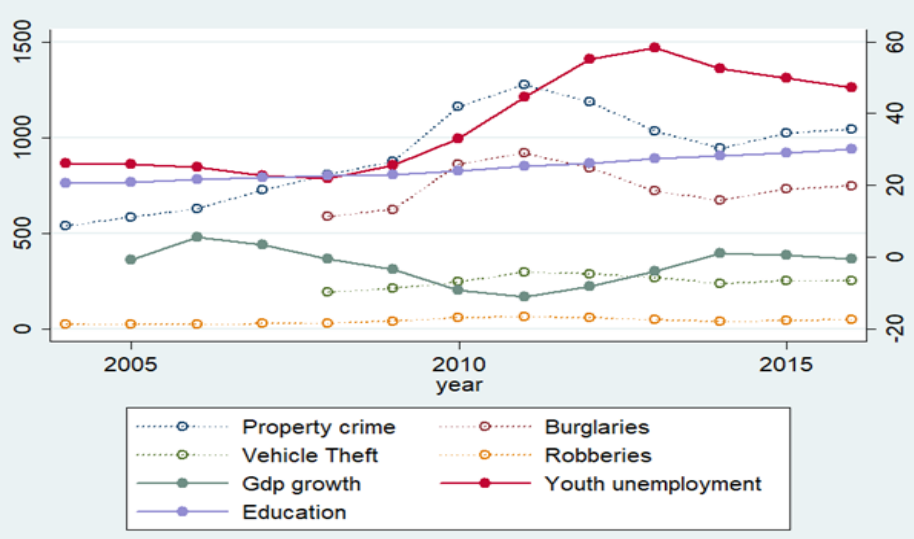


Source: Greek Ministry of Interior and Hellenic Police

Socioeconomic factors: The effect of unemployment on crime is still ambiguous on both its existence and its nature. When present, it has been proved to have little impact on the crime rates. Furthermore, I include the real per capita GDP in 2015 prices, GDP, which has seen a dramatic change in Greece during the period studied. Additionally, I include the squared GDP to check for a non linear relationship.

In figure 7, I scale all crime incidents per 100,000 inhabitants on the left axis and gdp growth, percentage of people with tertiary education or more, and youth unemployment on the right axis.

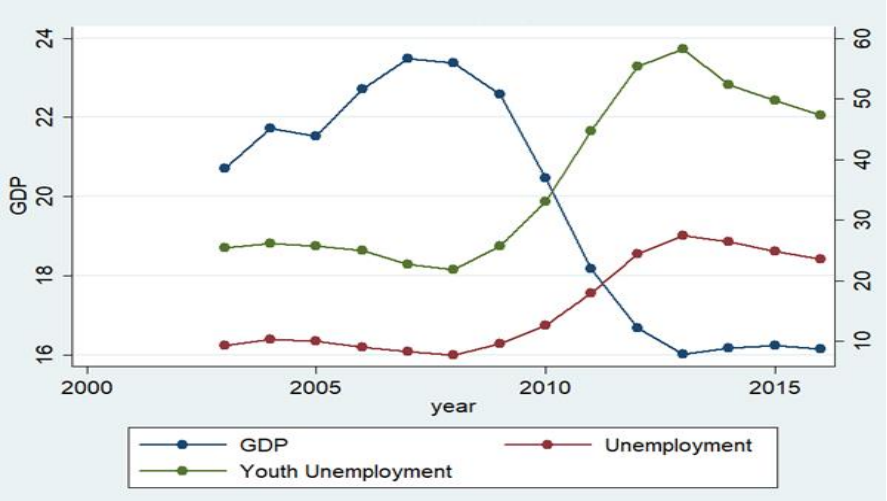
Figure 7: Socioeconomic Variables



Source: Eurostat and Hellenic Police

Police effectiveness: In line with the literature, (Bianchi 2012, Entorf and Spengler 2000), in order to catch the effectiveness of the police, I construct the clear up rate for each crime category, namely, the clear up rate of car theft clearup_ctheft, the clear up rate of robberies, clearup_rob, the clear up rate of burglaries, clearup_burg and the clear up rate of the overall property crime, clearup_prop. Clear up rate is constructed as the ratio of the number of cleared up crime incidents to the number of all reported crime incidents.

Figure 8: GDP and Unemployment

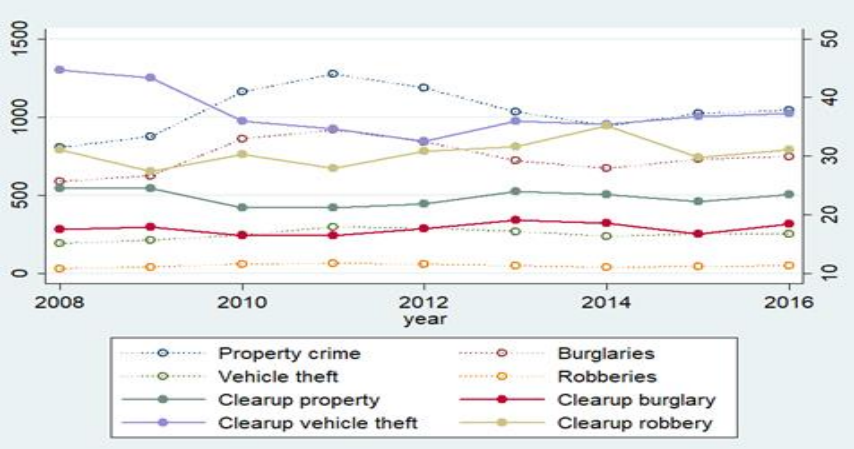


Source: Eurostat

$$Clear\,Up\,Rate = \frac{Cleared\,Up\,Crimes}{Commited\,Crimes + Attempted\,Crimes}$$

In figure 8, GDP (EU28=100) is scaled on the left axis and unemployment rates on the right axis.

Figure 9: Police Effectiveness



Source: Hellenic Police

Prison population is frequently used in the literature as a proxy for the severity of the punishment. The latter can affect the crime through two distinct effects; the deterrence effect and the incapacitation effect (see Winter, 2008). The deterrence effect works through the threat of a punishment whereas the incapacitation effect relies on the fact that imprisoned criminals are no longer able to commit crimes. Usually, it is difficult to disentangle the impact of those distinct effects. In figure 9, all crime incidents per 100,000 inhabitants are scaled on the left axis, while all clear up rates on the right axis.

Prisons in Greece have been constantly operating over their capacity limits, resulting in several respective warnings and penalties from the European Court of Human Rights[24]. The Greek government has imposed several prison decongestion laws since 2005 but it was not until

[24] See for example, Papakonstantinou v. Greece, application no 50765/11, 13.11.2014; Nikolaos Athanasiou and others v. Greece, application no 36546/10, 23.10.2014; BOUROS and others v. Greece, application nos 51653/12, 50753/11, 25032/12, 66616/12 et 67930/12, 12.3.2015 and regarding detention centres for third country nationals Mahammad and others v. Greece, No 48352/12, 15.01.2015; Al. K. v. Greece, No 63542/11, 11.12.2014; Mohamad v. Greece, No 70586/11, 11.12.2014.

the 27th of April 2015 when L. 4322/2015[25] finally dropped the prison population. The law was offering an early release under conditions[26] for prisoners who have completed the 1/10th of their sanction, for sanctions up to three years, the 1/5th of their sanction, for sanctions up to five years and the 2/5th of their sanction, for sanctions up to ten years. The government announced that the law would be in effect for one year only, i.e. until the April of 2016[27]. If an ex prisoner gets arrested for committing a new crime during the next five years (i.e. after her release), then she would have to serve the sanction associated with this new crime, as well as the time that was "left" from the previous sanction.

The impact of L.4322/2015 catches solely the incapacitation effect of this reduction in the severity of the punishment and the associated release of the eligible prisoners. Due to the nature of the law, there was no deterrence effect. This is because the law was announced to be in effect only for one year. Therefore, if one was considering engaging in a future criminal activity and make use of the early release that would not be possible; one is only eligible if she has completed a certain part of her sanction. Thus, a potential offender is not less deterred to commit a crime as the law does apply in her case (i.e. most likely, the previous law will be effective by the time she is arrested, convicted and have served the required part of her sanction).

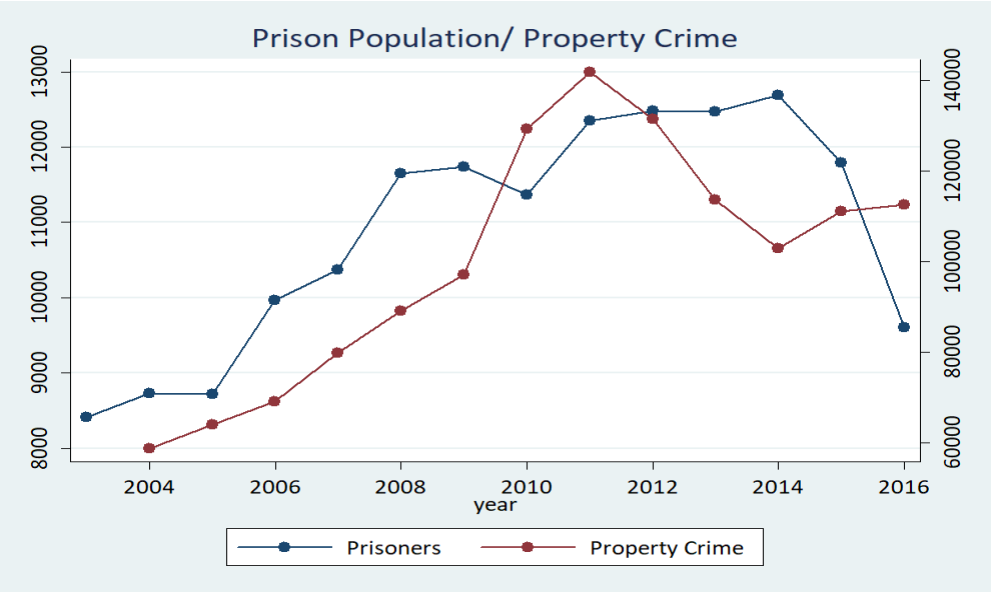
This consists a rare and interesting natural experiment. Unfortunately, data is available only in a national level (NUTS0), and the law has been effective in all Greek regions simultaneously. In figure 10, property crime incidents per 100,000 inhabitants are depicted on the left axis, while prison population is depicted on the right axis (in absolute numbers).

[25] For more see the government implementation announcement of L.4322/2015 in the Ministry of Justice website at 27/05/2015 (in Greek) http://www.ministryofjustice.gr/site/Portals/0/uploaded_files/uploaded_11/N_4322-2015.pdf

[26] Another condition was the nature of the committed crime, for example those who have committed crimes against children were not eligible.

[27] Despite the announcement, the duration of the validity of the law was extended until the 09/2017 and then further until 08/18.

Figure 10: Prison Population and Property Crime



Source: Eurostat and Hellenic Police

Another issue that has arisen during the crisis in Greece is the dramatic withdrawal of the deposits from the Greek systemic banks. Greeks feared that their euro deposits might be automatically converted to a new currency if the country left the Eurozone and would lose value, or that they could face a "haircut" to their deposit accounts if banks went bankrupt. Individuals have transferred their money abroad or have withdrawn and stored them in safe deposit boxes or even at home. According to the Greek central bank, only about a fifth of the total money withdrawn has gone abroad. Meanwhile, police reports claim that this has led to an increase in burglaries.

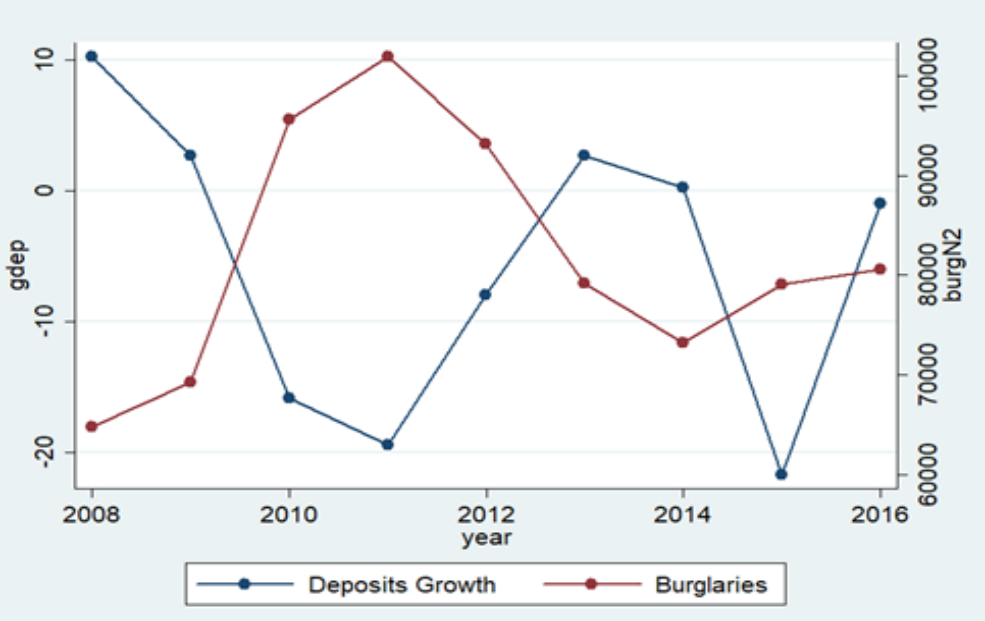
Figure 11 shows the deposits growth (scaled on the left axis) and the property crime incidents per 100,000 inhabitants (scaled on the right axis). An interesting pattern is revealed; when the growth of deposits falls, the property crime incidents increase. The same pattern is observed for burglaries (Figure 12) and robberies (Figure 13). This raises further the interest of whether there is indeed a causal relationship between the negative deposits growth and the increased property crime rate. Could the lack of trust in the banking system have raised crime as the police and media claim?

Figure 11: Deposits Growth and Property Crime

Source: Bank of Greece and Hellenic Police

In Figures 12 and 13, the number of crime (burglaries and robberies respectively) incidents per 100,000 inhabitants are depicted on the right axis. The growth rate of the deposits is depicted on the left axis.

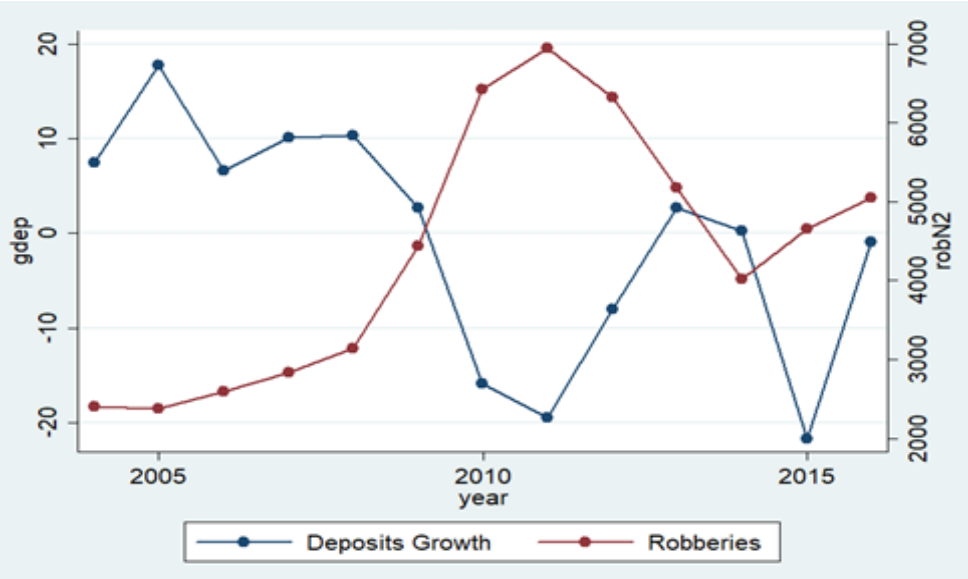
Figure 12: Burglaries and Property Crime



Source: Bank of Greece and Hellenic Police

Deposits decreased by 63.3 billion between 2009 and 2011. This equals more than one fourth of the total deposits stored in the Greek banks in December 2009. During this period, burglaries increased by 32,689 incidents. Additionally, deposits decreased by 38 billion between in the 1st semester of 2015. This equals almost the one third of the total deposits of June 2017. During 2015, burglaries increased by 5,900 incidents.

Figure 13: Robberies and Property Crime



3.

Source: Bank of Greece and Hellenic Police

3. Empirical Procedure

The empirical procedure I use follows closely that of the respective literature (see e.g. Fajnzylber et al. (2002), Buonanno and Montolio (2008)). The following specification is used:

$$CRIME_{i,t} = \beta_1 CRIME_{i,t-1} + \beta_2' X_{i,t} + \beta_3 t + \omega_i + \varepsilon_{i,t} \qquad (1)$$

where the subscripts i, t denote the region and time dimension of the panel. Furthermore, ω_i denotes the region fixed effect and $X_{i,t}$ is the set of explanatory variables and $\varepsilon_{i,t}$ is the error term. The dependent variable $CRIME_{i,t}$ is measured as the natural logarithm of the respective crime category over the population, which, together with the inclusion of fixed effects, helps

removing most of the measurement error which is usually present in this kind of data. Furthermore, I include a common time trend for all regions.

In order to estimate Eq. 1 I will employ the GMM-system estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998). The aforementioned technique uses the dynamic properties of the data to generate proper instrumental variables and, more specifically, it combines the regression equation both in first differences and levels into a single system. The instruments are chosen in a way that accounts for the fixed effects and at the same time the potential endogeneity of the explanatory variables with the dependent variable in the same time period.

3.1. Detailed methodology

In this subsection I describe the econometric methodology in detail. Naturally, the crime rate I use as dependent variable is based on reported crimes and as such it is subject to measurement error. If I use $CRIME^*_{i,t}$ to denote the true unobserved crime rate of region i at time t, then the specification I have chosen is a result of an underlying model for the true crime rate of the following form:

$$CRIME^*_{i,t} = \beta_1 CRIME^*_{i,t-1} + \beta_2' X_{i,t} + \beta_3 t + \eta_i + \varepsilon_{i,t} \quad (2)$$

The true crime rate is commonly assumed to be related to the observed reported crime rate through the following equation:

$$CRIME_{i,t} = CRIME^*_{i,t} + \lambda_i \quad (3)$$

where $CRIME_{i,t}$ is the observed crime rate which was described earlier and λ_i is a region-specific error, that is, it is assumed that the measurement error is driven by specific characteristics of each region.

Then I have that:

$$CRIME_{i,t} = \beta_1 CRIME_{i,t-1} + \beta_2' X_{i,t} + \beta_3 t + \omega_i + \varepsilon_{i,t} \quad (4)$$

where $\omega_i \coloneqq \lambda_i(1-\beta_1)+\eta_i$.

The estimation of the above model is complicated for several reasons. Firstly, the presence of the fixed effect ω_i in the right hand side of the equation and in $CRIME_{i,t-1}$, makes the pooled OLS inconsistent even if the ω_i is uncorrelated with the other explanatory variables in X_{it}. Furthermore, the explanatory variables contained in $X_{i,t}$ are potentially endogenous implying a correlation with $\varepsilon_{i,t}$ for the same time period t.

In order to overcome these issues, I employ a GMM-system approach selecting appropriate instruments by exploiting the dynamic structure of the model. First note that by taking the first difference of Eq. 1 it is possible to eliminate the fixed effects:

$$CRIME_{i,t} - CRIME_{i,t-1} = \beta_1\left(CRIME_{i,t-1} - CRIME_{i,t-2}\right) + \beta_2'\left(X_{i,t} - X_{i,t-1}\right) + \beta_3 + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (5)$$

Note however that $(CRIME_{i,t-1} - CRIME_{i,t-2})$ is correlated with the new error term $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$, as they both share the term $\varepsilon_{i,t-1}$. At the same time, $(X_{i,t} - X_{i,t-1})$ is potentially endogenous as I explained earlier.

In order to estimate the above equations I will use a GMM estimator exploiting the following moment conditions:

$$E\left[CRIME_{i,t-s}\left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\right] = 0 \text{ for } s \geq 2; \quad t = 3, \dots, T \quad (6)$$

and

$$E\left[X_{i,t-s}\left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\right] = 0 \text{ for } s \geq 2; \quad t = 3, \dots, T \quad (7)$$

Furthermore, assuming stationarity of $CRIME_{i,t}$ and $X_{i,t}$, the following moment conditions can be used for the level equation:

$$E\left[(CRIME_{i,t-s} - CRIME_{i,t-s-1})\left(\omega_i + \varepsilon_{i,t}\right)\right] = 0 \text{ for } s = 1; \quad t = 3, \dots, T \quad (8)$$

and

$$E\left[\left(X_{i,t-s} - X_{i,t-s-1}\right)\left(\omega_i + \varepsilon_{i,t}\right)\right] = 0 \text{ for } s = 1; \quad t = 3, \ldots, T \tag{9}$$

Exploiting all the aforementioned moment conditions in Eqs. 6, 7, 8 and 9 I follow Arellano and Bover (1995) in order to simultaneously estimate the system of equations consisting of Eqs. (1) and (5) by a GMM procedure.

In order for the parameter estimates to be consistent, the chosen instruments must be valid. I will therefore provide two specification tests suggested by Arellano and Bover (1991, 1995) to test that. The Sargan test of overidentifying restrictions tests the null hypothesis that all the moments conditions hold. I expect this test to fail to reject the null hypothesis which will then give support to the choice of the instruments. Furthermore, I will provide the test for serial correlation of the error term in the differenced equation, which tests the null hypothesis that the (differenced) error term is first and second order serially uncorrelated. Failure to reject the null hypothesis of no second-order serial correlation implies that the original error term is serially uncorrelated and the moment conditions are correctly specified.

4. Results

As mentioned above (equation 2), the main specification is:

$$CRIME^*_{i,t} = \beta_1 CRIME^*_{i,t-1} + \beta_2' X_{i,t} + \beta_3 t + \eta_i + \varepsilon^*_{i,t}$$

I include the lagged of the dependent variable, as it has been found that there can be crime inertia (Buoananno and Montolio, 2008). Furthermore, $X_{i,t}$ includes several socioeconomic, demographic and deterrence variables. The first variable, is the clear up rate. I expect a negative sign, which is that the higher the effectiveness of the police, the lower the crime rate (deterrence hypothesis). Next is the population density, which is usually expected to have a positive sign. Furthermore, I include the GDP which I expect to have negative impact on crime rate. I also include the square of GDP to test for a non linear relationship. Unemployment is also included and is expected to have a positive impact on crime rate. Despite that, the nature and existence of the relationship and unemployment has long been debated in the literature and has been shown to be less important determinant of crime than income level (Ehrich, 1973; Grogger, 1995;). Next, I

include three different categories of young male shares in the population: The share of males aged between 15 and 19 years old, the share of males aged between 20 and 24 years old and the share of males aged between 25 and 29 years old. I expect a positive sign are young males have been shown to be more prone to engage in criminal activities. Furthermore, I include the growth of the deposits. Although I do not expect the deposits level or an increase of the growth of the deposits to have any impact on the crime rate, I do expect that the sharp decrease and hence the negative growth rate to have increased property crime rate. As mentioned above, the lack of trust in the banking system has led many Greeks to withdraw a vast amount of money and store it in safe boxes or even at home. There have been numerous police and media reports that criminals have been rationally responding to these new opportunities, thus raising the overall property crime rate as well as its subcategories. I therefore expect a negative sign of the growth rate. The last variable is the prison population share. As discussed earlier, this variable mainly catches the incapacitation effect of the implementation L.4322/2015. I therefore expect it to have a negative sign too. Lastly, I include a time trend and a dummy variable that equals 1 when the year is after 2008, i.e. it takes the value 0 pre-crisis.

The regression results for each crime type are presented in Tables 2-5. First, I obtain our estimates using the pooled estimator and the FE estimator that allows controlling for unobserved province fixed effects. As previously discussed, given the dynamic nature of crime and the possibility of endogeneity and measurement errors that afflict crime data OLS estimates might be biased. Thus, I proceed using a GMM-system estimator.

The regressions for the overall crime rate are presented in Table 2. The coefficient of the lagged property crime rate is positive (0.5925) and significant at a 1% level, indicating that there is crime inertia. Furthermore, the deterrence hypothesis is confirmed with the coefficient of the clear up rate being equal to -0.0205 and significant at a 1% level. As far as the coefficient of the foreign population is concerned, it is positive and significant at a 1% when we use the within estimator (0.3764) but it drops significantly (0.1038) when we account for the endogeneity using the GMM estimator. We see that the coefficient of the GDP comes with the expected negative sign (-0.1011) and is significant at a 1% level. Also, we find that there is a non linear relationship with the coefficient of the squared GDP being positive (0.0019) and significant at a 1% level.

Table 2: Property Crime

Variables	Pooled	FE	GMM-System
Crime (-1)			0.5925***
			(0.0457)
Clear Up Rate	-0.0437***	-0.0192***	-0.0205***
	(0.0022)	(0.0022)	(0.02930)
Foreign	0.3359***	0.3764***	0.1038***
	(0.0281)	(0.0699)	(0.0293)
Population Density	0.0009***	0.0011	0.0001
	(0.0002)	(0.0018)	(0.0001)
GDP	-0.3640***	-0.1923***	-0.1011***
	(0.0389)	(0.0326)	(0.0298)
GDP^2	0.0066***	0.0035***	0.0019***
	(0.0009)		(0.0006)
Unemployment	-0.0045	0.0072	-0.0070
	(0.0073)	(0.0057)	(0.0056)
males1519	1.0998***	0.3060***	0.3303***
	(0.1431)	(0.1040)	(0.1090)
males2024	-0.1905	-0.2433***	-0.007
	(0.1175)	(0.0726)	(0.0480)
males2529	0.3366***	0.3959***	0.1386***
	(0.0928)	(0.0982)	(0.0426))
Deposits Growth	-0.0034	-0.0060***	-0.0064***
	(0.0028)	(0.0013)	(0.0012)
Prisoners	0.0039	0.0019	-0.0030**
	(0.0025)	(0.0014)	(0.0012)
Year	0.0691****	0.0418***	0.0247**
	(0.0164)	(0.0106)	(0.0109)
After 2008 Dummy	-0.1288	-0.0452	0.0833**
	(0.1240)	(0.0705)	(0.0388)
Constant	-144.2804***		-51.4811**
	(33.1881)		(21.8566)
Sargan test			257.3981
Serial correlation			
First order			-2.798***
Second order			0.3603
Observations	169	169	156
R-squared	0.8992	0.8482	

Table 2*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the*

*valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). GDP is the real GDP per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Property Crime Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification. Column (2) presents the fixed effect estimates from the main specification. Column (3) presents GMM- System estimates from the main specification. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

I also find that the share of male population aged between 15 and 19 years old as well as the share of male population aged between 25 and 29 years old have, as expected, a positive impact on the property rate (0.3303 and 0.1386 respectively) and are significant at a 1% level. Additionally, we find that a decrease in the growth rate of deposits will induce property crime rate. The coefficient of the growth of the deposits is negative (-0.0064) and significant at a 1% level. Also, the coefficient of the prison population is negative (-0.0030) and significant at a 5%.

Finally, both the year trend and the "After 2008 Dummy" coefficients are positive and significant at the 5% level (0.0247 and 0.0833 respectively). The latter gives evidence for the existence of a structural break during the crisis period. Apart from a change in the intercept, I have also examined whether the slope coefficients have changed after 2008, by estimating the above specification by including the interaction of all the explanatory variables with the "After 2008 dummy" where I strongly reject the null of no change for all variables. However, the results of this specification are not very useful as the inclusion of a large number of regressors reduces the explanatory power of the model (see Appendix F for an illustration of the estimation procedure in the whole sample and after the crisis).

Regarding the GMM specification tests, the insignificance of the Sargan statistic gives support to the used instruments and, as expected, there is evidence of first-order serial correlation in the errors of the equation in differences, while there is no evidence of second-order serial correlation.

Moving to burglaries, I again observe the presence of crime inertia, with a positive and significant at a 1% level coefficient of the lagged crime rate, equal to 0.4872. Next, we find a negative and significant at a 1% level coefficient of the clear up rate, equal to -0.0194. The

coefficient of the share of foreign population drops after controlling for endogeneity, from 0.5525 to 0.1670, but remains significant at a 1% level. Again, I find a non linear relationship with the GDP, with the GDP coefficient being equal to -0.1502 and the squared GDP coefficient equal to 0.0033 (both significant at a 5% level).

Table 3: Burglaries

Variables	Pooled	FE	GMM-System
Crime(-1)			0.4872*** (0.0720)
Clear Up Rate	-0.0362*** (0.0020)	-0.0160*** (0.0022)	-0.0194*** (0.0023)
Foreign	0.3851*** (0.0462)	0.5525*** (0.1349)	0.1670*** (0.0481)
Population Density	0.0008*** (0.0002)	0.0024 (0.0023)	0.0001 (0.0002)
GDP	-0.3939*** (0.0619)	-0.2173*** (0.0636)	-0.1502** (0.0625)
GDP^2	0.0076*** (0.0013)	0.0043*** (0.0010)	0.0033** (0.0013)
Unemployment	0.0058 (0.0101)	0.0154* (0.0093)	0.0072 (0.0107)
males1519	0.8184*** (0.2351)	-0.1741 (0.3771)	0.0173 (0.1843)
males2024	-0.0425 (0.1924)	-0.3395** (0.1359)	0.1886 (0.1626)
males2529	0.3363** (0.1456)	0.4621*** (0.1277)	0.1005 (0.1080)
Deposits Growth	-0.0063** (0.0030)	-0.0082*** (0.0017)	-0.0088*** (0.0016)
Prisoners	0.0004 (0.0047)	-0.0010 (0.0033)	-0.0093*** (0.0024)
Year	0.6963** (0.0326)	0.0325 (0.0273)	0.0048 (0.0207)
After 2008 Dummy	-0.0706 (0.1638)	-0.0609 (0.1001)	
Constant	-145.6139** (66.0137)		
Sargan test			169.5515
Serial correlation			
First order			-2.5**
Second order			0.5121

Observations	117	117	104
R-squared	0.8673	0.7378	

Table 3*: In all specifications, the dependent variable is the logarithm of burglaries over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 year. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years in region i. Clear up, is the clear up rate of burglaries. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Burglary Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification. Column (2) presents the fixed effect estimates from the main specification. Column (3) presents GMM- System estimates from the main specification. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Finally, the growth of the deposits coefficient equals -0.0088 and is significant at a 5% level, while the coefficient of the prison population is also negative and significant at a 5% level (-0.0093).

Next, I turn to robberies to confirm once more the existence of crime inertia. The coefficient of the lagged dependent value is positive and significant at a 1% level and is equal to 0.5642. Clear up rate has a coefficient equal to -0.0087 and is significant at a 1% level. The coefficient of the share of foreign population drops significantly after controlling for endogeneity, from 0.8050 to 0.1538 and becomes less significant (from 1% to 10% significance level). The coefficient of GDP is negative as expected (-0.1813) and significant at a 5% level. There is no indication of a non linear relationship. Unemployment has a negative and significant coefficient at a 1% level (-0.0176). The nature and the existence of the relationship between unemployment and crime rates has been puzzling and has been thoroughly studied in the related literature (CITE). I am revisiting these results later on this chapter.

Table 4: Robberies

Variables	Pooled	FE	GMM-System
Crime (-1)			0.5642***
			(0.0895)
Clear Up Rate	-0.0234***	-0.0087***	-0.0087***
	(0.0027)	(0.0021)	(0.0021)
Foreign	0.4157***	0.8050***	0.1538*

	(0.0580)	(0.1377)	(0.0817)
Population Density	0.0029***	-0.0019	0.0013***
	(0.0003)	(0.0043)	(0.0004)
GDP	-0.5013***	-0.1218	-0.1813**
	(0.0795)	(0.0751)	(0.0899)
GDP^2	0.0076***	0.0015	0.0025
	(0.0016)	(0.0014)	(0.0015)
Unemployment	-0.0225*	0.0191	-0.0176***
	(0.0124)	(0.0141)	(0.0058)
males1519	1.0025***	0.2403	0.4787
	(0.2844)	(0.2886)	(0.3103)
males2024	-0.1252	-0.2541	-0.1918
	(0.2634)	(0.1654)	(0.1932)
males2529	0.2479	0.7777***	0.1824
	(0.2253)	(0.1908)	(0.1821)
Deposits Growth	-0.061	-0.0110***	-0.0148***
	(0.0053)	(0.0034)	(0.0039)
Prisoners	0.0086	0.0033	-0.0052**
	(0.0054)	(0.0033)	(0.0026)
Year	0.0422	0.0623**	-0.0135
	(0.0344)	(0.0623)	(0.0174)
After 2008 Dummy	-0.0288	-0.1183	0.1374
	(0.2417)	(0.1532)	(0.1442)
Constant	-92.8036		24.2871
	(69.4253)		(35.3259)
Sargan test			207.5537
Serial correlation			
First order			-2.2864**
Second order			1.7709*
Observations	169	169	156
R-squared	0.7453	0.6891	

Table 4*: In all specifications, the dependent variable is the logarithm of robberies over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of robberies. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Robbery Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008.Column (1) presents the pooled OLS estimates from the main specification. Column (2) presents the fixed effect estimates from the main specification. Column (3) presents GMM- System estimates from the main specification. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Lastly, I find negative and significant coefficients for both the growth of the deposits and the prison population. The former is equal to -0.0148 and is significant at a 1% level, whereas the latter equals -0.0052 and is significant at 5% level.

Finally, I move into vehicle thefts. Again, I see a positive and significant at a 1% level coefficient for the lagged dependent variable (0.7744). The coefficient of the foreign population drops to 0.1023 from 0.4312 when we use the GMM estimator instead of the within estimator (but remains significant at a 1% level). The coefficient of the population density is significant at a 1% level and equals 0.0007. The coefficient of GDP is negative and significant at a 10% level (-0.1128), but there is no sign of a non- linear relationship.

Table 5: Vehicle Thefts

Variables	Pooled	FE	GMM-System
Crime(-1)			0.7744***
			(0.0339)
Clear Up Rate	-0.0065*	-0.0038**	-0.0027
	(0.0036)	(0.0016)	(0.0023)
Foreign	0.5048***	0.4312***	0.1023***
	(0.0711)	(0.0911)	(0.0390)
Population Density	0.0028***	0.0002	0.0007***
	(0.0003)	(0.0021)	(0.0002)
GDP	-0.5033***	-0.0431	-0.1128*
	(0.0986)	(0.0488)	(0.0586)
GDP^2	0.0073***	0.0001	0.0015
	(0.0021)	(0.0008)	(0.0010)
Unemployment	0.0122	0.0115**	-0.0013
	(0.0163)	(0.0057)	(0.0058)
males1519	1.4278***	-0.5865**	0.3503*
	(0.4122)	(0.2880)	(0.1859)
males2024	0.2765	0.1961*	-0.0635
	(0.2941)	(0.1175)	(0.0785)
males2529	-0.0044	0.1782	0.0612
	(0.0047)	(0.1151)	(0.0537)
Deposits Growth	-0.0044	-0.0040***	-0.0071***
	(0.0047)	(0.0016)	(0.0016)
Prisoners	-0.0088	0.006	-0.0076**
	(0.0081)	(0.0031)	(0.0034)
Year	-0.1203***	-0.0161	-0.0556***
	(0.0458)	(0.0259)	(0.0211)
After 2008 Dummy	-0.0854	-0.0179	
	(0.2471)	(0.0696)	

Constant	235.672** (92.763)		111.0636*** (42.7028)
Sargan test			125.0329
Serial correlation			
First order			-2.1568**
Second order			1.772*
Observations	117	117	104
R-squared	0.5629	0.5968	

Table 5*: In all specifications, the dependent variable is the logarithm of vehicle thefts over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita(in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of vehicle thefts. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the vehicle theft rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification. Column (2) presents the fixed effect estimates from the main specification. Column (3) presents GMM- System estimates from the main specification. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

The share of male population aged between 15 and 19 years old has a positive and significant coefficient at a 10% level (0.3503). The coefficients of the growth of the deposits and the prison population are both negative and significant at a 1% (-0.0071) and a 5% (-0.0076) respectively. The year trend is negative (-0.0556) and significant at a 1% level.

5. Conclusions

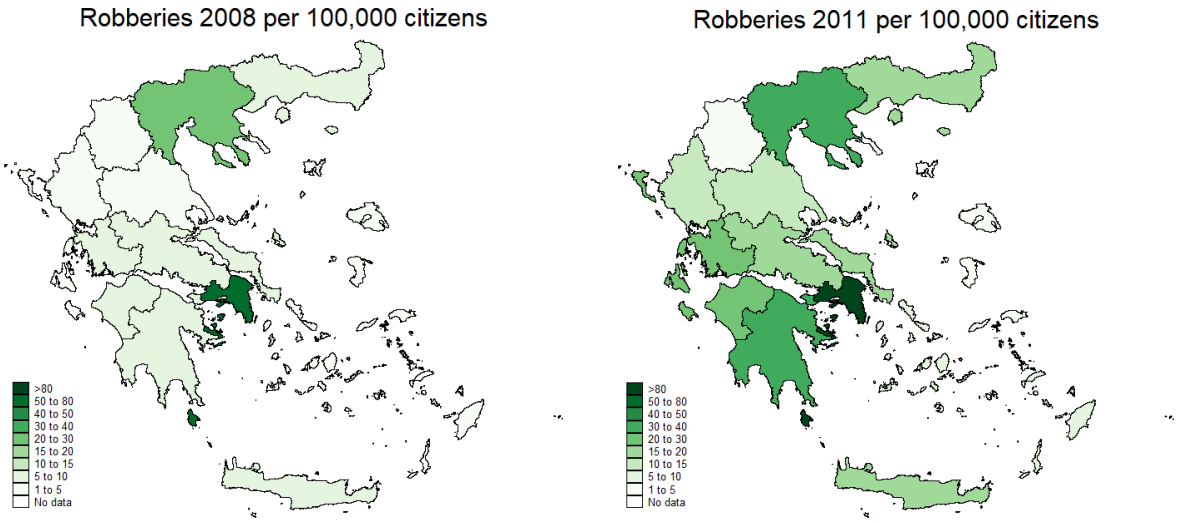
In this chapter, I have analyzed the socioeconomic and demographic determinants of property crime in Greece, during the period 2004-2016. Firstly, I find that there exists a positive serial persistence in all crime types, as well as the overall property crime rates. Secondly, I confirm the deterrence hypothesis finding that police effectiveness has a significant impact in reducing property crime. Thirdly, after controlling for endogeneity, immigration still all property crime subcategories and the overall property crime rates (but the magnitude of the coefficient significantly falls). Fourthly, I find that a decrease in the real GDP will increase the property crime rate, although there is indication that the relationship is non linear. Fifthly, in line with the

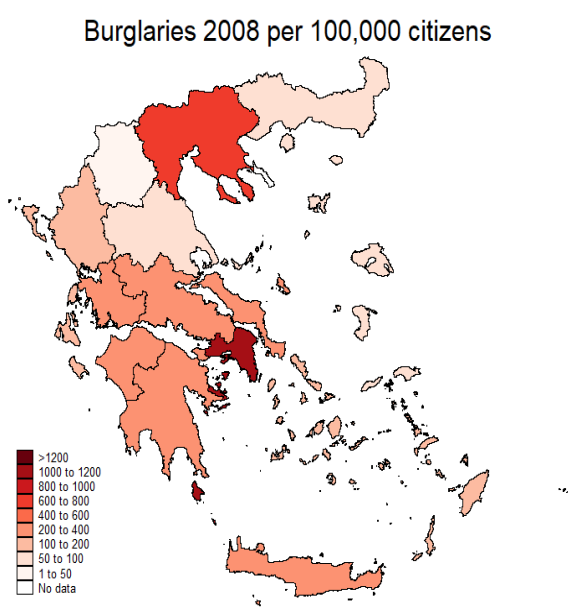
literature I find that young males are more prone to engage in a criminal activity. Furthermore, I add a new determinant, namely the growth of the real deposits of household and firms in the banking system. Due to the lack of trust to the banking system, there has been a sudden and sharp withdrawal of money in Greece, a big amount of which has been stored in safe deposits our even inside houses. In line with the economic theory of crime, I find that criminals do respond to incentives. Given these new property crime opportunities, I find that the deposits growth is negatively related to all property subcategories, as well as the overall property crime rate. I therefore show that a lack of trust in the banking system can have side effects in the crime sector by creating new opportunities for the offenders. Finally, my results indicate that a sharp decrease of the prison population resulting by the implementation of L.4322/2015 has had increased the property crime rate. As discussed earlier, this indicates the existence of the incapacitation effect, rather than the deterrence effect.

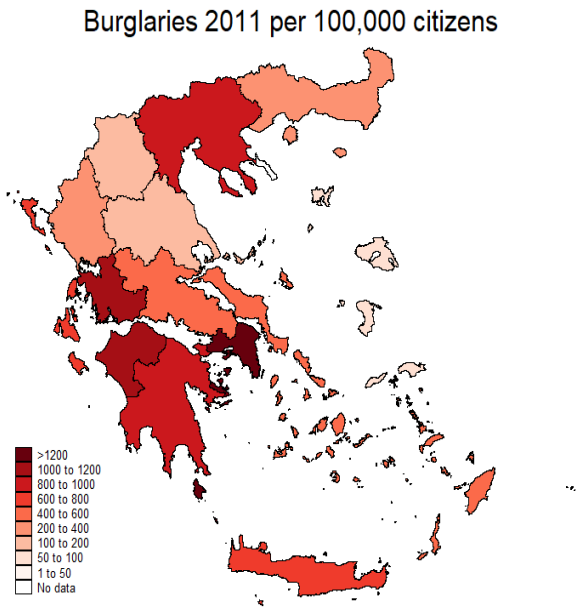
Future research suggestions include the extension of this work with the use of a more refined dataset (NUTS3). Although this dataset has already been assembled, the extension is not trivial due to multiple data handling issues and explanatory variables availability. Furthermore, I find indication of a structural break after the economic crisis which requires further studying. Also, the implementation of the L.4322/2015 as well as the deposits' withdrawals can be more thoroughly assessed with different kind of models. Finally, this study focuses on the within time variation of property crime. It would be interesting to examine the between region variation, with a use of appropriate models (See for example, Mundlak, 1978 and extension by Allison, 2009).

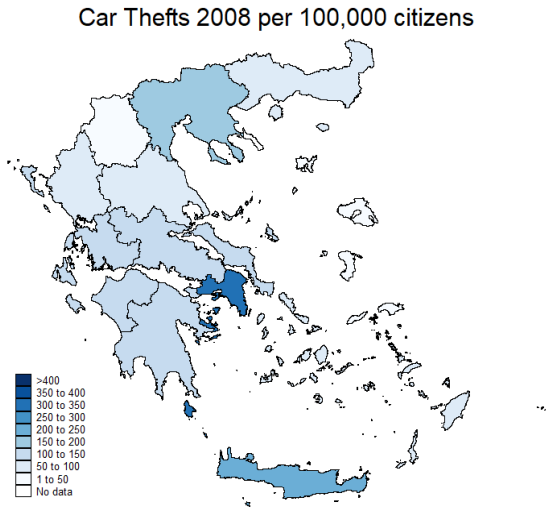
6. Appendix

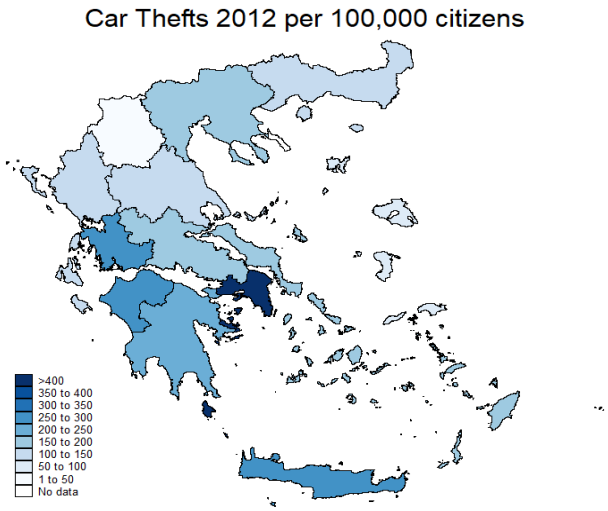
A. Maps of different crime types











B. Definitions of Crimes

Theft

Theft is taking place when one removes a mobile subject, owned (totally or partially) from its owner in order to take advantage of it illegally. (§ 372 of the Greek Penal Code)

It includes:

Thefts-Burglaries

Thefts- Burglaries from private cars

Thefts- Burglaries sacred temples

Thefts- Burglaries private shops

Thefts- Burglaries other

Thefts- Burglaries private houses

Thefts- Burglaries public transportation

Thefts including bag seizure

Thefts in public – minor thefts

Vehicle Thefts

Thefts of private cars

Thefts of private buses

Thefts of other vehicles

Thefts of motorbikes

Thefts of bikes

Robbery

Robbery is whenever someone using physical assault against another or using threats of physical assault or against life removes a mobile object, owned by the other (totally or partially) or forces the other to hand it, in order to take advantage of it illegally. (§ 380 of the Greek Penal Code)

It includes:

Robbery of a private shop

Robbery of a private house

Robbery of mobile phones- minor amount of money

Robbery other

Robbery including bag snatching

Robbery taxi drivers

Robbery gas stations

Robbery post office (EL.TA.)

Robbery in mini markets

Robbery kiosks

Robbery in gambling shops (OPAP)

Robbery super markets

Robbery courier

Robbery banks

C. Data Definitions and Sources

Variable	***Description***	***Source***
Rob	Robbery rate: Ratio of Robberies over population in each province	Greek Police
Burg	Burglary rate: Ratio of Burglaries over population in each province	Greek Police
Ctheft	Vehicle Theft rate: Ratio of vehicle thefts over population in each province	Greek Police
Property	Property crime rate: Ratio of Property crime incidents over	Greek Police

	population in each province. Property crime is the sum of robberies, burglaries and vehicle thefts	
clearup_rob	Clear Up rate of Robberies: Ratio of cleared robberies over total recorded robberies in each province	Greek Police
clearup_burg	Clear Up rate of Burglaries: Ratio of cleared burglaries over total recorded burglaries in each province	Greek Police
clearup_ctheft	Clear Up rate of Vehicle Thefts: Ratio of cleared vehicle thefts over total recorded robberies in each province	Greek Police
clearup_property	Clear Up rate of Property Crime: Ratio of cleared property crime incidents over total recorded property crime incidents in each province	Greek Police
popdensity	Population density: Population over province area (in squared km)	Eurostat
Unempy	Youth Unemployment Rate: Percentage of the unemployed in the age group 15 to 24 years old compared to the total labour force (both employed and unemployed) in that age group.	Eurostat
Edu58level	Education ratio: Ratio of people with tertiary education over overall population in each province	Eurostat provides Educational attainment levels. I use the percentage of people with tertiary education. This is classified as 5-8 levels, according to the International Standard Classification of Education (ISCED 2011)
Foreign	Immigration rate: Ratio of residence permits over total population	Residence Permit data were provided by the Greek Ministry of Interior, Ministry of Immigration
Gdp	Real per capita GDP in 2015 Prices	Eurostat
Gdp_growth	GDP Growth	Eurostat

D. Residence Permits

- Work/ Professional
- Short time

- Humanitarian
- Education/Research
- Human Trafficking Victims
- Family Reunion
- Long time

E. Descriptive Statistics by Region

Region: Greece

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	743.5707	110.9292	585.4387	916.7168
Ctheft100	9	247.6613	33.55894	190.6891	295.836
Rob100	13	39.38959	14.40196	21.72305	62.44498
Prop100	13	908.5679	239.9625	536.9289	1274.998
Foreign	13	5.1905	0.206466	4.964839	5.504102
Unemployment	14	15.86429	7.810112	7.8	27.5
GDP	14	19.71837	2.994422	16.01101	23.49311
Popdensity	14	83.48687	0.77199	81.88613	84.46521
Males1519	14	2.772503	0.234603	2.520967	3.202275
Males2024	14	3.205126	0.445031	2.632601	3.903747
Males2529	14	3.577933	0.4904	2.742748	4.036233
Clear up Burg	9	17.60688	0.96192	16.3685	19.03631
Clear up Ctheft	9	37.41046	4.0026	32.54365	44.7326
Clear up Rob	13	30.75755	1.854614	27.40774	35.17276
Clear up Prop	13	23.37621	1.305332	21.15991	24.45415
Deposits	14	1786276	408763.2	1212122	2503340

Region: Attiki

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	1226.833	148.1745	1079.603	1496.051
Ctheft100	9	421.701	64.22475	308.0892	513.0341
Rob100	13	84.21592	28.92963	50.92602	132.2594
Prop100	13	1556.985	347.5837	1058.127	2141.344
Foreign	13	6.354674	0.161683	6.180279	6.715647
Unemployment	14	15.72143	8.484844	6.7	28.7
GDP	14	26.39967	3.754106	21.84369	31.3363
Popdensity	14	1031.176	18.10763	990.8999	1048.97
Males1519	14	2.643274	0.292112	2.339804	3.151926
Males2024	14	3.354202	0.659354	2.524096	4.39889
Males2529	14	3.907271	0.690672	2.723421	4.558421
Clear up Burg	9	12.31184	2.107458	8.67678	14.94536
Clear up Ctheft	9	28.73928	8.849617	21.49697	45.46564
Clear up Rob	13	25.63837	2.232233	22.92094	29.77546
Clear up Prop	13	18.30429	3.302423	13.00907	21.53292
Deposits	14	978374.8	251887.4	626879.3	1397808

Region: Voreio Aigaio

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	82.67323	30.57065	49.61983	151.5352
Ctheft100	9	45.62088	18.47327	15.03631	72.28639
Rob100	13	2.898481	1.631871	0.502109	5.085073
Prop100	13	114.7237	45.9494	65.65856	213.5731
Foreign	13	4.075566	0.301225	3.70148	4.47999
Unemployment	14	13.14286	6.240157	4.7	22.4
GDP	14	15.35658	2.428245	12.26274	18.90666
Popdensity	14	51.73914	0.288536	51.10551	52.19101
Males1519	14	2.68144	0.222125	2.449154	3.072289
Males2024	14	3.1882	0.508467	2.472867	3.852054
Males2529	14	3.884115	0.226787	3.673213	4.467745
Clear up	9	70.45266	13.34604	45.03311	84.87395

Burg Clear up Ctheft	9	41.92878	7.899709	33.33333	54.20561
Clear up Rob	13	78.74237	13.90686	66.66666	100
Clear up Prop	13	59.61517	5.527844	46.59091	68.44262
Deposits	14	28987.74	5435.777	20515.37	39018.88

Region: Notio Aigaio

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	346.8876	115.8763	127.4562	452.4211
Ctheft100	9	152.8538	34.27285	91.64706	181.7458
Rob100	13	8.579638	4.856708	2.175278	15.03072
Prop100	13	416.1457	192.6589	178.6835	638.7649
Foreign	13	6.748709	0.414421	6.194747	7.309038
Unemployment	14	13.41429	4.284113	8.4	21.3
GDP	14	21.70237	3.556812	17.43542	26.54486
Popdensity	14	62.02725	1.195043	59.74675	63.05122
Males1519	14	2.835889	0.189161	2.579772	3.18898
Males2024	14	3.18719	0.4436	2.574143	3.85516
Males2529	14	4.095842	0.452908	3.268905	4.564865
Clear up Burg	9	48.48704	11.57315	34.65347	67.77963
Clear up Ctheft	9	38.87418	3.718422	32.41379	44.37086
Clear up Rob	13	64.37832	11.55735	45.45454	75.60976
Clear up Prop	13	48.90386	8.437465	34.26835	57.61099
Deposits	14	44797.82	8729.402	32215.42	61716.27

Region: Kriti

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	394.2978	170.6103	255.568	665.8758
Ctheft100	9	244.6617	44.62547	183.7572	303.1202
Rob100	13	9.361617	5.775767	2.532399	18.97491
Prop100	13	580.6652	209.7584	339.5224	987.9709
Foreign	13	5.646261	0.329738	5.303612	6.209307
Unemployme	14	13.79286	8.127206	5.4	25

nt					
GDP	14	17.14705	3.0453	13.25668	20.58591
Popdensity	14	73.93716	1.689527	71.06914	75.70237
Males1519	14	3.025456	0.23625	2.730585	3.433742
Males2024	14	3.414812	0.37611	2.917165	3.998867
Males2529	14	3.673319	0.479757	2.892791	4.100902
Clear up Burg	9	39.62114	14.68463	21.81513	61.10145
Clear up Ctheft	9	39.81938	8.083168	27.13781	52.54515
Clear up Rob	13	59.20529	25.71441	39.28571	110
Clear up Prop	13	37.45665	8.337373	29.24467	52.34568
Deposits	14	71018.49	13508.66	51692.45	96367.58

Region: Anatoliki Makedonia, Thraki

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	165.765	44.61551	96.77329	229.7108
Ctheft100	9	120.9872	26.31707	87.70901	169.6438
Rob100	13	7.211241	4.251304	2.833173	16.35128
Prop100	13	249.2053	91.87786	131.8729	384.1039
Foreign	13	2.243896	0.213031	1.953181	2.484577
Unemployment	14	16.5	6.488688	8.8	26.8
GDP	14	14.02477	2.261998	11.09614	16.68544
Popdensity	14	42.62034	0.45206	41.74022	43.14938
Males1519	14	2.91401	0.125295	2.751632	3.092114
Males2024	14	3.300364	0.075474	3.212651	3.39716
Males2529	14	3.550339	0.187922	3.289303	3.786119
Clear up Burg	9	45.98886	11.80834	33.30153	62.1164
Clear up Ctheft	9	44.48377	5.953223	37.14953	54.68114
Clear up Rob	13	50.93088	21.93989	32.43243	90.90909
Clear up Prop	13	44.69453	5.149665	38.21284	55.014
Deposits	14	62780.17	12382.83	44334.73	87221.6

Region: Kentriki Makedonia

Variable	Obs	Mean	Std. Dev.	Min	Max

Burg100	9	759.8632	82.57885	635.6039	882.3514
Ctheft100	9	176.3404	21.61316	135.5946	199.4872
Rob100	13	27.05004	10.85086	9.243596	38.08719
Prop100	13	825.4225	271.6127	253.5844	1116.567
Foreign	13	4.5597	0.235631	4.319934	4.946288
Unemployment	14	17.10714	8.308334	8.5	30.2
GDP	14	15.5233	2.551152	12.32508	18.74491
Popdensity	14	100.8056	1.044467	98.86273	102.2048
Males1519	14	2.778449	0.147253	2.614983	3.068444
Males2024	14	3.133694	0.438184	2.633249	3.920589
Males2529	14	3.374615	0.512599	2.577762	3.879658
Clear up Burg	9	16.8463	1.843504	13.95906	18.97708
Clear up Ctheft	9	73.72671	25.50429	46.44451	100
Clear up Rob	13	38.49228	4.421248	29.09836	47.78761
Clear up Prop	13	25.8553	5.343884	21.47077	34.95737
Deposits	14	229540.3	49155.16	156655.2	319389

Region: Dytiki Makedonia

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	96.16164	44.55065	45.693	181.8817
Ctheft100	9	32.9924	7.20498	22.60447	42.29998
Rob100	13	2.309259	1.523132	0.697662	6.042854
Prop100	13	110.355	52.08822	54.93149	220.2828
Foreign	13	3.945597	0.350908	3.527218	4.463115
Unemployment	14	20.79286	7.821909	12.1	31.6
GDP	14	17.46608	1.874501	14.05269	19.68202
Popdensity	14	30.02763	0.492846	28.94135	30.45075
Males1519	14	2.830936	0.136914	2.58493	3.166334
Males2024	14	2.991535	0.381514	2.562377	3.514225
Males2529	14	3.010938	0.382351	2.219885	3.406161
Clear up Burg	9	52.34726	13.8097	33.70787	71.09827
Clear up Ctheft	9	46.07986	9.94588	26.92308	59.82143
Clear up Rob	13	56.16246	19.439	40	100

Clear up Prop	13	49.70114	7.771111	37.94326	64.85355
Deposits	14	32226.74	6108.1	23866.21	43931.97

Region: Ipeiros

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	226.5536	74.37311	101.3327	295.2251
Ctheft100	9	84.69393	21.43675	56.90892	115.5059
Rob100	13	7.23559	4.393819	1.461463	15.92186
Prop100	13	256.7574	125.1072	78.04211	414.1312
Foreign	13	3.399869	0.280492	3.061788	3.807377
Unemployment	14	16.45	7.012708	9.8	27.4
GDP	14	13.98703	2.111004	11.33743	16.29893
Popdensity	14	37.47093	0.291802	36.80441	37.8609
Males1519	14	2.602472	0.145489	2.405516	2.784182
Males2024	14	2.908914	0.373956	2.382776	3.460451
Males2529	14	3.039929	0.438971	2.280352	3.409018
Clear up Burg	9	30.55725	8.424508	13.65228	45.69767
Clear up Ctheft	9	44.53102	11.14867	32.31198	64.28571
Clear up Rob	13	61.35032	12.20079	40.47619	85
Clear up Prop	13	36.75043	6.230263	20.06395	45.5036
Deposits	14	42256.85	7513.23	33261.62	57116.02

Region: Thessalia

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	160.4148	54.62541	90.53488	244.825
Ctheft100	9	95.68187	14.96579	68.55585	118.3438
Rob100	13	7.08285	4.397031	1.885334	15.11322
Prop100	13	223.7793	86.55035	124.4329	362.1425
Foreign	13	4.313985	0.315653	3.987433	4.836032
Unemployment	14	15.62857	7.83301	7.8	27.1
GDP	14	14.87965	2.380702	11.92089	17.61837
Popdensity	14	52.79326	0.363126	51.91389	53.21258
Males1519	14	2.850029	0.237993	2.562232	3.371757

Males2024	14	2.920624	0.269625	2.64202	3.406181
Males2529	14	3.118133	0.379154	2.504243	3.478662
Clear up Burg	9	50.24942	12.27092	32.9559	69.77225
Clear up Ctheft	9	51.62904	5.458757	39.29078	59.68992
Clear up Rob	13	73.6731	13.8168	54	88.46154
Clear up Prop	13	50.17436	6.245483	40.18059	62.87356
Deposits	14	73792.85	13675.87	55540.86	100977.6

Region: Ionia Nisia

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	417.0753	181.2229	150.8448	676.6503
Ctheft100	9	127.3715	18.15823	96.55988	153.3485
Rob100	13	9.537189	6.469204	2.416895	23.89817
Prop100	13	466.6366	216.6655	191.4181	841.4999
Foreign	13	6.42719	0.349501	5.986512	7.14608
Unemployment	14	13.25	4.24785	8.3	21.4
GDP	14	18.82086	3.53405	14.35862	23.29442
Popdensity	14	90.22888	0.411931	89.58757	90.92612
Males1519	14	2.655821	0.320778	2.416703	3.451534
Males2024	14	2.73375	0.484646	2.178121	3.411518
Males2529	14	3.172313	0.471793	2.260589	3.595497
Clear up Burg	9	39.03665	9.999859	17.98867	52.28951
Clear up Ctheft	9	48.68984	11.33656	31.50183	67.30038
Clear up Rob	13	49.86701	23.33754	27.27273	111.1111
Clear up Prop	13	39.62151	8.258709	22.20957	54.17348
Deposits	14	65855.69	13166.88	46808.34	89731.57

Region :Dytiki Ellada

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	716.4264	293.1481	255.4149	1082.35
Ctheft100	9	202.4021	40.69526	116.2139	251.4772
Rob100	13	14.60249	7.773168	4.44142	29.5086

Prop100	13	767.4797	378.6763	315.1889	1322.326
Foreign	13	3.675221	0.206979	3.397038	4.013613
Unemployment	14	17.31429	8.7018	9.6	29.8
GDP	14	14.85529	2.435161	11.74012	18.02866
Popdensity	14	60.9396	0.912692	59.06992	62.15107
Males1519	14	3.200287	0.334789	2.835731	3.879308
Males2024	14	3.565349	0.371245	3.00782	4.110309
Males2529	14	3.435478	0.349291	2.817475	3.757197
Clear up Burg	9	27.45865	9.921598	14.88487	42.38727
Clear up Ctheft	9	36.8821	6.804188	25.99232	48.88337
Clear up Rob	13	62.60878	8.859825	47.61905	70.90909
Clear up Prop	13	34.45908	9.989746	20.16477	44.86526
Deposits	14	65855.69	13166.88	46808.34	89731.57

Region: Sterea Ellada

Burg100	Obs	Mean	Std. Dev.	Min	Max
Ctheft100					
Rob100	9	389.1292	109.7765	239.3908	587.1475
Prop100	9	136.1108	23.03453	106.5782	170.1997
Foreign	13	12.35569	5.860255	6.303103	26.62354
Unemployment	13	468.633	155.9467	285.5424	775.2991
GDP	13	5.498077	0.236708	5.179892	5.894524
Popdensity	14	16.87143	8.120764	8.5	28.2
Males1519	14	17.86545	3.11927	13.99311	21.19835
Males2024	14	35.85111	0.155142	35.64647	36.09852
Males2529	14	2.767523	0.375248	2.415313	3.53583
Clear up Burg	14	2.996059	0.449168	2.333447	3.567557
Clear up Ctheft	14	3.441194	0.365545	2.706403	3.761855
Clear up Rob	9	24.63288	6.7224	12.05113	34.27992
Clear up Prop	9	36.42618	5.288303	27.58621	41.50077
Burg100	13	47.25931	13.14459	28.18792	75
Ctheft100	13	28.95107	4.320735	18.32219	34.1364
Deposits	14	55703.59	11065.6	39813.28	74713.64

Region: Peloponnisos

Variable	Obs	Mean	Std. Dev.	Min	Max
Burg100	9	713.9365	200.1095	363.7189	880.4244
Ctheft100	9	166.6853	33.93146	108.8938	215.4338
Rob100	13	16.78921	11.46283	3.070363	36.46527
Prop100	13	779.5457	274.7329	460.2577	1128.608
Foreign	13	5.286003	0.31407	4.968241	5.7889
Unemployment	14	13.21429	6.483097	7.1	23.4
GDP	14	15.73555	2.159409	13.03988	18.6304
Popdensity	14	37.82678	0.167246	37.46621	38.10453
Males1519	14	2.712077	0.395922	2.319962	3.440707
Males2024	14	2.699598	0.347729	2.095087	3.106953
Males2529	14	3.159042	0.222891	2.665974	3.363081
Clear up Burg	9	24.45466	5.013132	15.30874	30.95362
Clear up Ctheft	9	41.91121	3.911249	36.68508	49.84326
Clear up Rob	13	53.96506	11.48611	33.68421	73.9726
Clear up Prop	13	29.41955	3.685339	20.50917	33.30526
Deposits	14	74091.47	13880.32	55343.36	99176.35

Note*: The first column gives the name of the variables. Burg100, is the number of Burglaries per 100,000 inhabitants. Cthefts, is the number of Vehicle Thefts per 100,000 inhabitants. Rob100 is the number of Robberies per 100,000 inhabitants. Prop100 is the number of Property crime incidents per 100,000 inhabitants. Foreign is the share of foreign population, proxied by the valid residence permits. Unemployment is the unemployment rate. GDP is the Gross Domestic Product. Popdensity is the Population Density. Males1519 is the share of male population aged between 15 and 19 years old. Males2024 is the share of male population aged between 20 and 24 years old. Males2529 is the share of male population aged between 25 and 29 years old. Clear up Burg is the clear up rate of Burglaries. Clear up Ctheft is the clear up rate of Vehicle Thefts. Clear up Rob is the clear up rate of Robberies. Clear up Prop is the clear up rate of Property Crime incidents. Deposits is the real level of Deposits of households and firms in 2015 prices. The second column gives the number of observations of the variable in the region. The third column gives the mean of the variable in the region. The fourth column gives the standard deviation of the variable in the region. The fifth column gives the minimum value of the variable in the region. The sixth column gives the maximum value of the variable in the region.*

F. Estimations in the Whole Sample and After 2008

Property Crime (Whole Sample and After 2008 Sample)

Variables	GMM-System	GMM-System
	After 2008	Whole Sample
Crime (-1)	0.5424***	0.5925***
	(0.0505)	(0.0457)
Clear Up Rate	-0.0211***	-0.0205***
	(0.0025)	(0.02930)
Foreign	0.1499**	0.1038***
	(0.0336)	(0.0293)
Population Density	0.0003***	0.0001
	(0.0002)	(0.0001)
GDP	-0.1557***	-0.1011***
	(0.0343)	(0.0298)
GDP^2	0.0029***	0.0019***
	(0.0006)	(0.0006)
Unemployment	0.0009	-0.0070
	(0.0088)	(0.0056)
males1519	0.2582*	0.3303***
	(0.1455)	(0.1090)
males2024	0.0396	-0.007
	(0.0897)	(0.0480)
males2529	0.0945	0.1386***
	(0.0739)	(0.0426))
Deposits Growth	-0.0072***	-0.0064***
	(0.0012)	(0.0012)
Prisoners	-0.0077**	-0.0030**
	(0.0025)	(0.0012)
Year	-0.0095	0.0247**
	(0.0176)	(0.0109)
After 2008 Dummy		0.0833**
		(0.0388)
Constant	18.1530	-51.4811**
	(35.5940)	(21.8566)
Observations	104	156

Appendix F*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita(in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged*

*between 25-29 years. Clear up, is the clear up rate of property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the property crime rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the GMM- System estimates for the whole sample, i.e. 2004-2016. Column (2) presents the GMM- System estimates for the reduced sample, i.e. after 2008. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Chapter 3: Does Immigration Increase Crime? Evidence from Greece

1. Introduction

Immigration is frequently mentioned as one of the most important issues facing politicians in advanced economies. According to the Eurobarometer[28], the immigration of people from outside the EU evokes a positive feeling for just above a third of Europeans and a negative feeling for 56% of them. The percentage is strikingly high in Greece, with 78% of people reporting a negative feeling. Despite the fact that there is no empirical work supporting a negative impact of immigration in Greece, xenophobia and right wing extremism are in a rise[29].

After gaining ground spectacularly, immigration is now seen as the most important issue facing the EU, overtaking the economic themes that have led the hierarchy of main concerns. The most important issue for Europeans overall, immigration is in first position in 20 Member States. Concerns over terrorism have also increased sharply. Meanwhile, concern about economic themes has continued its downward trend.

Many media and social commentators posit there to be a direct connection between immigration and crime. Often this appears related to the commonly expressed concern that immigrants harm the labor market prospects of natives. This concern has received substantial, and sometimes controversial, attention in the academic labor economics literature (see, inter alia, Borjas, 1999, or Card, 2005, 2009). However, it also reflects a wider concern over the impact of large immigration flows on other aspects of society. Issues of relevance here cover competition for education and health services, congestion, housing demand, cultural identity and crime. The latter forms the focus of this study.

[28] Eurobarometer 83, (2015, p.36 and p. 38)

[29] In Greece, the Racist Violence Recording Network, developed by the United Nations High Commissioner for Refugees (UNHCR) and other civil society organizations, documented 166 racist crimes in 2013, 143 of which were committed against migrants or refugees. In a majority of these crimes, the victim suffered "severe personal injury" caused by a variety of weapons

There is a currently only a sparse, though growing, academic literature in economics examining evidence on crime and immigration. This seems surprising given that the economic and social costs of crime are usually estimated to be large, so any link between immigration and crime should be of significant concern to researchers and policymakers alike.

Although casual empiricism hints at a link between immigration and criminal activity, the empirical evidence is by no means unambiguous. On theoretical grounds there are a priori reasons to believe that immigration may affect crime rates. But the economic theory of crime offers little guidance as to the size, or even the sign of the effect.

On the one hand, theory predicts that, all else equal, individuals with lower outside options commit more crime. Low levels of education, low wages, higher levels of unemployment, and difficulties assimilating have all been documented for immigrants and can reasonably be associated with poorer outside options—at least if one regards legal labor market employment as the relevant margin. Furthermore, immigrants are disproportionately male and between the ages of 15 and 35. Existing research has shown these groups to be especially likely to be involved in criminal activity (Freeman, 1999).

On the other hand, the expected costs of committing a crime are likely higher for immigrants. Not only do they face the same set of punishments as natives, but they are also subject to deportation, which may be an important deterrent. Moreover, immigrants might be positively selected on various unobservable dimensions, and may thus have an inherently lower propensity to commit crime than natives may.

Another channel through which immigration may affect crime are spillover effects. Even if immigrants themselves commit fewer crimes than observationally similar natives do, immigration could cause an increase in crime if it reduces natives' labor market opportunities inducing them to substitute toward criminal activity. At the same time, immigration may be associated with positive spillover effects. For instance, immigrants might move into and improve transitional neighborhoods by bringing social capital that is otherwise lacking.

This paper contributes to the growing empirical literature on immigration and crime, with a particular application to Greek data on immigration and crime at regional level covering very recent years, including 2016. The case of Greece is of particular interest, as recently it has become the main entry and transit for a significant number of immigrants.

Positioned at the southeastern "gate" of the European Union, and with extensive coastlines and easily crossable borders, Greece has become a common transit country for those seeking entry into Europe. The evidence now indicates that nearly all irregular immigration to the European Union flows through the country's porous borders.

Since 2009, Greece is also struggling under the weight of what is perhaps the country's worst economic recession in recent memory. Huge public debt and the government's decision to borrow from the International Monetary Fund and the European Union have changed entirely the economic, political, and social environment of immigration in Greece.

At the same time, the crime rate in Greece, which has historically been amongst the lowest in Western Europe, displays varying dynamics across different time periods but does not reveal a definite pattern. There is a general tendency, which is not based on scientific method but rather public sentiment that foreigners are mainly responsible for most of the criminal activity.

Taking into account the distinguishing characteristics of the Greek reality, this paper attempts to give a persuasive answer to whether the variation in the crime rate can be partly explained by the changes in the proportion of documented immigrants to the native population.

I draw data on crime from the Greek Police records and use a new dataset on residence permits from the Greek Ministry of Migration Policy, for the period 2008-2016. Our OLS results show that immigration is positively correlated with the overall crime rate. As the composition of immigrants is very heterogeneous in terms of their origins (see Table 1), I break the immigrants into those originating from the Balkans and the former Soviet Union, and those originating from Middle-East, Asia and Africa. The fixed effects estimates show a positive and significant relation between immigration and crime only for the first group. After taking into account the endogeneity of immigration, using a GMM approach, the effect of the first group of immigrants drops and becomes statistically insignificant.

Table 1: Composition of the Immigrant Population in 2016

Albania	402,630	69.4%
Ukraine	19,965	3.4%
Georgia	19,411	3.3%
Pakistan	17,068	2.9%
Russia	15,306	2.6%
India	14,652	2.5%
Egypt	12,516	2.2%
Philippines	11,342	2.0%
Other	67,318	11.6%

Source: Greek Ministry of Interior, Ministry of Migration Policy

2. Conceptual Framework

2.1. Literature Review

Several empirical approaches have been pursued in this area (reviewed by Bell and Machin, 2011). These include cross-area panel studies, individual-level crime models and models studying imprisonment differences, migrant legalization and crime victimization. The most robust work probably comes from the cross-area panel data studies that have been undertaken, but additional insights can be obtained from the other approaches that the literature has followed.

Starting with the individual-level crime models, Butcher and Piehl (1998a) find that immigrants are less likely to report a crime or contact the criminal justice system in the United States. Following, Papadopoulos (2011), finds that immigrants are less likely to report involvement in property crime than natives in England and Wales.

Lastly, Nunziata (2011), looks at the probability of being a crime victim while conditioning on individual characteristics and the share of immigrants in the total area, in 17 European countries. He reports no significant relationship between them.

Moving on to models studying imprisonment differences, Butcher and Piehl (1998b, 2007), find that immigrants are less likely to be institutionalized than natives in the United States are. Bell, Fasani and Machin (2010), compare the imprisonment rates of UK nationals with foreign nationals and find that asylum wave imprisonment rates are marginal higher, but they report no difference for immigrants from EU accession countries that occurred from 2004 onwards (A8 wave) .

Another part of the literature focuses on the effects of migrant legalization. Mastrobuoni and Pinotti (2010), study the difference in the recidivism rate of Romanians and Bulgarians, after they became legal immigrants (2007), in comparison to foreigners from EU candidate countries. They report a strong reduction in recidivism of Romanians and Bulgarians compared to control group.

Baker (2014) studies the impact of the 1986 Immigration Reform and Control Act (IRCA) on crime. His findings suggest that a 1% point increase in the number of legalized IRCA applicants per capita reduces crime by 1.6%.

Moving on to studies around crime victimization, Krueger and Pischke (1997), find that hate crime is higher in the East Germany and in fact rises with distance from the former West German border. Martens (1997), finds that immigrants tend to have higher crime rates than the natives and are more likely to report being victims of crime. Bell et al. (2010) report that immigrants are less likely to report being victims of crimes in Britain.

Following, there is a series of studies on immigrant neighborhood effects. Lee et al. (2001), find that immigration does not increase levels of homicide amongst Latinos and African Americans. Graif and Sampson (2009), report that immigrant concentration is either unrelated or negatively related to homicide in Chicago during the period 1995-2006. Lastly, Bell and Machin (2011), find a non linear relationship between immigrant concentration and crime, as well as crime victimization in Britain in 2001.

The cross-panel data studies include models of self-reported individual crime experiences, analysis of data on imprisonment and immigration, crime and migrant legalization, crime victimization and immigration and immigrant neighborhood effects and crime.

Bell, Fasani and Machin (2010), examine England and Wales over the period 2002 to 2009. They study the impact on violent and property crime of two immigrant waves; the first was associated with a large increase in asylum seekers while the second flow resulted from the expansion of the European Union in 2004 (A8 wave). They find that a 1% increase in asylum seekers is associated with a 1.09% rise in property crime while a similar rise in the A8 wave reduces property crime by 0.39%.

Bianchi, Buonanno and Pinotti (2008) study the crime immigration link across Italian provinces over the period 1990-2003. They report that the causal effect of total immigration on crime is not significantly different from zero.

Spenkuch (2011), uses census data on US counties across the years 1980, 1990 and 2000. He finds generally positive and significant effects from immigrant stocks on property crime rates but no such effect for violent crimes. When the author breaks the immigrant stock into Mexicans and non-Mexicans, he finds a significantly positive effect for Mexican immigrants, while it is negative and insignificant for all other immigrants.

Alonso, Garoupa, Perera and Vazquez (2012) use annual data on reported crime and convictions at the province level in Spain for the period between 1999 and 2006. They find a significant, positive relationship between immigrant share and crime rates.

Finally, Butcher and Piehl (1998a) present evidence on the crime-immigration link across 43 cities in the United States over the period 1981-1990. The authors report no significant correlation between immigrant stocks in a city and crime.

2.2. Channels through which immigration can cause crime

How can the way in which economists model crime be used to consider the crime-immigrant relation? The typical approach to criminal behavior followed by economists, postulates that individuals undertake some kind of expected cost-benefit analysis when considering whether to participate in criminal activities or not. The standard model, first

introduced by Becker (1968) and further developed by Ehrlich (1973) and others (see Freeman, 1999, for a review), argues that individuals participate in crime if their expected utility from doing so outweighs the expected utility from a competing alterative, usually formal work in the labor market. Under-compliance with the law arises when the benefits of compliance are lower than the costs. Usually the benefits of a crime include the illegal gain obtained by the criminal whereas the costs include the probability and severity of punishment. The economic model hypothesizes that everyone is a potential criminal, therefore it does not provide any particular argument for why immigrants should under-comply with the law more or less frequently than natives, except that their profile of benefits and costs of crime could be different from that of natives.

In this context, from a theoretical perspective, there are countervailing arguments about the higher or lower propensity of immigrants towards crime with respect to natives. However, the strength of these arguments depends obviously on empirical confirmation.

The first argument is that, due to difficulties in the labor market and for lack of economic opportunities, the illegal gain obtained by immigrants is relatively higher than that of natives. The argument is based on the income/employment status of the immigrant and the fact that a higher proportion of the immigrant population has economic problems or has fewer economic opportunities.

A second argument looks at cooperative crimes that require a close network of trust and coordination. The economic literature has discussed how organized crime can develop mechanisms of control and quality assurance (Garoupa, 2007) and has identified ethnic homogeneity as a very powerful mechanism to guarantee the success of a criminal organization.

A third argument relies on the cost of under-compliance. It has been documented by legal economists (McAdams, 2000) that compliance with the law is easier to achieve when it embodies social norms shared by most individuals in a community. We can talk of under-compliance due to different cultural perceptions. Examples could include terrorist acts, gender violence, antisocial behavior and more.

A fourth argument could be less knowledge of local laws. Immigrants could violate the law by mistake more frequently simply because they ignore the law or are unaware of the specific enforcement choices of national authorities.

A final argument has to do with risk aversion. If criminals have a less risk averse utility profile (Becker, 1968), it may be that immigrants are on average closer to such profile than natives because there is a selection effect due to immigration, which is, intrinsically, a risky activity. However, notice that the underlying risks, for immigration and for crime, are different and hence the selection effect could well not be very relevant (Bianchi, Buonanno, and Pinotti, 2008).

So far, I have identified reasons for why immigrants could be more prone to commit certain crimes. However, there are also good economic reasons for why immigrants could be less prone to commit other types of crime.

One obvious reason has to do with opportunities. First, earning potentials could be higher for immigrants, so that the lost legal earnings due to criminal activities could be more significant as a deterrent.

Second, if immigrants tend to be located in more depressed economic neighborhoods, then they have fewer opportunities for property crime.

Third, even if economic well-being determines that immigrants could be more likely to commit certain economic crimes, it is also likely that those crimes that require specific levels of human capital or technology will be committed less by immigrants (for example, regulatory and administrative crimes).

Another line of reasoning could be that if immigrants have certain distinct characteristics that make them easier to be targeted by the enforcement authorities, then they could be more deterred since the expected severity of punishment could be higher. Furthermore, the risk of deportation could make punishment more costly.

Finally, less knowledge of local laws could drive them to comply due to overestimating punishment.

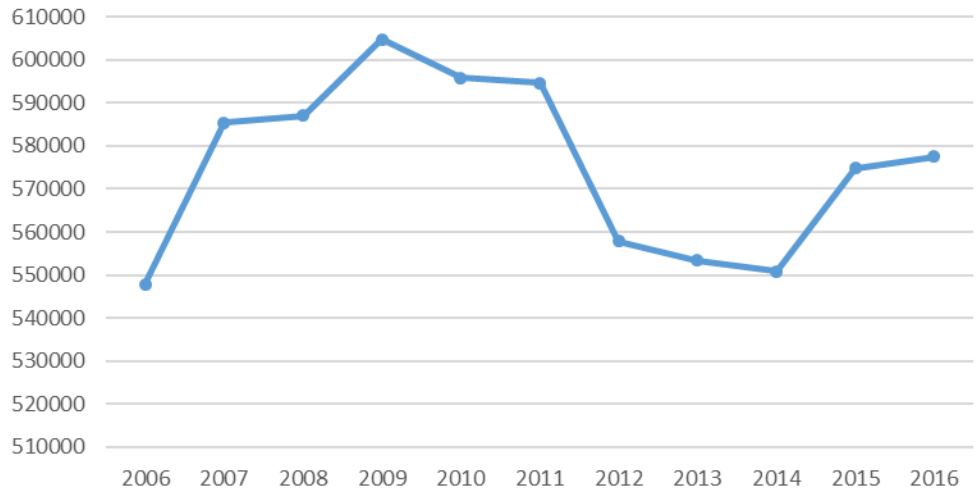
In conclusion, there is no economic theory that provides support to the hypothesis that there is a strong correlation between crime and immigration. In fact, the economic arguments about differential behavior towards crime among natives and immigrants are mixed. Furthermore, the sign and the degree of correlation between crime and immigration is expected to differ by crime types. If there exists a linkage between immigration and certain crime types, it

is probably better explained by incentives that factor into opportunism rather than by any specific attribute of the immigrant community.

3. Data Analysis

As a proxy for immigration, I use the number of valid residence permits every month, *permits*, from a new dataset acquired by the Greek Ministry for Migration Policy for the period 2006-2016. The data is available at a NUTS 3 level (51 provinces), and include the nationality, the age and the gender of the holder, the province at which the permit was issued, the reason of the issuance and its duration. However, in this chapter I aggregate the data to a NUTS2 level (13 regions) to make them compatible with the rest of the dataset. Resident permits show a sharp increase from 2006 until 2009, followed by a dramatic drop until 2014 leading to the levels of 2006. Finally, there is an increase in the next two years (Figure 1).

Figure 1: Residence Permits

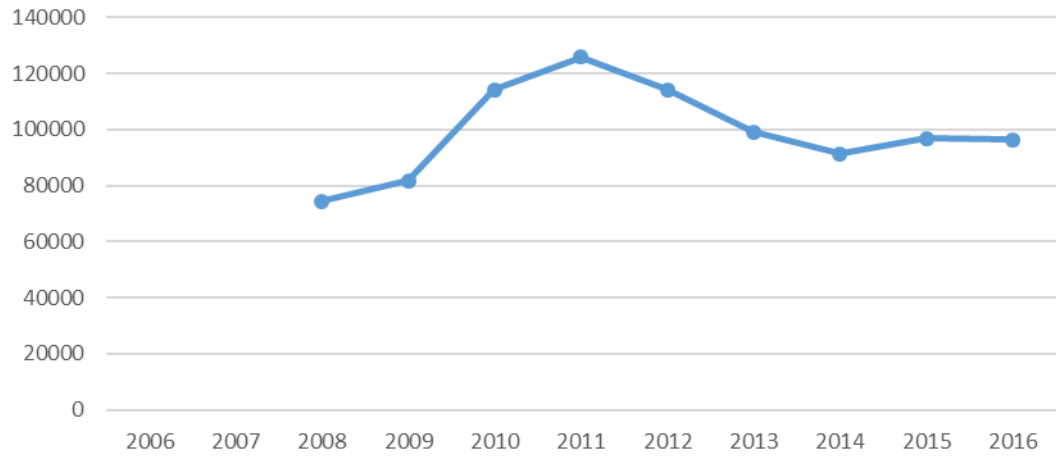


Source: Greek Ministry for Migration Policy (Ministry of Interior)

Furthermore, I have annual data on crime, *crime*, from the Greek police records on a NUTS 2 level (regions), available from 2008 to 2016 on the overall property crime rate, as well

as various subcategories[30]. Property crime is defined as the sum of burglaries, robberies and vehicle thefts. Although all these are thefts, robberies differ from the rest because they are violent[31]. Figure 2 shows that the overall crime level increases until 2011 and then drops until 2014. Following, I observe a slight increase until 2016.

Figure 2: Property Crime



Source: Hellenic Police

Turning to the control variables, I compute the *clear up rate* using data from the Greek police records, as follows:

$$clear\ up\ rate = \frac{cleared\ up\ crimes}{commited\ crimes + attempted\ crimes}$$

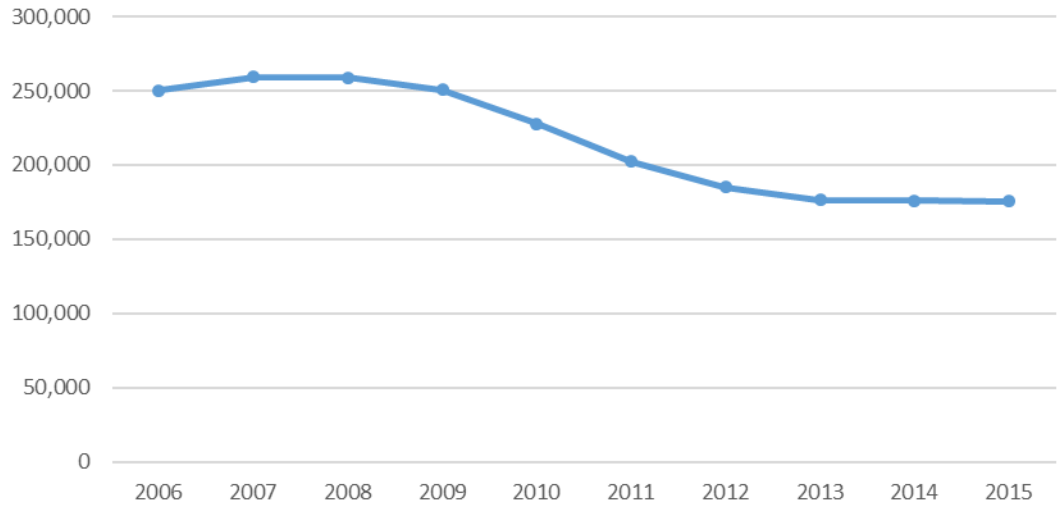
Using data from Eurostat, for the period 2006-2016 on a NUTS2 level, I compute the proportion of three different groups of young males, namely males aged between 15 and 19, *males1519*, males aged between 20 and 24, *males1924*, and males between 25 and 29, *males2529*. Also, available from the same source, is the unemployment rate, *unemp* and the population density, *popdensity* which is constructed as the ratio of the population of the area of each province (in squared km). I have also collected the Gross Domestic Product at current market prices, which I

[30] Robberies, Burglaries and Vehicle Thefts.

[31] For more on the definition of different crime types, see the Appendix of Chapter 2

have deflated using the HICP (2015=100) to obtain the GDP in constant prices, *gdp*. Real GDP shows a consistent decrease during the recession years, 2008-2015 (see Figure 3). Finally, I include the squared GDP, *gdp_sq*, to test for a nonlinear relationship, the prison population, *prisoners*, to proxy the severity of punishment and the growth of the deposits, *gdep*, to catch the rational behavior of criminals to new opportunities, as described in the previous chapter.

Figure 3: Real GDP



Source: Eurostat, Author's Calculation.

4. Empirical Procedure

Identifying the effect of migration on crime requires to control for other factors that may affect both variables. The main estimating equation is

$$crime_{it} = \beta_1 foreign_{it} + \beta_2' X_{it} + \beta_3 t + \phi_i + \varepsilon_{it}$$

where $crime_{it}$ is the log of the crime rate reported by the police in region i during year t; $foreign_{it}$ is the log of immigrants over population; X_{it} is a set of control variables; ϕ_i are region fixed effects; t is a time trend and finally, ε_{it} is an error term. We are mainly interested in identifying the coefficient β.

Note that the last three terms represent unobserved variables that capture region-level unobserved heterogeneity, aggregate shocks common to all regions, and a term that comprises idiosyncratic shocks, measurement errors in the dependent variable, and aggregation errors.

First, assuming that region-level unobserved heterogeneity is invariant over time, we can exploit the longitudinal data structure, and apply a fixed effects transformation to remove this unobserved component. Namely, denoting Δ as the first differences operator the fixed-effects transformation yields the following model:

$$\Delta crime_{it} = \beta_1 \Delta foreign_{it} + \beta_2' \Delta X_{it} + \beta_3 \Delta t + \Delta \phi_i + \Delta \varepsilon_{it}$$

The set of observables X_{it} comprises demographic and socioeconomic determinants of crime. Demographic variables include the population density, which is the population of the region divided by its area in squared km. Also, since young men are said to be more prone to engage in criminal activities than the rest of the population (Freeman, 1991; Levitt, 1998; Grogger, 1998), I add the percentage of men aged 15-19, $males1519$, the percentage of men aged 20-24, $males2024$ and the percentage of men aged 25-29, $males2529$.

Turning to the socioeconomic variables, I include the real GDP per capita (in 2015 prices) and the unemployment rate, which measure the legitimate and illegitimate earning opportunities (Ehrlich, 1973; Raphael and Winter-Ember, 2001; Gould et al., 2002). As a proxy for the expected costs of crime, I follow Ehrlich (1996) in using the *clearup* rate, defined as the ratio of crimes cleared up by the police over the total number of reported crimes (by type of offense). In addition, I include the prison population as a proxy of the severity of the expected punishment and the growth of the deposits to examine the impact of the lack of trust in the banking system on the property crime rate (see Chapter 2 for more). Furthermore, I add a dummy variable that takes the value 0 pre-crisis and the value 1 after 2008. Finally, fixed effects control for other unobserved factors that do not vary within regions or years.

However, there could be several reasons why the size of the immigrant population is systematically correlated with crime rate, some of which may not be adequately captured by control variables. Thus, the distribution of the immigrant population across regions could be

correlated with the error term, which implies that immigration can be endogenous**.** Therefore, identifying causality requires a source of exogenous variation in the immigrant population, that is, one or more instrumental variables that are correlated with immigration but not with crime.

Several such instruments have been proposed in the literature. The most common approach is to use the (exogenous) supply-push component of migration by nationality as an instrument for shifts in the immigrant population across regions. Supply-push factors are all events in origin/host countries that increase the propensity to emigrate such as economic crises, political turmoil, wars and natural disasters. Since these are both important in determining migration outflows and independent of regional differences within the host country, they have often been used as a source of exogenous variation in the distribution of the immigrant population.

I construct three instruments and compare the results. First, following the approach pioneered by Card (2001)**,** I construct an outcome-based measure of supply-push factors using total migration flows by nationality toward Greece; variation of the instrument results from differences in the beginning-of-period composition by nationality of the immigrant population across different areas within Greece (see, for instance, Ottaviano and Peri, 2011; Cortes, 2008; Card, 2009). The predictive power of the instrument exploits the fact that new immigrants of a given nationality tend to settle into the same areas as previous immigrants from the same country (see e.g. Munshi, 2003; McKenzie and Rapoport, 2007).

Specifically, the instrument for the permits of region i is constructed as:

$$IV1_{it} = \sum_{\eta} foreign^{\eta}_{it-1} \times growth\_permits\_total^{\eta}_{t}$$

where $foreign^{\eta}_{it-1}$ is the stock of immigrants of nationality η during the period t and $growth\_permits\_GR^{\eta}_{t}$ is the growth rate of total permits in Greece for immigrants of nationality η**.**

However, in the above instrument, the growth rate of total permits will be the weighted growth rate of all regions, thus it will still be correlated with pull factors for a given region, and

this will be especially pronounced in my case as the number of regions is not very large and, furthermore, since the region of Attiki contains the largest share of immigrants. As an extreme case scenario, if all immigrants from a given country moved to the same Greek region, it would be impossible to disentangle push and pull factors based on total inflows by nationality. Thus, I also construct the following instrument.

$$IV2_{it} = \sum_{\eta} foreign^{\eta}_{it-1} \times growth\_permits\_total\_excl\_region^{\eta}_{it}$$

where $growth\_permits\_total\_excl\_region^{\eta}_{it}$ denotes the growth rate of total permits in Greece excluding the permits of region i, for immigrants of nationality η.

Nevertheless, both of the aforementioned instruments will still perform poorly if there are common pull factors across all Greek regions. In this case, immigration to other regions will be correlated with the pull factors of a given region. In order to overcome this problem, Bianchi et al. (2012) propose the use of bilateral migration flows toward other destination countries, as these are much less likely to be correlated with pull factors by Greek regions or Greece as a whole. Thus, using data on immigration per nationality available from Eurostat, I construct the following instrument:

$$IV3_{it} = \sum_{\eta} foreign^{\eta}_{it-1} \times growth\_permits\_EU^{\eta}_{t}$$

where $growth\_permits\_EU^{\eta}_{t}$ is the growth rate of permits in E.U. countries excluding Greece, per nationality η.

5. Estimation and Results

First, I estimate the effect of the immigration on crime rates using the Fixed Effects estimator accounting for region-specific fixed effects and controlling for variables that could be related with crime. Table 2 shows the results of the pooled OLS estimator, the fixed effects estimator and the *IV* estimator when I use instrumental variable *IV1* to instrument the endogenous variable *foreign*. Using the fixed effects estimator, the coefficient estimate for the

effect of immigration on crime is 0.3764 and statistically significant at the 1% level of significance. However, when using the *IV* estimator with the instrument *IV1*, the coefficient drops in magnitude (0.3234) but remains significant at the same level. The F-statistic on the excluded instruments gives a value of 56.919 indicating that the used instrument is strong.

Table 2: Instrument IV1

Variables	Pooled	FE	IV1
Clear Up Rate	-0.0437***	-0.0192***	-0.0198***
	(0.0022)	(0.0022)	(0.0023)
Foreign	0.3359***	0.3764***	0.3234***
	(0.0281)	(0.0699)	(0.0840)
Population Density	0.0009***	0.0011	0.0017
	(0.0002)	(0.0018)	(0017)
GDP	-0.3640***	-0.1923***	-0.2111***
	(0.0389)	(0.0326)	(0.0372)
GDP²	0.0066***	0.0035***	0.0033***
	(0.0009)	(0.0006)	(0.0006)
Unemployment	-0.0045	0.0072	0.0124**
	(0.0073)	(0.0057)	(0.0059)
males1519	1.0998***	0.3060***	0.2650
	(0.1431)	(0.1040)	(0.1707)
males2024	-0.1905	-0.2433***	-0.1077*
	(0.1175)	(0.0726)	(0.0614)
males2529	0.3366***	0.3959***	0.3654***
	(0.0928)	(0.0982)	(0.0896)
Deposits Growth	-0.0034	-0.0060***	-0.0067***
	(0.0028)	(0.0013)	(0.0013)
Prisoners	0.0039	0.0019	-0.0038**
	(0.0025)	(0.0014)	(0.0015)
Year	0.0691****	0.0418***	0.0026
	(0.0164)	(0.0106)	(0.0026)
Constant	-144.2804***		
	(33.1881)		
F-stat. (excl. instr.)			56.919> 16.38
Observations	169	169	130
R-squared	0.8992	0.8482	0.8687

Table 2*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Property Crime Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the IV estimates from the main specification, when I use variable IV1 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

As discussed earlier, the instrumental variable *IV1* is constructed in a way that will only partially exclude the pull factors of each region, therefore it will only partially control for the possible endogeneity resulting from this. On the other hand, instrumental variable *IV2* excludes the pull factors of each specific region, as discussed earlier. I therefore expect it to correct the endogeneity issue further. Table 3 shows the results of the pooled OLS estimator, the fixed effects estimator and the *IV* estimator when I use instrumental variable *IV2* to instrument the endogenous variable foreign. I observe that indeed the coefficient drops further to 0.3169 and it remains significant at the 1% level.

Table 3: Instrument IV2

Variables	Pooled	FE	IV2
Clear Up Rate	-0.0437***	-0.0192***	-0.0199***
	(0.0022)	(0.0022)	(0.0023)
Foreign	0.3359***	0.3764***	0.3169***
	(0.0281)	(0.0699)	(0.0848)
Population Density	0.0009***	0.0011	0.0016
	(0.0002)	(0.0018)	(0.0017)
GDP	-0.3640***	-0.1923***	-0.2120***
	(0.0389)	(0.0326)	(0.0373)
GDP^2	0.0066***	0.0035***	0.0033***
	(0.0009)	(0.0006)	(0.0006)
Unemployment	-0.0045	0.0072	0.0122**
	(0.0073)	(0.0057)	(0.0060)
males1519	1.0998***	0.3060***	0.2704

	(0.1431)	(0.1040)	(0.1707)
males2024	-0.1905	-0.2433***	-0.1078*
	(0.1175)	(0.0726)	(0.1707)
males2529	0.3366***	0.3959***	0.3667***
	(0.0928)	(0.0982)	(0.0896)
Deposits Growth	-0.0034	-0.0060***	-0.0067***
	(0.0028)	(0.0013)	(0.0013)
Prisoners	0.0039	0.0019	-0.0038**
	(0.0025)	(0.0014)	(0.0015)
Year	0.0691****	0.0418***	0.0027
	(0.0164)	(0.0106)	(0.0146)
Constant	-144.2804***		
	(33.1881)		
F-stat. (excl. instr.)			54.799>16.38
Observations	169	169	130
R-squared	0.8992	0.8482	0.8686

Table 3*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term.* ***Unemployment****, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level)****.*** *Crime (-1), the lagged value of the Property Crime Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the IV estimates from the main specification, when I use variable IV2 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Finally, Table 4 reports the results of the pooled OLS estimator, the fixed effects estimator and the IV estimator when I use instrumental variable *IV3* to instrument the endogenous variable foreign. The instrumental variable *IV3* totally excludes the pull factors of each region, as well as those of the whole country. I therefore expect it to perfectly account for the endogeinity resulting from this source. The coefficient now drops sharply and in fact becomes negative (-0.1258) and insignificant.

Table 4: Instrument IV3

Variables	Pooled	FE	IV3

Clear Up Rate	-0.0437***	-0.0192***	-0.0208***
	(0.0022)	(0.0022)	(-0.0208)
Foreign	0.3359***	0.3764***	-0.1258
	(0.0281)	(0.0699)	(0.1933)
Population Density	0.0009***	0.0011	-0.0021
	(0.0002)	(0.0018)	(0.0021)
GDP	-0.3640***	-0.1923***	-0.3635***
	(0.0389)	(0.0326)	(0.0751)
GDP²	0.0066***	0.0035***	0.0055***
	(0.0009)	(0.0006)	(0.0010)
Unemployment	-0.0045	0.0072	0.0022
	(0.0073)	(0.0057)	(0.0084)
males1519	1.0998***	0.3060***	0.3213
	(0.1431)	(0.1040)	(0.5028)
males2024	-0.1905	-0.2433***	-0.0356
	(0.1175)	(0.0726)	(0.1526)
males2529	0.3366***	0.3959***	0.2972**
	(0.0928)	(0.0982)	(0.1257)
Deposits Growth	-0.0034	-0.0060***	-0.0079***
	(0.0028)	(0.0013)	(0.0018)
Prisoners	0.0039	0.0019	-0.0107***
	(0.0025)	(0.0014)	(0.0038)
Year	0.0691****	0.0418***	-0.0646**
	(0.0164)	(0.0106)	(0.03132)
Constant	-144.2804***		
	(33.1881)		
F-stat. (excl. instr.)			24.111>16.38
Observations	169	169	104
R-squared	0.8992	0.8482	0.7409

Table 4*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita in (in 2015 prices). Gdp² is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Property Crime Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the IV estimates from the main specification, when I use variable IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A1 in the Appendix presents the results of a GMM estimator, which uses *IV1*, *IV2* and *IV3* as instruments for the endogenous variables. Again the coefficient for the immigrants of the first group drops and is statistically insignificant at all levels of significance but the Hansen J statistic indicates that all instruments are not plausible.

5.1. Robustness: Spatial Correlation

Cross area comparisons may be uninformative due to the mobility of criminals, which gives rise to spatial correlation in local crime data. I thus control for spatially lagged crime rates by constructing the variable "*spatial*" which consists of weighted averages of crime rates in neighboring provinces, using the inverse of the distance in travel time (hours) between their respective capital cities. Spatial correlation might exist in the data as is evident from the main specification. However, once I include the temporal lag of the dependent variable its effect is statistically insignificant. This is because although Greek regions are not especially large geographical areas compared to other countries, I expect that crime trips occur mostly within rather than across provinces.

$$Y_{it} = \beta_0 + \rho \sum_{j \neq i} d_{ij} Y_{jt} + \beta_1 X_{it} + \phi_i + t + \varepsilon_{it}$$

where d_{ij} is the inverse "distance" of region i from region j.

Table 5: Robustness : Spatial Correlation

Variables	FE	FE (Spatial)	IV3	IV3 (Spatial)
Spatial		0.0468*		-0.0288
		(0.0236)		(0.0317)
Clear Up Rate	-0.0192***	-0.0192***	-0.0208***	-0.0211***
	(0.0022)	(0.0020)	(-0.0208)	(0.0029)
Foreign	0.3764***	0.4053***	-0.1258	-0.1592
	(0.0699)	(0.0918)	(0.1933)	(0.1938)
Population Density	0.0011	0.0016	-0.0021	-0.0022

	(0.0018)	(0.0017)	(0.0021)	(0.0020)
GDP	-0.1923***	-0.1935***	-0.3635***	-0.3586***
	(0.0326)	(0.0401)	(0.0751)	(0.0763)
GDP²	0.0035***	0.0035***	0.0055***	0.0054***
	(0.0006)	(0.0008)	(0.0010)	(0.0011)
Unemployment	0.0072	0.0086	0.0022	0.0006
	(0.0057)	(0.0056)	(0.0084)	(0.0086)
males1519	0.3060***	0.3048**	0.3213	0.3383
	(0.1040)	(0.1081)	(0.5028)	(0.5091)
males2024	-0.2433***	-0.2060**	-0.0356	-0.0350
	(0.0726)	(0.0912)	(0.1526)	(0.1577)
males2529	0.3959***	0.3620**	0.2972**	0.3193**
	(0.0982)	(0.1047)	(0.1257)	(0.1338)
Deposits Growth	-0.0060***	-0.0048**	-0.0079***	-0.0087***
	(0.0013)	(0.0012)	(0.0018)	(0.0021)
Prisoners	0.0019	-0.0017	-0.0107***	-0.0082*
	(0.0014)	(0.0028)	(0.0038)	(0.0048)
Year	0.0418***	0.0523**	-0.0646**	-0.0679**
	(0.0106)	(0.0106)	(0.03132)	(0.0314)
After 2008	-0.0452	-0.1480		
	(0.0514)	(0.0912)		
Constant	-90.3034***	-110.2708***		
	(20.8289)	(21.4011)		
F-stat. (excl. instr.)			21.111> 9.08	23.524> 16.38
Observations	169	169	104	104
R-squared	0.8482	0.8735	0.7409	0.7342

Table 5*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables**,** foreign is the share of foreign population over the population in region I, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km**).** Gdp is the real gdp per capita (in 2015 prices). Gdp² is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level**).** Spatial, is the variable constructed to account for spatial correlation between regions and Crime (-1), the lagged value of the Property Crime Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable and account for spatial correlation. Column (3) presents the IV estimates from the main specification, when using variable IV3 to proxy the endogenous variable, foreign. Column (4) presents the IV estimates from the main specification, when using variable IV3 to proxy the endogenous variable, foreign, and account for spatial correlation. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

6. Conclusion

This paper constitutes a first attempt to investigate and quantify the relationship between immigration and crime in Greece using yearly regional data which are available at least for the years from 2008 through 2016. During this period, apart from facing perhaps the worst economic recession in recent memory, Greece has become the main entry and transit for hundreds of thousands of unauthorized immigrants from Africa, Asia and the Middle East. All the more, this results in a high degree of variability in the included variables and thus allows to better identify the effect of immigration on crime.

A standard OLS approach with fixed effects showed that the size of the immigrant population is positively correlated with the overall crime rate. Immigration might be endogenous as criminal opportunities in the host destination might serve as a pull factor and attract foreign criminals. In order to account for endogeneity I construct three instrumental variables. The first one, *IV1*, excludes only partially these pull factors and slightly reduces the magnitude of the coefficient. The second one, *IV2*, corrects further the endogeneity as it excludes the pull factors of each region. The coefficient now drops more but remains significant. The last instrument, *IV3*, perfectly corrects for the pull factors of each region and the country and the coefficient now becomes negative and insignificant.

As a future research consideration I plan to construct a proxy for undocumented immigrants using regional data on apprehensions for illegal stay in the country and a) examine the degree of correlation with documented immigrants, and b) its effect on the crime rates. Also, I aim to construct a variable that will measure the cultural diversity of foreigners in each region using the permits data for each nationality and examine its explanatory power over the crime rates. Furthermore, data on NUTS 3 regions which will require the construction of variables that are not available on such level of disaggregation and, in addition, a careful evaluation of other region-specific factors that may need to be accounted for.

7. Appendix

Table A1: Property Crime : All instruments

Variables	Pooled	FE	IV
Clear Up Rate	-0.0437***	-0.0192***	-0.0197***
	(0.0022)	(0.0022)	(0.0026)
Foreign	0.3359***	0.3764***	0.168202
	(0.0281)	(0.0699)	(0.1095)
Population Density	0.0009***	0.0011	-0.0002
	(0.0002)	(0.0018)	(0.0016)
GDP	-0.3640***	-0.1923***	-0.2957***
	(0.0389)	(0.0326)	(0.0580)
GDP²	0.0066***	0.0035***	0.0048***
	(0.0009)	(0.0006)	(0.0009)
Unemployment	-0.0045	0.0072	0.0064
	(0.0073)	(0.0057)	(0.0078)
males1519	1.0998***	0.3060***	0.0549
	(0.1431)	(0.1040)	(0.3921)
males2024	-0.1905	-0.2433***	-0.0794***
	(0.1175)	(0.0726)	(0.1430)
males2529	0.3366***	0.3959***	0.3047***
	(0.0928)	(0.0982)	(0.1140)
Deposits Growth	-0.0034	-0.0060***	-0.0071***
	(0.0028)	(0.0013)	(0.001)
Prisoners	0.0039	0.0019	-0.0066**
	(0.0025)	(0.0014)	(0.0025)
Year	0.0691****	0.0418***	-0.0325
	(0.0164)	(0.0106)	(0.0234)
Constant	-144.2804***		
	(33.1881)		
F-stat. (excl. instr.)			21.145> 9.08
Hansen J statistic			0.0895< 0.1
Observations	169	169	104
R-squared	0.8992	0.8482	0.7902

Table A1*: In all specifications, the dependent variable is the logarithm of property crime over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp² is the squared gdp term.* ***Unemployment****, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years.*

Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the property crime. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). ***Crime (-1), the lagged value of the Property Crime Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (3) presents the IV estimates from the main specification, when I use variables IV1, IV2 and IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A2: Burglaries: All Instruments

Variables	Pooled	FE	IV
Clear Up Rate	-0.0362***	-0.0160***	-0.0175***
	(0.0020)	(0.0022)	(0.0025)
Foreign	0.3851***	0.5525***	0.1188
	(0.0462)	(0.1349)	(0.1583)
Population Density	0.0008***	0.0024	-0.0013
	(0.0002)	(0.0023)	(0.0018)
GDP	-0.3939***	-0.2173***	-0.3358***
	(0.0619)	(0.0636)	(0.0835)
GDP^2	0.0076***	0.0043***	0.0059***
	(0.0013)	(0.0010)	(0.0013)
Unemployment	0.0058	0.0154*	0.0010
	(0.0101)	(0.0093)	(0.0111)
males1519	0.8184***	-0.1741	-0.0544
	(0.2351)	(0.3771)	(0.5740)
males2024	-0.0425	-0.3395**	-0.0897
	(0.1924)	(0.1359)	(0.1660)
males2529	0.3363**	0.4621***	0.3733**
	(0.1456)	(0.1277)	(0.1439)
Deposits Growth	-0.0063**	-0.0082***	-0.0098***
	(0.0030)	(0.0017)	(0.0021)
Prisoners	0.0004	-0.0010	-0.0089**
	(0.0047)	(0.0033)	(0.0038)
Year	0.6963**	0.0325	-0.0275
	(0.0326)	(0.0273)	(0.0332)
Constant	-145.6139**		
	(66.0137)		
F-stat. (excl. instr.)			21.479> 9.08
Hansen J statistic			0.1670> 0.1
Observations	117	117	104
R-squared	0.8673	0.7378	0.7245

Table A2*: In all specifications, the dependent variable is the logarithm of burglaries over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population in region I, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term**. Unemployment**, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of burglaries. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level)**. Crime (-1), the lagged value of the burglary Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (3) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the IV estimates from the main specification, when I use variables IV1, IV2 and IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A3: Burglaries: Instruments IV1, IV2 and IV3

Variables	IV1	IV2	IV3
Clear Up Rate	-0.0163***	-0.0163***	-0.0182***
	(0.0022)	(0.0022)	(0.0028)
Foreign	0.3692**	0.3674**	-0.2744
	(0.1543)	(0.1539)	(0.2853)
Population Density	0.0009	0.0009	-0.0040
	(0.0021)	(0.0021)	(0.0028)
GDP	-0.2555***	-0.2559***	-0.4246***
	(0.0640)	(0.0644)	(0.1103)
GDP^2	0.0047***	0.0047***	0.0068***
	(0.0010)	(0.0009)	(0.0015)
Unemployment	0.0135	0.0135	0.0045
	(0.0091)	(0.0091)	(0.0118)
males1519	0.0095	0.0113	0.2834
	(0.3919)	(0.3911)	(0.7308)
males2024	-0.3157**	-0.3156**	-0.0288
	(0.1342)	(0.1343)	(0.1804)
males2529	0.4701***	0.4702***	0.3647**
	(0.1263)	(0.1263)	(0.1646)
Deposits Growth	-0.0088***	-0.0088	-0.0109***
	(0.0019)	(0.0019)	(0.0026)
Prisoners	-0.0034	-0.0034	-0.0146***
	(0.0037)	(0.0037)	(0.0056)
Year	0.0159	0.0157	-0.0714
	(0.0295)	(0.0295)	(0.0456)
Constant			

F-stat. (excl. instr.)	48.057>16.38	48.088>16.38	22.519>16.38
Observations	117	117	104
R-squared	0.7915	0.7914	0.6511

Table A3*: In all specifications, the dependent variable is the logarithm of burglaries over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the burglaries. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Burglary Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the IV estimates from the main specification, when I use variable IV1 to instrument the endogenous variable, foreign. Column (2) presents the IV estimates from the main specification, when I use variable IV2 to instrument the endogenous variable, foreign. Column (3) presents the IV estimates from the main specification, when I use variable IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A4: Robberies: All instuments

Variables	Pooled	FE	IV3
Clear Up Rate	-0.0234***	-0.0087***	-0.0063***
	(0.0027)	(0.0021)	(0.0024)
Foreign	0.4157***	0.8050***	0.6128**
	(0.0580)	(0.1377)	(0.2543)
Population Density	0.0029***	-0.0019	-0.00314
	(0.0003)	(0.0043)	(0.0058)
GDP	-0.5013***	-0.1218	-0.4528***
	(0.0795)	(0.0751)	(0.1175)
GDP^2	0.0076***	0.0015	0.0052**
	(0.0016)	(0.0014)	(0.0022)
Unemployment	-0.0225*	0.0191	0.0227
	(0.0124)	(0.0141)	(0.0166)
males1519	1.0025***	0.2403	2.5042***
	(0.2844)	(0.2886)	(0.7723)
males2024	-0.1252	-0.2541	-0.2253
	(0.2634)	(0.1654)	(0.3392)
males2529	0.2479	0.7777***	0.7849***
	(0.2253)	(0.1908)	(0.2251)
Deposits Growth	-0.0610	-0.0110***	-0.0135***
	(0.0053)	(0.0034)	(0.0035)
Prisoners	0.0086	0.0033	-0.0092
	(0.0054)	(0.0033)	(0.0064)
Year	0.0422	0.0623**	-0.0523
	(0.0344)	(0.0623)	(0.0522)

Constant	-92.8036 (69.4253)		
Hansen J statistic			
F-stat. (excl. instr.)			22.866> 9.08
			0.0292 < 0.1
Observations	169	169	104
R-squared	0.7453	0.6891	0.6664

Table A4*: In all specifications, the dependent variable is the logarithm of robberies over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of robberies. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Robbery Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (3) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the IV estimates from the main specification, when I use variables IV1, IV2 and IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A5: Robberies: Instruments IV1, IV2 and IV3

Variables	IV1	IV2	IV3
Clear Up Rate	-0.0074*** (0.0021)	-0.0074*** (0.0021)	-0.0055** (0.4562)
Foreign	0.8282*** (0.1670)	0.8068*** (0.0021)	-0.2641 (0.0027)
Population Density	-0.0022*** (0.0040)	-0.0024 (0.0040)	-0.0010 (0.0066)
GDP	-0.2963*** (0.0696)	-0.2993*** (0.0699)	-0.6562*** (0.1648)
GDP^2	0.0033** (0.0014)	0.0034** (0.0014)	0.0072*** (0.0026)
Unemployment	0.0271* (0.0147)	0.0264* (0.0147)	0.0095 (0.0193)
males1519	0.8516** (0.4213)	0.8673** (0.4203)	3.2389*** (0.9718)
males2024	-0.2449* (0.1363)	-0.2463* (0.1366)	-0.1378 (0.3665)
males2529	07022*** (0.1777)	0.7071*** (0.1774)	0.7920*** (0.2657)
Deposits Growth	-0.0127*** (0.0039)	-0.0127*** (0.0033)	-0.0163*** (0.0041)
Prisoners	-0.0087** (0.0039)	-0.0086** (0.0039)	-0.0221** (0.0089)

Year	-0.0454 (0.02818)	-0.0454 (0.0282)	-0.1578** (0.0742)
F-stat. (excl. instr.)	61.938>16.38	59.538>16.38	20.188>16.38
Observations	130	130	104
R-squared	0.7098	0.7102	0.5801

Table A5*: In all specifications, the dependent variable is the logarithm of robberies over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita in (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of the robberies. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level). Crime (-1), the lagged value of the Robbery Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the IV estimates from the main specification, when I use variable IV1 to instrument the endogenous variable, foreign. Column (2) presents the IV estimates from the main specification, when I use variable IV2 to instrument the endogenous variable, foreign. Column (3) presents the IV estimates from the main specification, when I use variable IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A6: Vehicle Thefts: All instruments

Variables	Pooled	FE	IV
Clear Up Rate	-0.0065* (0.0036)	-0.0038** (0.0016)	-0.0024 0.0017
Foreign	0.5048*** (0.0711)	0.4312*** (0.0911)	0.3624*** 0.1377
Population Density	0.0028*** (0.0003)	0.0002 (0.0021)	-0.0002 0.0024
GDP	-0.5033*** (0.0986)	-0.0431 (0.0488)	-0.0882 0.0629
GDP^2	0.0073*** (0.0021)	0.0001 (0.0008)	0.0005 0.0011
Unemployment	0.0122 (0.0163)	0.0115** (0.0057)	0.0093 0.0063
males1519	1.4278*** (0.4122)	-0.5865** (0.2880)	-0.3740 0.3595
males2024	0.2765 (0.2941)	0.1961* (0.1175)	0.2451 0.2524
males2529	-0.0044 (0.0047)	0.1782 (0.1151)	0.1501 0.1156

Deposits Growth	-0.0044	-0.0040***	-0.0041**
	(0.0047)	(0.0016)	0.0017
Prisoners	-0.0088	0.006	-0.0013
	(0.0081)	(0.0031)	0.0041
Year	-0.1203***	-0.0161	-0.0332
	(0.0458)	(0.0259)	0.0324
Constant	235.672**		
	(92.763)		
F-stat. (excl. instr.)			22.738> 9.08
Hansen J statistic			0.1510> 0.100
Observations	117	117	104
R-squared	0.5629	0.5968	0.5985

Table A6*: In all specifications, the dependent variable is the logarithm of vehicle thefts over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of vehicle thefts. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level)**. *Crime (-1), the lagged value of the Vehicle theft Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the pooled OLS estimates from the main specification, when using foreign as the main explanatory variable. Column (2) presents the fixed effect estimates from the main specification, when using foreign as the main explanatory variable. Column (3) presents the IV estimates from the main specification, when I use variables IV1, IV2 and IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Table A7: Vehicle Thefts

Variables	IV1	IV2	IV3
Clear Up Rate	-0.0036**	-0.0036**	-0.0030*
	(0.0017)	(0.0017)	(0.0018)
Foreign	0.5107***	0.5106***	0.0473
	(0.1491)	(0.1475)	(0.2205)
Population Density	0.0008	0.0008	-0.0025
	(0.0024)	(0.0024)	(0.0028)
GDP	-0.0234	-0.0234	-0.1665**
	(0.0579)	(0.0578)	(0.0742)
GDP^2	-0.0001	-0.0001	0.0014
	(0.0009)	(0.0009)	(0.0011)
Unemployment	0.0126**	0.0126**	0.0042
	(0.0060)	(0.0060)	(0.0068)
males1519	-0.6725**	-0.6724**	-0.0969

	(0.3140)	(0.3129)	(0.4029)
males2024	0.1876	0.1876	0.2771
	(0.1186)	(0.1185)	(0.2629)
males2529	0.1776	0.1776	0.1400
	(0.1163)	(0.1163)	(0.1196)
Deposits Growth	-0.0037**	-0.0037**	-0.0051***
	(0.0017)	(0.0017)	(0.0019)
Prisoners	0.0017	0.0017	-0.0060
	(0.0035)	(0.0035)	(0.0051)
Year	-0.0078	-0.0078	-0.0714*
	(0.0295)	(0.0294)	(0.0377)
Constant			
F-stat. (excl. instr.)	48.904>16.38	48.917>16.38	19.448>16.38
Observations	117	117	104
R-squared	0.6844	0.6844	0.5652

Table A7*: In all specifications, the dependent variable is the logarithm of vehicle thefts over the population. Regarding the explanatory variables, foreign is the share of foreign population over the population, proxied by the valid residence permits. Popdensity, is the population density, i.e. the population of a region divided by the size of the region (in squared km). Gdp is the real gdp per capita in (in 2015 prices). Gdp^2 is the squared gdp term. Unemployment, is the unemployment rate. Males1519 is the proportion of males aged between 15-19 years. Males2024 is the proportion of males aged between 20-24 years. Males2529 is the proportion of males aged between 25-29 years. Clear up, is the clear up rate of vehicle theft. Deposits Growth, is the growth of real deposits (in 2015 prices) in millions euros. Prisoners is the absolute number of prisoners (at a national level)**. **Crime (-1), the lagged value of the Vehicle theft Rate. Year is a year trend. After 2008 is a dummy variable that takes the value 1 after 2008. Column (1) presents the IV estimates from the main specification, when I use variable IV1 to instrument the endogenous variable, foreign. Column (2) presents the IV estimates from the main specification, when I use variable IV2 to instrument the endogenous variable, foreign. Column (3) presents the IV estimates from the main specification, when I use variable IV3 to instrument the endogenous variable, foreign. *, ** and *** denote rejection of the null hypothesis that the coefficient is equal to 0 at 10%, 5% and 1% significance level, respectively.*

Chapter 4: Irregular Immigration and Tax Evasion in the Presence of an Informal Sector: A Search-Equilibrium Approach

1. Introduction

Shadow economy is of great importance in most world economies. It significantly affects macroeconomic factors, such as wages and unemployment while tax evasion constitutes a key controversy between politicians. Schneider (2010) finds that the average size of the informal sector of southern Europe countries[32], during the period 1999-2007, was 25% of official GDP.

There is a rich literature studying the size of the informal sector, the reasons of its existence and how it emerges. For example, Bosh and Pretel (2012) use data from Brazil to calibrate a two- sector search and matching model. They suggest that policies reducing the cost of entry in the formal sector or increase the cost of informality increase the size of the formal sector. Fugazza et al (2004) also employ a search and matching model and suggest a similar way to deal with the problem; increase incentives to participate in the formal sector, rather than employ deterrence policies. Zenou (2008) suggests a model with search frictions in the formal sector and a competitive informal sector. He finds a clear positive effect on the employment in the formal sector, when a policy of wage subsidy or hiring subsidy is incorporated.

Immigration and its impact on the labor market outcomes has been in the center of a lively debate among economists. The empirical results on the subject are often ambiguous; some, such as Card (1990), find little or no effect of immigration on the wage of native workers, whereas others, such as Borjas et al (1997), find a strong negative effect.

Irregular immigrants can only be employed in the informal sector. In this sector, firms are unregulated and therefore cannot be directly affected by labor market policies. Although, they might have indirect effects through policies applied in the formal sector, such as unemployment benefits, taxes and severance payments.

[32] Spain, Portugal ,Greece and Italy

Cuff et al. (2011) have studied irregular immigration in an economy with two sectors. They construct a simple model with a formal and an informal sector and consider the role of documented and undocumented workers on optimal tax and enforcement policy. Domestic workers can work in either sector but undocumented workers can only work informally. In this context, they analyze optimal policies and find that in equilibrium, wages between undocumented workers and domestic workers are equal, even if they work in a different sector. They also find that enforcement may not always be decreasing in its cost and that it is not optimal for the government to enforce market segmentation if enforcement costs are too high.

Boeri and Garibaldi (2005) create a search and matching model with two sectors, a formal and an informal. Firms optimally choose to create jobs in either sector through a mechanism that is akin to tax evasion. There is a positive probability that irregular employment is detected and the match is destroyed. Workers differ in terms of productivity and sort across sectors. Worker's sorting will determine the productivity level for which a worker is indifferent between working in the formal or the informal sector[33]. They experiment with various policies such as in change in taxation, regulation, the monitoring rate and the unemployment benefits.

The effect of a change in taxation (or regulation) on unemployment is not sharp, since there are two countervailing effects; the indirect effect on job creation via the increase in the reservation productivity is reducing unemployment while the direct effect of taxes on market tightness in the legal sector is increasing it. Furthermore, an increase in monitoring intensity reduces the shadow rate, but it increases unemployment. Finally, an increase in unemployed benefits reduces the size of the informal sector and increases unemployment. The increase in participation in the formal sector increases formal employment and reduces informal employment. Labor market tightness falls in both sectors

Di Porto et al. (2016) suggest a search and matching model with an informal sector. They find that an increase in the inspection rate leads to higher destruction of informal jobs, which in turn reduces the flow of temporary workers into the informal sector and a lower level of job creation in the informal sector. Therefore, the size of the informal sector drops.

[33] The reservation property is satisfied.

Furthermore, lower taxation (or firing costs) induces an increase in both job destruction and job creation of permanent positions, with a prevalence of the latter, and boosts the flow of workers from informal to formal positions. However, combinations of lower payroll taxes for permanent contracts and a higher inspection rate are more effective on the reduction of the shadow sector, as opposed to combinations of lower firing costs and a higher inspection rate.

The present paper contributes to the related search and matching models with an informal sector literature by adding a worker type with different labor market opportunities. This is important as this type cannot be formally employed, therefore the incentive and deterrence policies cannot have a direct effect on her decisions. I suggest a rich model with various policies that can affect the size of the informal sector, namely incentive, deterrence and immigration policies.

Specifically, it is a dynamic search and matching model, with two sectors, a formal and an informal one. Workers can be either natives or irregular immigrants. The former have access in both sectors, whereas the latter can only be employed in the informal sector. Native workers trade of the costs and benefits of the two sectors in order to make an optimal decision. If they find a job in the formal sector, they have to pay an income tax but are entitled to unemployment benefits and a severance payment.

Firms also decide optimally the sector in which they want to post a vacancy. Firms operating in the formal sector, are entitled to a subsidy for maintaining a position, but are obliged to pay a payroll tax and face a firing cost, which includes a severance payment, as well as some administrative costs.

On the other hand, workers and firms in the informal sector do not have to pay taxes or a firing cost, but face the probability to get audited. If that happens, the match is terminated and the firm has to pay a penalty. If an irregular immigrant is caught working in the informal sector, she gets deported. Separation rate is higher in the informal sector. Search frictions exist in both sectors and wages in each sector are determined by Nash bargaining between firms and workers. Irregular immigrants have lower outside option, and thus lower bargaining power. The wage of each worker is a combination of her outside option and her productivity in that job.

There are two intermediate goods produced in the formal and the informal sector respectively. When produced, they are sold in a competitive market to produce the final good, which uses intermediate goods as inputs.

I experiment with several policies, namely, an immigration influx, a change in unemployment benefits, and a change in payroll tax rates. Furthermore, I prove that under certain conditions, a steady-state equilibrium exists and is unique. I study the abovementioned labor market policies in the special case that formal sector intermediate good and the informal sector intermediate good are perfect substitutes and obtain analytical results.

Specifically, I find that an irregular immigration influx will increase the size of the informal sector. This is the exact opposite result of that of an immigration amnesty. Following, I show that an increase in unemployment benefits in the formal sector can possibly increase the unemployment in the same sector, leading us to the Todaro paradox[34] . In this sense, this paper is related to the literature on rural-urban migration, where Todaro (1976) shows that creating urban jobs can increase urban unemployment due to the negative effect of rural migration, being stronger than the positive effect of creating jobs. The analytical results suggest that an increase or a decrease of a labor policy instrument can increase both employment and unemployment.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 presents the calibration of the model for Greece in the period 2000-2007. Section 4 presents the simulations of various policies. Section 5 concludes the paper and Section 6 proves the existence of a unique equilibrium and reports the analytical results of various policy experiments.

2. The Model

Consider an economy that has two sides: a formal and an informal one. Both sides consist of two sectors, one that produces an intermediate input and one that produces the final good. Throughout the paper, I take the final good to be the numeraire.

[34] See Zenou (2008) ,Todaro (1969) and Harris and Todaro (1970) .

There is a continuum of workers, who are either natives (N) or irregular immigrants (M) and are indexed by $i \in \{N, M\}$.[35]

The mass of native workers is normalized to one, while that of irregular immigrants is also constant and denoted by M. Native workers seek employment in any of two intermediate sectors, whereas irregular immigrants can work only in the informal intermediate sector. The mass of jobs in each intermediate sector is determined endogenously, as specified below. Time is continuous. All agents are risk neutral and discount the future at a constant rate $r > 0$.

2.1. Production

I start with the formal side of the economy. An intermediate input L_F is produced using only (native) labor. More specifically, firms operate a simple linear technology

$$L_F = e_{NF} \quad (1)$$

where e_{NF} is the number of native (N) workers who are employed in the formal intermediate sector (F). Accordingly, a job in that sector can be filled only by a native worker and the outcome from such a pair is one unit of L_F. Moreover, there are firms of the final good operating in the formal side; they use L_F to produce the final good Y_F according to the following technology

$$Y_F = A_F L_F, A_F > 0 \quad (2)$$

The informal side of the economy has a similar structure. There are two intermediate inputs L_{NI} and L_{MI}, which are produced using only native and immigrant labor respectively.

[35] I abstract from legal immigration. Alternatively, one can assume that legal immigrants are lumped together with natives.

$L_{NI} = e_{NI}$ and $L_{MI} = e_{MI}$

where e_{ij} is the number of workers who are employed in the intermediate informal (I) sector and are of origin $i \in \{N, M\}$. Accordingly, a position in the informal intermediate sector can be filled either by a native or by an immigrant.

There are also informal firms that produce the final good. They do so using the technology

$$Y_I = A_I L_I, A_I > 0 \quad (3)$$

where

$$L_I = [x(L_{NI})^\rho + (1-x)(L_{MI})^\rho]^{\frac{1}{\rho}} \quad (4)$$

The final goods Y_F and Y_I are perfect substitutes; in particular, the total quantity of the final good Y is $Y = Y_F + Y_I$

2.2. Markets

Each of the two intermediate inputs, L_F and L_I, is sold in a competitive market. Thus, their prices are equal to their marginal products:

$$p_F \equiv \frac{\partial Y_F}{\partial L_F} = A_F \quad (5)$$

$$p_{NI} \equiv \frac{\partial Y_I}{\partial L_{NI}} = A_I x \left(\frac{L_I}{L_{NI}}\right)^{1-\rho} \quad (6)$$

$$p_{MI} \equiv \frac{\partial Y_I}{\partial L_{MI}} = A_I(1-x)\left(\frac{L_I}{L_{MI}}\right)^{1-\rho}$$

(7)

Finally, in the labor markets, there are search and matching frictions that prevent market clearing. More specifically, each firm possesses one vacancy and must decide first whether to open it in the formal (F) or in informal (I) sector. I use the index $j \in \{F, I\}$ to distinguish between the two types of jobs. There is free-entry in both markets. After opening a vacancy, the firm starts seeking for a worker. Similarly, native workers decide first whether to seek employment in the formal or the informal sector (as mentioned above, irregular migrants have no such option).

Job seekers and vacant jobs are matched in a pair-wise fashion. The mass of successful job matches in the formal sector is determined by the matching function $M_F(v_F, u_{NF})$ where v_F is the mass of formal vacancies and u_{NF} denotes the mass of unemployed native workers in the formal sector. Similarly, the mass of matches in the informal sector is given by the matching function $M_I(v_I, u_{NI} + u_{MI})$ where v_I is the mass of informal vacancies and $u_{NI}(u_{MI})$ is the mass of unemployed native (immigrant) workers in the informal sector. The matching functions $M_j(.), j = F, I$, are assumed to be twice continuously differentiable, strictly increasing and strictly concave with respect to each of their arguments, exhibit constant returns to scale and satisfy the Inada conditions.

I follow the literature and define the labor market tightness, θ_j, as the number of jobs per unemployed worker; that is, in the formal sector $\theta_F = v_F / u_{NF}$ and in the formal sector as $\theta_I = v_I / (u_{NI} + u_{MI})$. The rate at which vacancies in sector j are filled is $q_j(\theta_j) = M_j / v_j$, $j = F, I$ where $q_j'(\theta_j) < 0$. On the hand, the rate at which unemployed workers (native or immigrant) find jobs in each sector is $m_j(\theta_j) = \theta_j q_j(\theta_j)$

2.3 Institutions

There are some fundamental differences between firms and workers that operate in the two intermediate sectors. First, to maintain a vacancy in the formal sector a firm must pay an advertising cost $c_j, j \in \{F, I\}$.

Second, firms that operate in the formal sector pay a payroll tax at a rate t_F, a tax on profits t_Π and face some firing costs. I consider two components of firing costs: The first component includes various administrative costs captured by the parameter $f > 0$. These costs include the requirement to give the worker advance notice, procedures that the firm must follow if it wants to lay off, legal expenses in case of a trial, etc. The second component of firing costs is a severance payment, i.e., a transfer from the firm to the employee[36]. As it is the case in most countries, I assume that the severance payment is proportional to the wage, that is, it equals γw_{NF}, where w_{NF} is the wage rate of a worker who is employed in the formal sector (F) and is native (she is of origin N). On the other hand, firms that operate in the informal sector receive no subsidies and pay neither taxes nor firing costs. However, the labor market is monitored and if a firm is caught operating in the informal sector, it is forced to terminate the match and pay a penalty rate η on output[37]. Such an event occurs with a probability (arrival rate) δ. Hence, $\delta\eta$ is the expected penalty rate paid by a firm in the informal sector.

Third, native workers who work in the formal sector pay an income tax at a rate t_w. On the other hand, workers in the informal sector do not pay taxes. Nevertheless, informal jobs are less stable for the following two reasons. First, the arrival rate of negative shocks is probably higher, i.e., the separation rate in the informal sector s_I is higher than that in the formal s_F. Second, as mentioned above, firms are audited at a rate δ and if they are caught operating illegally then they have to terminate the match. Finally, during unemployment, native workers receive a flow of income b_{ij}, $i \in \{N, M\}$, $j \in \{F, I\}$ which captures the opportunity cost of employment, e.g., the payoff from home production, leisure and unemployment benefits. This

[36] In this model, there are no quits and every termination of employment is a no-fault dismissal

[37] I assume that η is the penalty rate net of any administrative cost that is necessary to enforce the law.

income is net of any search cost that they incur when looking for a job. Typically, workers in the informal sector do not receive any unemployment benefits, that is, $b_{NI} = 0$. On the other hand, irregular immigrants do not receive unemployment benefits; nevertheless, they also incur a cost of searching for a job, which is, in general, higher than that faced by natives[38]. Let b_{MI} denote the income of an immigrant in unemployment, which could be negative. Thus, I have $b_{NF} > b_{NI} = 0 > b_{MI}$. Moreover, throughout the paper, I assume that the output of match between a vacancy and a worker exceeds the income of the unemployed worker of the same type, i.e., $p_F > b_{NF}$, $p_{NI} > b_{NI}$ and $p_{MI} > b_{MI}$.

2.4 Asset Values

In general let Π and V be the values associated with a filled and an unfilled vacancy, and E and U the values associated with an employed and an unemployed worker respectively. More specifically, let Πij be the present discounted value associated with a firm in sector $j \in \{F, I\}$ that is matched with a worker of origin $i \in \{N, M\}$. Then in steady state:

$$r\Pi_{NF} = (1 - t_{\Pi})[p_F - (1 + t_F)w_{NF}] - s_F(\Pi_{NF} - V_F + f + \gamma w_{NF}),$$

(8)

$$r\Pi_{NI} = (1 - \delta\eta)p_{NI} - w_{NI} - (s_I + \delta)(\Pi_{NI} - V_I),$$

(9)

$$r\Pi_{MI} = (1 - \delta\eta)p_{MI} - w_{MI} - (s_I + \delta)(\Pi_{MI} - V_I),$$

(10)

[38] Battisti et al. (2014) cite empirical evidence in support of this assumption.

where w_{ij} is the wage rate of a worker who is employed in the intermediate sector $j \in \{F, I\}$ and is of origin $i \in \{N, M\}$ and V_j is the value associated with an unfilled (vacant) position in intermediate sector j. As mentioned above, the total firing cost in the formal intermediate sector is $f + \gamma w_{NF}$, where $f > 0$ is a fixed amount. Recall the assumption that jobs matched with natives in the informal sector have a higher separation rate than jobs matched with natives in the formal sector

$$s_I + \delta > s_F$$

The expected income streams accrued to an unfilled vacancy in the intermediate sector $j \in \{F, I\}$ are given by

$$rV_F = -c_F + q(\theta_F)(\Pi_{NF} - V_F),$$

(11)

$$rV_I = -c_I + q(\theta_I)[\phi_{NI}\Pi_{NI} + (1 - \phi_{NI})\Pi_{MI} - V_I],$$

(12)

where ϕ_{NI} represents the probability that a vacancy meets a native worker, N, in the informal sector, I. More specifically,

$$\phi_{NI} = \frac{u_{NI}}{u_{NI} + u_{MI}} \quad (13)$$

I next turn to values associated with the workers. The expected income streams accrued to employed workers are given by

$$rE_{NF} = (1 - t_W)w_{NF} - s_F(E_{NF} - U_{NF} - \gamma w_{NF}),$$

(14)

$$rE_{NI} = w_{NI} - (s_I + \delta)(E_{NI} - U_{NI}),$$

(15)

$$rE_{MI} = w_{MI} - (s_I + \delta)(E_{MI} - U_{MI}),$$

(16)

Similarly, the values associated with unemployed workers are:

$$rU_{NF} = b_{NF} + m_F(\theta_F)(E_{NF} - U_{NF}),$$

(17)

$$rU_{NI} = b_{NI} + m_I(\theta_I)(E_{NI} - U_{NI}),$$

(18)

$$rU_{MI} = b_{MI} + m_I(\theta_I)(E_{MI} - U_{MI}),$$

(19)

I also assume free entry in establishing either type of vacancy. Thus, in equilibrium, the expected payoff of posting a vacancy is equal to zero that is,

$$V_j = 0, j = F, I$$

(20)

2.5 Wage Determination

Once a worker meets a firm, they bargain over the wage rate. I assume that they essentially solve a generalized Nash bargaining problem given by[39]

$$\underset{w_{NF}}{Max}(E_{NF} - U_{NF} - \gamma w_{NF})^{\beta}(\Pi_{NF} - V_F + f + \gamma w_{NF})^{(1-\beta)},$$

for the matches in the formal sector and by

$$\underset{w_{ij}}{Max}(E_{ij} - U_{ij})^{\beta}(\Pi_{ij} - V_j)^{(1-\beta)},$$

for the matches in the informal sector, where $\beta \in (0,1)$ represents the worker's bargaining strength. The solution to each of these two problems gives, respectively,

$$(1-\beta)[(1-t_{\Pi})(1+t_F) - r\gamma][E_{NF} - U_{NF} - \gamma w_{NF}] = \beta(1 - t_w - r\gamma)[\Pi_{NF} - V_F + f + \gamma w_{NF}]$$

(21)

$$(1-\beta)(E_{ij} - U_{ij}) = \beta(\Pi_{ij} - V_j),$$

(22)

The total surplus generated by a match in the formal and the informal sector is $S_{NF} = \Pi_{NF} - (V_F - f) + E_{NF} - U_{NF}$ and $S_{iI} = \Pi_{iI} - V_i + E_{iI} - U_{iI}, i = N, M$ respectively. Notice that the severance payment, γw_{NF}, being a pure transfer from the firm to the worker, drops out of the definition of the surplus S_{NF}. Nevertheless, the compensation rate and the tax rates, t_F

[39] I assume that wages are constantly renegotiated at no cost. Hence, the relevant wage for an unemployed worker who contacts a firm in the formal sector for the first time, and hence is not entitled to a severance payment, is the same wage as the one for an already employed worker. This is so, because the unemployed worker will immediately renegotiate the wage once a contract is signed.

and t_w affect the workers' and firms' shares in the formal sector. More specifically, in the case of a formal match, workers get a share[40]

$$\beta_F = \frac{\beta(1-t_w-r\gamma)}{\beta(1-t_w-r\gamma)+(1-\beta)(1-t_\Pi)(1+t_F)-r\gamma}$$

and firms $1-\beta_F$. In the case of an informal match, on the other hand, workers and firms get a share β and $1-\beta$, respectively of the surplus. By using the above asset value equations, I can derive the expressions for the wage rates.

Substituting for $E_{ij}-U_{ij}$ and Π_{ij}, using equations (8-9) and (14-19), in equations (21) and (22), and noting that $V_j = 0$ (equation 20), I find

$$w_{NF} = \frac{\beta(r+s_F+m_F)\Delta[(1-t_\Pi)p_F+rf]+(1-\beta)(r+s_F)\Gamma b_{NF}}{\Phi_F},$$

(23)

[40] To obtain the worker's share of the surplus in the formal sector, β_F , recall the respective Nash bargaining problem given by :

$$\underset{w_{NF}}{Max}(E_{NF}-U_{NF}-\gamma w_{NF})^{\beta}(\Pi_{NF}-V_F+f+\gamma w_{NF})^{(1-\beta)}$$

Where $(E_{NF}-U_{NF}-\gamma w_{NF})$ is the fraction of the surplus, $S_{NF,}$ associated with the worker.

Rearranging the solution to the Nash bargaining problem in the formal sector (21) I have:

$$(E_{NF}-U_{NF}-\gamma w_{NF}) = \frac{\beta(1-t_W-r\gamma)}{\beta(1-t_W-r\gamma)+(1-\beta)(1-t_\Pi)(1+t_F)-r\gamma} S_{NF}$$

Therefore, a worker in the formal sector gets a share of the surplus :

$$\beta_F = \frac{\beta(1-t_W-r\gamma)}{\beta(1-t_W-r\gamma)+(1-\beta)(1-t_\Pi)(1+t_F)-r\gamma}$$

$$w_{NI} = \frac{\beta(r+s_I+\delta+m_I)(1-\delta\eta)p_{NI}+(1-\beta)(r+s_I+\delta)b_{NI}}{\Phi_I},$$

(24)

$$w_{MI} = \frac{\beta(r+s_I+\delta+m_I)(1-\delta\eta)p_{MI}+(1-\beta)(r+s_I+\delta)b_{MI}}{\Phi_I},$$

(25)

where $\Phi_F = \beta\Gamma\Delta m_F + (r+s_F)\Gamma[\Delta - \gamma(1-\beta)m_F], \Gamma = (1-t_\Pi)(1+t_F) - r\gamma$, $\Delta = 1 - t_w - r\gamma$ and $\Phi_I = r + s_I + \delta + \beta m_I$. In each case, the worker's wage when employed in a particular job is basically a combination of her outside option and her productivity in that job.

2.6 Steady-State Composition of the Labor Force

The following definitions apply regarding the different sub-groups in the labor force:

$$u_{NF} + e_{NF} = \lambda,$$

$$u_{NI} + e_{NI} = 1 - \lambda,$$

$$u_{MI} + e_{MI} = M,$$

where $\lambda \in (0,1)$ and $1-\lambda$ represent the share of native workers in the formal and informal sector, respectively and M denotes the mass of irregular immigrants. The share λ is determined endogenously below. Moreover[41], in steady state, where the flows in and out of unemployment for each sub-group are equal to each other,

[41] Changes in unemployment result from the difference between the flow of workers who lose their job (given the by the separation rate, s_F) and the flow of workers who find a job (given by m_F).

$$u_{NF} = \frac{s_F}{s_F + m_F}\lambda, \quad e_{NF} = L_F = \frac{m_F}{s_F + m_F}\lambda,$$

$$u_{NI} = \frac{s_I+\delta}{s_I+\delta+m_I}(1-\lambda), \quad e_{NI} = L_{NI} = \frac{m_I}{s_I+\delta+m_I}(1-\lambda),$$

(26)

$$u_{MI} = \frac{s_I + \delta}{s_I + \delta + m_I}M, \quad e_{MI} = L_{MI} = \frac{m_I}{s_I + \delta + m_I}M.$$

Next, I can write the expression regarding the probability that a firm finds a native worker in the informal sector as

$$\phi_{NI} = \frac{u_{NI}}{u_{NI}+u_{MI}} = \frac{1-\lambda}{1-\lambda+M}$$

(27)

2.7 Steady-State Equilibrium

As mentioned above, native workers must decide in advance whether to search in the formal or in the informal sector. In making their decision, they compare the values of being in each of the two sectors. In equilibrium, they are indifferent between entering the formal or the informal sector. Therefore, the no-arbitrage condition is given by

$$U_{NF} = U_{NI}.$$

$\dot{U}_F = s_F(1-U_F) - m_F(\theta)U_F$

In steady state $\dot{U}_F = 0$ so $s_F - s_F U_F = m_F U_F$

where $U_F = \frac{u_{NF}}{\lambda}$ is the unemployment rate in the formal sector. The flow into unemployment U_{NF}, is

$$u_{NF} = \frac{s_F}{s_F + m_F}\lambda.$$

The rest of the equations (26) are acquired respectively.

Using equations (8), (17) and (21) to solve U_{NF} equations (9), (18) and (22) to solve for U_{NI}, this equality can be written as:

$$\frac{\beta m_F(1-t_W+s_F\gamma)[(1-t_\Pi)p_F+rf]\Delta+\Gamma\Delta(r+s_F)b_{NF}}{\Phi_F} = \frac{\beta m_I(1-\delta\eta)p_{NI}+(r+s_I+\delta)b_{NI}}{\Phi_I}$$

(28)

where it may be recalled that $\Phi_F = \beta\Gamma\Delta m_F + (r+s_F)\Gamma[\Delta-\gamma(1-\beta)m_F], \Gamma = (1-t_\Pi)(1+t_F)-r\gamma,$ and $\Phi_I = r+s_I+\delta+\beta m_I$

Definition. A steady-state equilibrium is a set $\{\theta_j^*, e_{ij}^*, u_{ij}^*, w_{ij}^*, \lambda^*\}$where $i \in \{N, M\}$ and $j \in \{F, I\}$ such that

1. The intermediate input markets clear (Equations 5,6 and 7);
2. The free-entry condition for vacancies of each sector $j \in \{F, I\}$ is satisfied (Equation 20);
3. The Nash bargaining condition between a worker of origin $i \in \{N, M\}$ and a firm in sector $j \in \{F, I\}$ holds (Equations 21and 22);
4. The numbers of employed and unemployed workers of origin $i \in \{N, M\}$in sector $j \in \{F, I\}$ remain constant (Equation 26);
5. The no-arbitrage condition regarding workers' mobility between sectors is satisfied (Equation 28);

Substituting in the free-entry conditions, I derive the following two equations

$$\frac{c_F}{q_F} = \frac{\Theta_F[(1-t_\Pi)p_F + rf] - (1-\beta)\Psi\Gamma b_{NF}}{\Phi_F} - f$$

(29)

$$\frac{c_I}{q_I} = (1-\beta)\frac{\phi_{NI}[(1-\delta\eta)p_{NI} - b_{NI}] + (1-\phi_{NI})[(1-\delta\eta)p_{MI} - b_{MI}]}{\Phi_I}$$

(30)

where $\Theta_F = (1-\beta)\Gamma\Delta - \Gamma\gamma(1-\beta)m_F - \gamma\beta(r + s_F + m_F)\Delta$, $\Psi = (1-t_\Pi)(1+t_F) + s_F\gamma$ and ϕ_{NI} is defined in equation (27). Next, substituting the steady-state values of L_F and L_I (determined by equations 1, 4 and 26) into the price equations of p_{NI} and p_{MI} (equations 6 and 7) yields

$$p_{NI} = A_I x\left[x + (1-x)\left(\frac{M}{1-\lambda}\right)^\rho\right]^{\frac{1-\rho}{\rho}}$$

$$p_{MI} = A_I(1-x)\left[x\left(\frac{1-\lambda}{M}\right)^\rho + (1-x)\right]^{\frac{1-\rho}{\rho}}$$

Next, substituting the expressions for p_F, p_{NI} and p_{MI} into equations (28), (29)and (30) forms a system of three equations that describes the behavior of the three variables $\{\theta_F, \theta_I, \lambda\}$[42] . Having determined θ_F^*, θ_I^* *and* λ^* I can obtain the equilibrium values for all the other variables by substituting in the appropriate equations.

Proposition 1 (Existeness and Uniqueness). Under certain parameter restrictions, confined in the Appendix, a steady-state equilibrium exists and is unique.

3. Calibration

[42] Recall that m_j is a function of θ_j, $j \in \{F, I\}$

I calibrate the model using data from Greece. I choose the parameters of the model to match the period 2000-2007 in Greece. One period in the model represents 3 months, so all the parameters are interpreted quarterly. In order to perform the model calibration, I have chosen parameter values according to the relevant literature, the national legislation, and the statistics provided by various formal offices for statistics.

Recall the previous assumption that the number of new matches is given by a matching function $M(u,v)$, depending on the number of unemployed workers u and the number of vacancies v. Following the common practice, I assume a Cobb- Douglas function of the form $\mathrm{M(u,v)} = \varepsilon u^{\alpha} v^{1-\alpha}$. I have also previously defined the rate at which an unemployed worker finds a job, is given by $\mathrm{m(\theta)} = \mathrm{M(u,v)/u}$. Following Shimer (2005), I infer the job-finding rate from the dynamic behavior of the unemployment level and short-term unemployment level. Let u_t^s denote the number of workers unemployed for under a quarter in quarter t. Then assuming all unemployed workers find a job with probability m_t in quarter t and no unemployed worker exits the labor force, I have $u_{t+1} = u_t(1-m_t) + u_{t+1}^s$. The unemployment in the next quarter is the sum of the number of unemployed workers this quarter who fail to find a job and the number of newly unemployed workers. Therefore, the job-finding rate is given by $m_t = 1 - \frac{u_{t+1} - u_{t+1}^s}{u_t}$. Given the matching function and the job-finding rate, one can compute the labor market tightness in each sector.

Following, I calculate the separation rate in the formal sector, from data on employment, short-term unemployment and the hiring rate. When a worker loses her job, she becomes unemployed. The separation rate can be computed as the ratio $\frac{u_{t+1}^s}{e_t}$. In this case though, I ignore the fact that the individual can get a new job before she gets recorded as an unemployed. Assuming that during this quarter the individual has half the quarter to find a job before she gets recorded as unemployed, the short-term unemployment equals $u_{t+1}^s = s_t e_t \left(1 - \frac{1}{2} f_t\right)$. Separation rate is then calculated using the formula $s_t = \frac{u_{t+1}^s}{e_t(1-0.5m_t)}$, where u_t^s is the number of native workers unemployed for under a quarter in quarter t, e_t denotes the number of employed

workers in quarter t and m is the job finding rate, given by the formula $m_t = 1 - \frac{U_{t+1} - U^s_{t+1}}{U_t}$. I assume that the separation rate in the informal sector is equal to the one in the formal sector, that is $s_F = s_I$. I use data from Eurostat to obtain the value for the overall unemployment rate, u_{rate}.

Next, I obtain the size of undocumented immigrant workers, M, from the European Commission's Clandestino project. Next, I turn to the value of the proportion of native workers that choose to work in the formal sector, λ. I follow Hazans (2011) who calculates the percentage of labor force employed in the formal sector in southern Europe. I set the probability to get audit, δ, equal to 0.05, which falls in the range suggested by the literature[43]. Next, I set the production parameter ρ=0.85 as in Ottaviano and Peri (2011). I also set x equal to 0.5 and $A_F = 1$. I calculate the size of the informal sector using data from Schneider & Williams (2013).

Following Chassamboulli and Palivos (2013) I calculate the interest rate in the following way: using data from Eurostat, I calculate the average yield to 10- year government bonds and using data from the World Bank I calculate the average growth rate of the Consumer Price Index over the period 2000-2007. Following the common practice, I set the elasticity of the matching function ε=0.5, which satisfies the range given by Petrongolo and Pissarides (2001). I also follow the literature, setting workers bargaining power β=0.5, so that the Hosios condition is met (see Hosios ,1990) I use data from the OECD to calculate the value of the unemployment benefits of the native workers in the formal sector, b_{NFrate}. I calculate the value of the various taxes, namely t_F, t_w and t_Π using data from the OECD taxing wages. Finally, I set the penalty rate, η, as in Di Porto et al. (2016) I set the value of the administrative cost, frate, as in Mortensen and Pissarides (1999) and set the severance payment, γ, equal to 1.

Table 1: Baseline Calibration

Variable	***Value***	***Interpetation***	***Source***
s_F	*0.0072*	*Separation Rate in*	*Authors' calculation*

[43] See for example in Pappa et al. (2015), Boeri and Garibaldi (2007)

		Formal sector	
m_F	*0.082*	*Rate at which a worker finds a job in the Formal sector*	*Authors' calculation*
u_{rate}	*0.1*	*Unemployment rate* $u_{rate}= (u_{NF}+u_{NI}+u_{MI})/ M+1$	*OECD*
M	*0.0562*	*Irregular Immigrants*	*Clandestino, World Bank*
λ	*0.71*	*Percentage of labor force employed in formal sector in Southern Europe*	*Hazans (2011)*
s_I	*0.0072*	*Separation Rate in Informal sector*	*Assume* $S_I=S_F$
δ	*0.02*	*Probability to get audit*	*Di Porto et al. (2013)*
x	*0.5*	*Production function parameter*	*Set*
ρ	*0.85*	*Production function parameter*	*Ottaviano and Peri (2011)*
Y_I/Y_F	*0.274*	*As a % of GDP*	*Schneider and Williams (2013)*
A_F	*1*	*Production function parameter*	*Set*
r	*0.0035*	*Interest rate*	*World Bank*
β	*0.5*	*Worker's Bargaining Power*	*Standard in literature*
ε	*1*	*Matching function parameter*	*Standard in literature*
α	*0.5*	*Matching function parameter*	*Standard in literature*
b_{NFrate}	*0.21*	*Unemployment income*	*OECD*

		in F sector	
t_{Π}	*0.031*	*Tax on profits*	*World Bank*
f_{rate}	*0.78*	*Administrative firing cost*	*Mortensen and Pissarides*
t_F	*0.28*	*Payroll tax*	*OECD Wages and Benefits*
t_W	*0.4*	*Income tax*	*OECD Wages and Benefits*
γ	*1*	*Severance payment*	*Set*
η	*0.42*	*Penalty rate*	*Di Porto et al. (2017)*

4. Simulations

There are three different type of policies that can affect the relative size of the informal sector. I start with the deterrence policies, namely increasing the probability to get audited, δ, and the severity (penalty) of the punishment when a firm gets caught operating in the informal sector, η. These policies do not affect the labor market tightness in the formal sector, and thus formal wages will remain unchanged. Deterrence policies reduce the expected value of a filled value in the informal sector and change the labor market tightness, θ_I, which in turn changes the share of people who choose to work in the formal sector, λ.

The second type is the incentive policies, such as a tax reduction or an increase in the unemployment benefits. These directly affect the labor market tightness and the wages in the formal sector. Consequently, labor market tightness and wages in the informal sector are affected and so is the fraction of workers who chose to participate in the formal sector. Naturally, deterrence and incentive policies are combined to obtain a more desirable result.

The final type of policies I study are immigration policies. These can include an influx of (undocumented) migration, a naturalization or a deportation of a fraction of the (undocumented) migrant population. These policies do not affect the labor market tightness and the

unemployment of the native workers in the formal sector, but they do affect the size of the fraction of native workers to go formal and the size of the informal sector.

Table 2: An increase in the auditing rate, δ.

	Benchmark	(+) 1%	(+) 5%	(+) 10%
	δ=0.02	δ= 0.0202	δ= 0.021	δ= 0.022
u_{NF}	**0.0573**	0.0578	0.0599	0.0620
u_{NFrate}	**0.0807**	0.0807	0.0807	0.0807
u_{NI}	**0.0405**	0.0396	0.0365	0.0332
u_{NIrate}	**0.1396**	0.1399	0.1415	0.1434
u_{rate}	**0.1**	0.0997	0.0988	0.0978
e_{NF}	**0.6526**	0.6589	0.6821	0.7067
e_{NI}	**0.2496**	0.2436	0.2215	0.1981
e_{MI}	**0.0484**	0.0483	0.0482	0.0481
λ	**0.7099**	0.7168	0.742	0.7687
w_{NF}	**0.7437**	0.7437	0.7437	0.7437
w_{NI}	**0.4941**	0.4942	0.495	0.4959
w_{MI}	**0.2964**	0.2938	0.2835	0.2716
Y_I/Y_F	**0.2742**	0.2662	0.2384	0.2109
m_F	**0.0820**	0.0820	0.0820	0.0820
m_I	**0.1677**	0.1684	0.1711	0.1744
θ_F	**0.0067**	0.0067	0.0067	0.0067
θ_I	**0.0281**	0.0284	0.0293	0.0304

I start with a rise in the auditing rate, δ, that does not affect θ_F as one can see from equation (29). Since the only influence of aggregate labor market conditions on the wage occur via θ_F, wages in the formal sector remain intact. The increase of δ leads to an increase of the job destruction in the informal sector, which in turns raises the labor market tightness in the sector, θ_I. The unemployment rate in the informal sector rises, but vacancies fall at a higher rate. More

people decide to go to the formal sector and thus λ rises. All the above lead to a decrease of the relative size of the informal sector and a subsequent rise of the formal employment as well as a decrease of the informal employment. Finally, the overall unemployment rate drops. For a more detailed analysis, see Appendix 6.3. , case 3.

Table 3: An increase in the penalty in the informal sector, η.

		(+) 1%	(+) 5%	(+) 10%
	Benchmark	η=0.4242	η=0.441	η=0.462
u_{NF}	**0.0573**	0.0573	0.0574	0.0575
u_{NFrate}	**0.0807**	0.0807	0.0807	0.0807
u_{NI}	**0.0405**	0.0404	0.0402	0.0400
u_{NIrate}	**0.1396**	0.1395	0.1394	0.1393
u_{rate}	**0.1**	0.1	0.0999	0.0998
e_{NF}	**0.6526**	0.6529	0.654	0.6554
e_{NI}	**0.2496**	0.2494	0.2483	0.247
e_{MI}	**0.0484**	0.0484	0.0484	0.0484
λ	**0.7099**	0.7102	0.7114	0.713
w_{NF}	**0.7437**	0.7437	0.7437	0.7437
w_{NI}	**0.4941**	0.4941	0.494	0.4939
w_{MI}	**0.2964**	0.2963	0.2961	0.2957
Y_I/Y_F	**0.2742**	0.2738	0.2724	0.2707
m_F	**0.0820**	0.0820	0.0820	0.0820
m_I	**0.1677**	0.1677	0.1679	0.1680
θ_F	**0.0067**	0.0067	0.0067	0.0067
θ_I	**0.0281**	0.0281	0.0282	0.0282

Based on the aforementioned arguments, an increase of the penalty rate, η, does not affect labor market tightness in the formal sector, θ_F. Again, θ_I increases and as a result more workers chose to go to the formal sector (λ rises). All these translate to a fall of the relative size of the

shadow sector. Similarly to the case of δ, I find a rise of the formal employment and a reduction of the informal employment and the overall unemployment.

Both the auditing rate and the penalty rate consist deterrence policies. In terms of reduction of the (relative) size of the informal sector, an increase of the former policy seems to be more effective than the latter. This means that a 1% increase of the auditing rate results in a larger reduction of the informal sector than a 1% increase of the penalty rate. On the other hand, one has to consider that the former policy requires more resources in its implementation than the latter. Furthermore, in the case of δ, unemployment rate in the informal sector increases, while it falls in the case of η. In conclusion, an increase in η is a more mild policy than an increase in δ; the labor market tightness increases less and the job destruction is lower. For a more detailed approach, see Appendix 6.3., case 4.

Table 4: A reduction of the payroll tax, t_F.

		(-) 1%	(-) 5%
	Benchmark	t_F=0.2772	t_F=0.266
u_{NF}	**0.0573**	0.0579	0.0601
u_{NFrate}	**0.0807**	0.0807	0.0808
u_{NI}	**0.0405**	0.0393	0.0349
u_{NIrate}	**0.1396**	0.1389	0.1364
u_{rate}	**0.1**	0.0994	0.0972
e_{NF}	**0.6526**	0.6592	0.684
e_{NI}	**0.2496**	0.2436	0.221
e_{MI}	**0.0484**	0.0484	0.0485
λ	**0.7099**	0.7171	0.7441
w_{NF}	**0.7437**	0.7454	0.7519
w_{NI}	**0.4941**	0.4947	0.4975
w_{MI}	**0.2964**	0.2962	0.2954
Y_I/Y_F	**0.2742**	0.2661	0.2377

m_F	**0.0820**	0.0820	0.0819
m_I	**0.1677**	0.1686	0.1723
θ_F	**0.00672**	0.00672	0.00671
θ_I	**0.0281**	0.0284	0.0297

Moving on to incentive policies, I study a decrease of the payroll tax, t_F. This reduction induces job creation, vacancies increase more than unemployment rate and the labor market tightness in the formal sector, θ_F, increases. More people decide to work in the formal sector. The wages of the native workers rise and the size of the informal sector falls. Finally, the informal unemployment falls and thus labor market tightness in the informal sector rises. See more on the Appendix 6.3., case 5.

Table 5: A reduction in the worker's income tax, t_W.

		(-) 1%	(-) 5%	(-) 10%
	Benchmark	t_W=0.396	t_W=0.38	t_W=0.36
u_{NF}	**0.0573**	0.0587	0.0632	0.0666
u_{NFrate}	**0.0807**	0.0804	0.0794	0.0782
u_{NI}	**0.0405**	0.0371	0.0266	0.0182
u_{NIrate}	**0.1396**	0.1377	0.1306	0.1227
u_{rate}	**0.1**	0.0981	0.092	0.0868
e_{NF}	**0.6526**	0.6718	0.7328	0.7847
e_{NI}	**0.2496**	0.2323	0.1774	0.1304
e_{MI}	**0.0484**	0.0485	0.0489	0.0493
λ	**0.7099**	0.7306	0.796	0.8513
w_{NF}	**0.7437**	0.7436	0.7432	0.7427
w_{NI}	**0.4941**	0.4961	0.5042	0.5147

w_{MI}	**0.2964**	0.2958	0.2947	0.2952
Y_I/Y_F	**0.2742**	0.2516	0.1877	0.1407
m_F	**0.0820**	0.0823	0.0835	0.0849
m_I	**0.1677**	0.1704	0.1811	0.1945
θ_F	**0.00672**	0.00677	0.00697	0.00721
θ_I	**0.0281**	0.0290	0.0328	0.0378

A decrease of the income tax gives an incentive to more workers to enter the formal sector, thus increasing λ (see how it directly increases the left-hand side of equation 28). The relative size of the informal sector falls. Unemployment rate in the formal sector falls, so the formal labor market tightness increases. Similarly, unemployment rate in the informal sector falls and the respective labor market tightness rises. As a result, the overall unemployment rate also increases. Net native wages fall in the formal sector, while they increase in the informal sector. For a more detailed approach, see Appendix 6.3., case 6.

Table 6: Replacement Rate in the Formal Sector, b_{NFrate}.

		(+) 5%	(+) 10%
	Benchmark	b_{NFrate}=0.2205	b_{NFrate}=0.231
u_{NF}	**0.0573**	0.0588	0.0603
u_{NFrate}	**0.0807**	0.0822	0.0837
u_{NI}	**0.0405**	0.0396	0.0388
u_{NIrate}	**0.1396**	0.1391	0.1386
u_{rate}	**0.1**	0.1006	0.1012
e_{NF}	**0.6526**	0.6564	0.66
e_{NI}	**0.2496**	0.2453	0.2409
e_{MI}	**0.0484**	0.0484	0.0484
λ	**0.7099**	0.7151	0.7203
w_{NF}	**0.7437**	0.7443	0.7448
w_{NI}	**0.4941**	0.4946	0.495

w_{MI}	**0.2964**	0.2963	0.2961
Y_I/Y_F	**0.2742**	0.2688	0.2635
m_F	**0.0820**	0.0804	0.0788
m_I	**0.1677**	0.1684	0.1690
θ_F	**0.0067**	0.0065	0.0062
θ_I	**0.0281**	0.0284	0.0286

An increase in b_{NFrate} works in two opposite directions; while it directly increases the value of being unemployed in the formal sector, U_{NF}, it also increases u_{NF}, which in turn decreases U_{NF}. An increase of the replacement rate in the formal sector, increases the formal net wage, w_{NF}, and decreases the labor market tightness in the sector, θ_F. This reduction is the result of an increase in the unemployment rate u_{NF} (and a reduction in v_{NF}). Through the no arbitrage condition a change in the labor market tightness in the informal sector, θ_I, is imposed. This is translated to a lower unemployment rate, u_{NI} (and a higher v_{NI}). More people decide to go to the formal sector and thus λ rises. Consequently, the relative size of the informal sector falls. This result is referred in the literature as the Todaro paradox Todaro (1976) shows that creating urban jobs can increase urban unemployment due to the negative effect of rural migration, being stronger than the positive effect of creating jobs. Finally, it is interesting to note that unemployment and employment rates co- move in both sectors. The overall unemployment rises. For more details, see Appendix 6.3., case 2.

Table 7: An increase in the immigrant population, M.

		(+) 1%	(+) 5%	(+) 10%
	Benchmark	M=0.056762;	M=0.05901;	M=0.06182;
u_{NF}	**0.0573**	0.0571	0.0561	0.0549
u_{NFrate}	**0.0807**	0.0807	0.0807	0.0807
u_{NI}	**0.0405**	0.0409	0.0425	0.0446

u_{NIrate}	**0.1396**	0.1396	0.1396	0.1396
u_{rate}	**0.1**	0.1002	0.1009	0.1018
e_{NF}	**0.6526**	0.6499	0.6392	0.6259
e_{NI}	**0.2496**	0.2521	0.2621	0.2746
e_{MI}	**0.0484**	0.0488	0.0508	0.0532
λ	**0.7099**	0.707	0.6954	0.6808
w_{NF}	**0.7437**	0.7437	0.7437	0.7437
w_{NI}	**0.4941**	0.4941	0.4941	0.4941
w_{MI}	**0.2964**	0.2964	0.2964	0.2964
Y_I/Y_F	**0.2742**	0.278	0.2939	0.3144
m_F	**0.0820**	0.0820	0.0820	0.0820
m_I	**0.1677**	0.1677	0.1677	0.1677
θ_F	**0.0067**	0.0067	0.0067	0.0067
θ_I	**0.0281**	0.0281	0.0281	0.0281

Moving on to the immigration policies, I simulate an influx of the undocumented immigrant population, M. As indicated by equation (29), labor market tightness in the formal sector is not affected by a change in M, therefore θ_F remains intact. An increase in M leads λ to adjust so that θ_I remains constant. The resulting rise of 1-λ induces more native workers to participate in the informal sector. Consequently, I observe a rise of the relative size of the informal sector. Since θ_F and θ_I remains constant in both sectors, unemployment in both sectors does not change, but the overall unemployment increases. The employment in the formal sector fall, but the informal employment increases and so is the overall unemployment. See more on the Appendix 6.3., case 1.

Table 8: Naturalization

		1%	10%
	Benchmark	Naturalization	Naturalization
u_{NF}	**0.0573**	0.0575	0.0592

u_{NFrate}	**0.0807**	0.0807	0.0807
u_{NI}	**0.0405**	0.0402	0.0372
u_{NIrate}	**0.1396**	0.1396	0.1396
u_{rate}	**0.1**	0.0998	0.0982
e_{NF}	**0.6526**	0.6552	0.6792
e_{NI}	**0.2496**	0.2472	0.2247
e_{MI}	**0.0484**	0.0479	0.0435
λ	**0.7099**	0.7122	0.7333
w_{NF}	**0.7437**	0.7437	0.7437
w_{NI}	**0.4941**	0.4941	0.4941
w_{MI}	**0.2964**	0.2964	0.2964
Y_I/Y_F	**0.2742**	0.2703	0.2371
m_F	**0.0820**	0.0820	0.0820
m_I	**0.1677**	0.1677	0.1677
θ_F	**0.0067**	0.0067	0.0067
θ_I	**0.0281**	0.0281	0.0281

A naturalization policy decreases the size of the immigrant population and increases the native population. Now more workers have the option to work in the formal sector and thus λ rises. Naturally, I observe a reduction of the size of the informal sector. Again, since a change in M does not affect the labor market tightness in either sector, the respective unemployment rates remain unchanged. Formal employment rises, while informal employment and overall unemployment falls. Finally, I do not observe any change in wages, as all labor market changed are imposed into the wage equations through the labor market tightness.

Table 9: Combined Polices

	(I)	(II)	(III)	(IV)

		δ=0.0202	δ=0.0202	η=0.4242	η=0.4242
	Benchmark	t_W=0.396	t_F=0.2772	t_W=0.396	t_F=0.2772
u_{NFrate}	**0.0807**	0.0804	0.0807	0.0804	0.0807
u_{NF}	**0.0573**	0.0592	0.0584	0.0588	0.0579
u_{NIrate}	**0.1396**	0.1381	0.1393	0.1377	0.1389
u_{NI}	**0.0405**	0.0363	0.0385	0.0371	0.0393
u_{rate}	**0.1**	0.0979	0.0992	0.0981	0.0994
e_{NF}	**0.6526**	0.6775	0.6654	0.6721	0.6595
e_{NI}	**0.2496**	0.2269	0.2377	0.2321	0.2433
e_{MI}	**0.0484**	0.0484	0.0484	0.0485	0.0484
λ	**0.7099**	0.7368	0.7238	0.7309	0.7174
w_{NF}	**0.7437**	0.7436	0.7454	0.7436	0.7454
w_{NI}	**0.4941**	0.4962	0.4949	0.496	0.4947
w_{MI}	**0.2964**	0.2932	0.2936	0.2957	0.2961
Y_I/Y_F	**0.2742**	0.2448	0.2586	0.2513	0.2658
m_F	**0.0820**	0.0823	0.0820	0.0823	0.0820
m_I	**0.1677**	0.1710	0.1693	0.1704	0.1686
θ_F	**0.00672**	0.00677	0.00672	0.00677	0.00672
θ_I	**0.0281**	0.0292	0.0287	0.0290	0.0284

Finally, I present some combined policies. Scenario (I) involves a 1% increase of the auditing rate, δ and a 1% reduction of the workers' income tax, t_W. Scenario (II) involves a 1% increase of the auditing rate, δ and a 1% reduction of the payroll tax, t_F. Scenario (III) involves a 1% increase of the penalty rate, η and a 1% reduction of the workers' income tax, t_W. Scenario (IV) involves a 1% increase of the auditing rate, η and a 1% reduction of the payroll tax, t_F. In all scenarios, I have a decrease in unemployment rates in both sector, as well as the overall unemployment rate. However, scenario (I) is the most effective in terms of reducing the overall unemployment and the unemployment in the formal sector. Furthermore, in this case the fraction

of people who choose to participate in the formal sector, λ, is the highest. Also, in all scenarios the size of the immigrant sector falls. In scenario (IV) the drop is the highest of all cases and it is followed by scenarios (II), (III) and (I). Finally, it is worth noting that formal wages fall in scenarios (I) and (III), while they rise in (II) and (IV).

5. Conclusions

I construct a search and matching model with two sectors, a formal and an informal. The two sectors differ in the sense that the formal sector is regulated; firms and workers are subject to paying taxes. Firms bear some firing costs and workers are entitled to unemployment benefits. The informal sector is unregulated but firms can get audited and if caught they have to pay a penalty and the match is terminated. There are two types of workers; natives, who can choose in which sector they want to work and irregular immigrants who can only be employed in the informal sector. I calibrate the model for the Greek economy for the period 2000-2007 and conduct various experiments on different policies, namely deterrence, incentive and immigration policies.

Starting with the deterrence policies, I observe that an increase in the auditing rate,δ, or the penalty rate, η, will not affect the labor market tightness or the wages in the formal sector. Increasing the auditing rate seems to be more effective in terms of reducing the size of the informal sector, while it also reduces more the overall unemployment rate and rises more the fraction of workers who chose to search for a job in the formal sector. Despite this, one should note that increasing the auditing rate requires more resources than increasing the penalty rate

In terms of a reduction of the size of the informal sector, decreasing the workers' income tax is the most effective incentive policy. This is also the only incentive policy reducing the unemployment rate in the informal sector and the one reducing the most the unemployment in the informal sector, as well as the overall unemployment. These come in the cost of a reduction of the formal wages, while they rise in both the other policies studied. Finally, in this case the fraction of people who decide to work in the formal sector is the highest. Another policy that is

effective in reducing the relative size of the informal sector is an immigration amnesty. The opposite is true for an influx of the (undocumented) immigrant population.

Finally, I find that the best option is to impose a policy mix. A combination of a reduction of the workers' income tax, t_W, and an increase in the auditing rate, δ, provides the best results in the reduction of the relative size of the informal sector.

Future research suggestions include the introduction of a government budget constraint that will provide more policy instruments. Furthermore, the model allows for additional policy experiments, e.g. an increase in the profit tax, the severance payment or the administrative costs.

6. Appendix

6.1 Restrictions on Parameter Values

To ensure that all types of workers are employed, all surpluses must be positive. Given the Nash sharing rule this requires that $\Pi_{NF} + f + \gamma w_{NF}$, Π_{NI} and Π_{MI} are all positive. For $\Pi_{NI} > 0$, it is necessary and sufficient to assume that $(1-\delta\eta)p_{NI} > b_{NI}$; similarly, $\Pi_{MI} > 0$, iff $(1-\delta\eta)p_{MI} > b_{MI}$. Finally, a necessary and sufficient condition for the employability of native workers in the formal sector, i.e., $\Pi_{NF} + f + \gamma w_{NF} > 0$, is

$$(1-t_{\Pi})p_F > \frac{(1-t_{\Pi})(1+t_F) - r\gamma}{1-t_w+\gamma s_F} b_{NF} - rf.$$

This implies that the output from a match between a native worker and a vacancy in the formal sector exceeds the worker s outside option.

The assumption that $(1-\delta\eta)p_{NI} > b_{NI}$ guarantees also that $\Pi_{NI} > V_I = 0$. Thus, a firm that meets a native worker will form an employment relation and will not decide to wait for an irregular immigrant.

6.2. Proofs

Proof of Proposition 1: From equation (29), I have

$$\frac{\Phi_F}{q_F} = \frac{\Theta_F[(1-t_{\Pi})p_F + rf] - (1-\beta)\Psi\Gamma b_{NF} - \Phi_F f}{c_F},$$

where

$\Theta_F = (1-\beta)\Gamma\Delta - \Gamma\gamma(1-\beta)m_F - \gamma\beta(r+s_F+m_F)\Delta, \Phi_F = \beta\Gamma\Delta m_F + (r+s_F)\Gamma[\Delta - \gamma(1-\beta)m_F], \Gamma = (1-t_{\Pi})(1+t_F) - r\gamma, \Delta = 1-t_w - r\gamma,$

and $\Psi = (1-t_{\Pi})(1+t_F) + s_F\gamma$.

Note that

$$\frac{d\left[\frac{\Phi_F}{q_F}\right]}{d\theta_F} = \frac{q_F \frac{d\Phi_F}{d\theta_F} - \Phi_F \frac{dq_F}{d\theta_F}}{q_F^2}$$

For $\frac{d\left[\frac{\Phi_F}{q_F}\right]}{d\theta_F} > 0$, I need to have $\frac{dq_F}{d\theta_F} < 0$ (which already holds), $\Phi_F > 0$ and $\frac{d\Phi_F}{d\theta_F} > 0$ which are both satisfied when

$$\beta\Delta > (1-\beta)\gamma(r + s_F).$$

(A.1.)

Similarly, I have

$$\frac{d\left[\frac{\Theta_F[(1+t_\Pi)p_F + rf] - (1-\beta)\Psi\Gamma b_{NF} - \Phi_F f}{c_F}\right]}{d\theta_F} = \frac{1}{c_F}\left[[(1+t_\Pi)p_F + rf]\frac{d\Theta_F}{d\theta_F} - f\frac{d\Phi_F}{d\theta_F}\right].$$

For $\frac{d[\frac{\Theta_F[(1+t_\Pi)p_F+rf]-(1-\beta)\Psi\Gamma b_{NF}-\Phi_F f}{c_F}]}{d\theta_F} < 0,$

I need to have $\frac{d\Theta_F}{d\theta_F} < 0$, which requires $-\gamma[\Gamma(1-\beta) + \beta\Delta] < 0$ and $\frac{d\Phi_F}{d\theta_F}$. The latter requires condition (A.1.) to hold.

Furthermore, $\lim_{\theta_F \to 0} \frac{\Phi_F}{q_F} = 0$ and $\lim_{\theta_F \to \infty} \frac{\Phi_F}{q_F} = \infty$ if condition (A.1.) holds. To ensure that there exists a unique solution of θ_F for equation (29), I need to have

$$\lim_{\theta_F \to 0} \frac{\Theta_F[(1+t_\Pi)p_F + rf] - (1-\beta)\Psi\Gamma b_{NF} - \Phi_F f}{c_F} > 0.$$

This is satisfied when

$$(1-\beta)\Gamma\Delta - \gamma\beta(r+s_F)\Delta[(1+t_\Pi)p_F + rf] > (1-\beta)\Psi\Gamma b_{NF} + (r+s_F)\Gamma\Delta$$

From equation (28), I have

$$\frac{\beta m_I(1-\delta\eta)p_{NI}+(r+s_I+\delta)b_{NI}}{\Phi_I} - \Sigma_F = 0,$$

where the expression of Σ_F is given by

$$\Sigma_F = \frac{\beta m_F(1-t_w+s_F\gamma)[(1+t_\Pi)p_F + rf]\Delta + \Gamma\Delta(r+s_F)b_{NF}}{\Phi_F}.$$

Define

$$\Upsilon_I = \frac{\beta m_I(1-\delta\eta)p_{NI}+(r+s_I+\delta)b_{NI}}{\Phi_I} - \Sigma_F.$$

Note that for a given value of θ_F I have

$$\frac{d\Upsilon_I}{d\theta_I} = \frac{\beta[(1-\delta\eta)p_{NI} - b_{NI}](r+s_I+\delta)\frac{dm_I}{d\theta_I}}{\Phi_I^2} > 0.$$

Furthermore, to have a unique value of θ_I that solves equation (28), I require

$$\lim_{\theta_I \to 0} \Upsilon_I = b_{NI} - \Sigma_F < 0,$$

and

$$\lim_{\theta_I \to \infty} \Upsilon_I = (1-\delta\eta)p_{NI} - \Sigma_F > 0.$$

Finally, I substitute the values of θ_F and θ_I into equation (30) to obtain a unique value of λ.

6.3 Cases

Equation (30) becomes

$$\frac{c_I \Phi_I}{q_I(1-\beta)} = (1-\delta\eta)p_{MI} - b_{MI} + \frac{1-\lambda}{1-\lambda+M}[(1-\delta\eta)(p_{NI} - p_{MI}) - (b_{NI} - b_{MI})],$$

(A.2.)

the left-hand side of above equation increases in θ_I. If there is a policy that changes θ_I, the right-hand side will adjust λ to make this equality hold. In particular, when θ_I rises, $1-\lambda$ increases if $(1-\delta\eta)(p_{NI} - p_{MI}) > b_{NI} - b_{MI}$.

(A.3.)

Alternatively, $1-\lambda$ reduces if

$(1-\delta\eta)(p_{NI} - p_{MI}) < b_{NI} - b_{MI}$,.

(A.4.)

Case 1: the impact of an increase in M

Equation (28) includes p_{NI} on the right hand side, which in turn includes M. An increase in M causes (1-λ) to adjust so that the ratio M/(1-λ) remains constant. As a result of this, and given equation (29) θ_F and θ_I are not determined by M. Thus, an increase in M will not have an effect on the unemployment rate in both sectors. Furthermore, using equation (30) I show that $1-\lambda$ increases in M, implying that irregular immigration induces more native workers to participate in the informal sector.

Case 2: the impact of an increase in b_{NF}

Using equation (29), an increase in b_{NF} lowers θ_F indicating a higher unemployment rate in the formal sector. I show that the left-hand side of equation (28) increases in θ_F if the following condition holds.

$$(1-t_{\Pi})p_F + rf > \frac{-\beta\Gamma\Delta-(1-\beta)\gamma\Gamma(r+s_F)}{\beta\Delta(1-t_w+s_F\gamma)} b_{NF}.$$

(A.5.)

An increase in b_{NF} lowers θ_F and in turn lowers the left-hand side of equation (28). It also directly increases the left-hand side. How b_{NF} affects the left-hand side depending on the magnitude of these two forces that work in opposite directions. The first force results from the fact that an increase in b_{NF} increases u_{NF}, which in turn decreases the value of being unemployed in the formal sector, U_{NF}. The second force is the direct effect b_{NF} on U_{NF}; an increase in b_{NF} raises the value of being unemployed in the formal sector. As the right-hand side of equation (28) increases in θ_I, θ_I reduces when the net effect of b_{NF} on the left-hand side is negative. If θ_I reduces, $1-\lambda$ increases when condition (A.4.) is true.

Case 3: the impact of an increase in δ

From equation (29), it is clear that θ_F is not determined by δ. Therefore, when there is a change in δ, θ_F will remain unchanged. Using equation (28), I have

$$h_F(r+s_I+\delta+\beta m_I) - (r+s_I+\delta)b_{NI} = \beta m_I(1-\delta\eta)p_{NI}$$

where I define

$$h_F = \frac{\beta m_F(1-t_w+s_F\gamma)[(1+t_{\Pi})p_F+rf]\Delta + \Gamma\Delta(r+s_F)b_{NF}}{\Phi_F}.$$

I further simplify the above equation as

$$(r+s_I+\delta)(h_F-b_{NI}) = \beta m_I[(1-\delta\eta)p_{NI}-h_F]. \qquad \text{(A.6.)}$$

I show that it is possible that θ_I increases in δ if $(1-\delta\eta)p_{NI} > h_F > b_{NI}$. If θ_I increases, $1-\lambda$ decreases when condition (A.4.) is true.

Note that an increase in δ increases the left-hand side of equation (A.2.) through Φ_I.

Case 4: the impact of an increase in η

From equation (29), it is clear that θ_F is not determined by η. Therefore, when there is a change in η, θ_F will remain unchanged. Using equation (A.6.), I show that θ_I increases in η if $(1-\delta\eta)p_{NI} > h_F > b_{NI}$. If θ_I increases, $1-\lambda$ decreases when condition (A.4.) is true.

Case 5: the impact of an increase in t_F

From equation (29), I have

$$\frac{\Phi_F}{q_F} = \frac{\Theta_F[(1+t_\Pi)p_F + rf] - (1-\beta)\Psi\Gamma b_{NF} - \Phi_F f}{c_F}$$

I show that

$$\frac{d\Phi_F}{dt_F} > 0.$$

Under the conditions for existence and uniqueness of steady-state equilibrium, I show that θ_F increases in t_F. From equation (28), the left-hand side increases in θ_F if condition (A.5.) holds.

Moreover, an increase in t_F can directly decrease the left-hand side of equation (28). How an increase in t_F affects the left-hand side depends on the magnitude of two forces that work in opposite directions. If t_F lowers the left-hand side, it will lower θ_I as the right hand side of equation (28) increases in θ_I. If θ_I decreases, $1-\lambda$ increases when condition (A.4) is true.

Case 6: the impact of an increase in t_w

From equation (29), I have

$$\frac{\Phi_F}{q_F} = \frac{\Theta_F[(1+t_\Pi)p_F + rf] - (1-\beta)\Psi\Gamma b_{NF} - \Phi_F f}{c_F}.$$

I show that

$$\frac{d\Phi_F}{dt_w} < 0,$$

and

$$\frac{d\Theta_F}{dt_w} < 0.$$

Under the conditions for existence and uniqueness of steady-state equilibrium, I show that θ_F decreases in t_w.

Furthermore, if $(1-t_\Pi)p_F + rf > 0$, the right-hand side of above equation increases in t_w. From equation (28), the left-hand side increases in θ_F if condition (A.5.) holds.

Moreover, an increase in t_w can directly decrease the left-hand side of equation (28). Therefore, t_w lowers the left-hand side, it will thus lower θ_I as the right-hand side of equation (28) increases in θ_I. If θ_I decreases, $1-\lambda$ increases when condition (A.4.) is true.

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