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Estimating Shadow Economy Size in Greece 2000 - 2018: A Flexible MIMIC Approach

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Abstract

Greek economy suffers from economic crisis for over a decade. A continuing problem has been the persistence of a large shadow economy which results in a gap between the tax and social security contribution owed and collected. In this paper, the size of shadow economy (SE) in Greece is estimated using a flexible MIMIC approach with time series data from 2000 to 2018. Our variables focused on instead of in most representative data of the Greek economy as causes (e.g. unemployment, self–employment, epidemic etc.) and indicators (official economy, energy consumption, income inequality and poverty, labour force participation). We found that the average size of shadow economy in Greece was up to 37.63% for the reference period, above the average size of other studies up to 23.35%. The study focuses on the significance of each determinant of the shadow economy, resulting in an improved estimation method to identify and tackle shadow transactions and increase public revenues.

JEL Classification: O17, C20, D73, E26.
Keywords: Greek economy; shadow economy; estimation; flexible MIMIC Model.

1. Introduction

There are many definitions of the shadow economy (Tanzi, 2002; Boeke, 1953; Lewis, 1954; Smith, 1994; Kuznetsova and Kuznetsova, 2015). Most common definition (Koufopoulou et al., 2019) argues that the shadow economy is all market-based legal production of goods and services that are deliberately concealed from public authorities in order to avoid taxes and social security contributions, labour regulations and other administrative procedures (Chen et al., 2020). There are also many alternative terms used to describe this activity, including the informal, underground, black and non-observed economy (Koufopoulou et al., 2019).

Medina and Schneider (2019) estimate the shadow economy in 157 countries to be an average 30.9% of official GDP over the period 1991 to 2017. Its highest estimates are in Bolivia, Georgia and Nigeria where it accounts for 62.9%, 61.7% and 56.8% of GDP respectively. The lowest estimates are in Austria, USA and Switzerland where it accounts for 7.9%, 7.6% and 6.4% of GDP respectively. These illegal transactions affect the economy by distorting economic policies and market mechanisms via unfair firm competition (Hajilee et al., 2017; Schneider and Hametner, 2014; Zaman and Goschin, 2015). It also leads to income inequality (Kar and Saha, 2012) and results in tax evasion and corruption which reduces public revenues and the quality of public services (Gonzalez–Fernandez and Gonzalez–Velasco, 2014).

Unregistered economic activities are well established in the Greek economy and many methods have been used for the estimation of its size. Pavlopoulos (1987) estimated the shadow economy by using a discrepancy method and found that in 1984 it was 28.6% of GDP. Negreponti–Delivani (1991), Vavouras et al. (1990) and Tatsos et al. (2001) have used the Currency Demand Approach revealing the average size of the shadow economy to be 11%, 26.6% and 30.1% over the periods 1958–1988 and 1967–1997. In addition, Kanellopoulos et al. (1995) estimates the shadow economy's size between 27.6% (1982) to 34.6% (1988) by comparing data from the Household Budget Surveys with the private consumption registered in National Accounts. Besides these methods, multifunctional models are being used (Chen et al., 2020; Zukauskas and Schneider, 2016; Awad and Allazeh, 2020). The most used methods are Structural Equation Model, Error Correction MIMIC Model, Multiple Indicators–Multiple Causes Model and Two–Sector General Equilibrium Model. For the last two, the shadow economy is a latent variable (Elgin and Oztunali, 2012; Hayat and Rashid, 2020) based on a structural equation model construction and a macroeconomic model focused on shadow transactions' causes and consequences.

Many methods have been therefore used for shadow economy estimation (Schneider and Williams, 2013; Dybka et al., 2020). Dellas et al. (2017) with Dynamic Stochastic General Equilibrium model counted the shadow economy as 26% of GDP over the period 2010–2015. One of the most credible estimation approaches is the MIMIC approach (Medina and Schneider, 2019; Boitano–Castro and Aranda, 2019; Dell' Anno et al., 2007; Kelmanson et al., 2019). Dell' Anno et al. (2007), Gauci and Rapa (2020), Schneider et al. (2010) and Schneider and Buehn (2012) by using this method noticed that shadow economy over the periods 1968–2002, 1999–2007 and 1999–2010 ranged between 26% and 28%. An alternative method of the MIMIC model is the DYMIMIC approach. Schneider and Savasan (2007) used this method and found that shadow economy in Greece was about 29.44% over the period 1999–2005. The present paper makes use of the above mentioned model, by taking into account the COVID-19 pandemic as a parameter influencing the shadow economy in Greece, thus aiming to contribute to the research of the field (Berdiev et al., 2020).

Specifically, we use a flexible MIMIC model over the period 2000–2018 based on the Chen et al. (2020) paper, interpreting the shadow economy's causes and effects. This research is

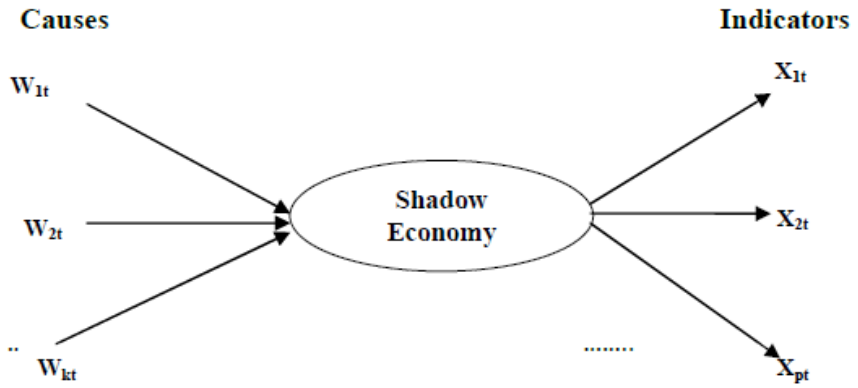
undertaken for three reasons: first, to measure Greece's shadow economy as precisely as possible and therefore provide reliable information; second, to check and develop the causes of the Greek shadow economy; and third, to provide suggestions for tackling the shadow economy. In Section 2, detailed information is given about MIMIC model approach. In Section 3, shadow economy's causes and indicators are then analyzed. In Section 4, Greece's shadow economy is measured over the 2000–2018 period by constructing a new flexible MIMIC model. Finally, in Section 5 we provide discussion and some policy suggestions to prevent and tackle the shadow economy, based on its instead of its determinants.

2. MIMIC model approach for the shadow economy estimation.

The model of multiple indicators - multiple causes comes from factor analysis of Zellner (1970), Joreskog and Goldberger (1975), Frey and Weck (1983, 1984) with further additions (Aigner et al., 1988; Giles, 1999; Giles et al., 1999). It is a Structural Equation Model (Mueller, 1996) based on the statistical theory of unobserved variables, using an analytical factor to estimate the shadow economy as an unobserved variable (Rocque et al., 2019). It takes into account the determinants divided into causes and indicators (Medina and Schneider, 2019).

Figure 1.

"Shadow Economy depiction with MIMIC Model"



Source: Own remarks, from Buehn and Schneider (2013).

Based on the statistical idea of a sample frame of variation of the observed variables, it includes a parametric structure through one hypothetical model. Unobserved and observed variables are linked to a measurement model, utilizing variation information between observed variables. Estimation of parameters with coefficients and variations and the evaluation of the application of the model is done by using a confirming factor. Shadow activities analysis begins by estimating the relationship between variables with indicators and causes and the identification of theory data or hypotheses. It contains a Structural Equation and a measurement model (Schneider, 2018). In the Structural Equation Model the unobserved variable η_t, results from a set of exogenous causes $x'_t = (x_1, x_2, \ldots .., x_{qt})$ 'which can be useful in predicting its mobility and size, and are subject to structural disturbance error term ς_t. The structural equation is expressed as follows:

$$\eta_t = \gamma' x_t + \varsigma_t \quad (1)$$

where γ' is a q vector sequence of structural parameters. Additionally, in measurement model the latent variable η_t, identifies a p vector $y'_t = (y_1t, y_{2,}\ldots., y_p)$ 'of the indices, reflecting observed variables, which are subject to a p vector of random error terms $\varepsilon'_t = (\varepsilon_1, \varepsilon_2, \ldots .., \varepsilon pt)$ '. Thus, unobserved variable η, is a scale and λ is a vector p column of the parameters that correlate y_t and η_t. Measurement equation is as follows:

$$y_t = \lambda\eta_t + \varepsilon_t \tag{2}$$

Substituting equation (1) to equation (2) yields a reduced form of equation expressing the relation between observed causes and indices, between x_o and $y_{o,}$ as shown in equation (3):

$$y_o = \Pi x_o + z_o \tag{3}$$

where $\Pi = \lambda y$' is a reduced form correlation coefficient and $z_o = \lambda_{\varsigma o} + \varepsilon_o$ is a vector of a linear transformation form of a disorder having a reduced form coefficient frame Ω given as:

$$\Omega = \mathrm{Cov}\,(z_o) = \mathrm{E}\,[(\lambda\varsigma_o + \varepsilon_o)(\lambda\varsigma_o + \varepsilon_o)'] = \lambda\psi\lambda' + \Theta_\varepsilon \tag{4}$$

where $\psi = Var\ (\varsigma_o)$ and $\Theta_\varepsilon = E\ (\varepsilon_o\varepsilon_o')$ are the coefficient of variation of the measurement error. In essence, it uses data sample correlation information to derive estimates of population parameters. Zero the distance between an observed (sample) covariance table and the covariance table predicted by the model that the researcher imposes on the data. A structural element of this approach is that the correlation table of the observed variables is a function of the model parameters:

$$\Sigma = \Sigma\,(\theta) \tag{5}$$

where Σ is the population of the covariance table of the observed variables, θ is a vector containing the parameters of the model and $\Sigma(\theta)$ is the covariance table as a function of θ, implying that each element of the covariance table is a function of one or most parameters of the model. If the hypothetical model is correct and the parameters are known, the population of the correlation table will be accurately reproduced, and, Σ will be equal to $\Sigma(\theta)$. Population fluctuations and covariates or parameters are unknown, but the sample estimates of the unknown estimation parameters are used (Bollen, 1989).

Davidescu and Scheider (2019) argue that the shadow economy is caused by unemployment, quality of regulation, self-employment and indirect taxation, and its size in Romania equal to 27.8% of official GDP. Boitano-Castro and Aranda (2019) estimated the shadow economy in Latin America as around 34%, while in OECD countries it is around 19.83%. Furthermore, Chen et al. (2020) showed that the shadow economy in 30 Chinese provinces ranged from 13.55% (1995) to 14.39% (2009) and then declined to 12.3% in 2016, over the period 1985-2016. Also, Angour and Nmili (2019) estimated the shadow economy as 38.74% of GDP in Morocco for the period 1985-2016.

The shadow economy is estimated only at relative values, while measurement errors occur due to the use of certain ad hoc econometric specifications (Hassan and Schneider, 2016). Since there are no conclusions at microeconomic level, a huge data set is used to fulfill the state of stagnation and regularity. A subjective selection of variables is also developed where some indicators such as unemployment are used alternately as causes or as indicators (Fedajev and Arsic, 2017). These models ensure formal evaluation and testing procedures, such as those with the least probability method, mostly known and applicable to large sample (Giles and Tedds, 2002). In addition, the formulated hypotheses are unlimited (Cassar, 2001) for the application of selected variables (Thomas, 1992). It prevailed over other estimation methods (Schneider and Enste, 2000) due to its flexibility. However, there have been

criticisms of the application of the model, the sample, the reliability of the estimates (Schneider, 2018) and the conceptual definition of the shadow economy (Helberger and Knepel, 1988; Dell' Anno, 2003). Structural Equation Model estimations lead to unstable coefficients which are minimized by increasing the sample and alternative model specifications (Helberger and Knepel, 1988). Time series data is an issue as only simple analytical tools are available to analyze the properties of the balance (Dell 'Anno, 2003).

3. Determinants

3.1.1. Tax and social security burden.

Over–taxation and social security contributions (Manolas et al., 2013a) create complex tax systems (Schneider and Neck, 1993) and facilitate individuals' participation in illegal activities (Koyuncu and Unal, 2019). In essence, individuals and legal entities evade taxes, aiming at higher profits and firms at labor cost reduction (Buehn and Schneider, 2013) by depriving employees of basic rights (FEIR, 2012). Indicative, global labor cost index in 2020 ranged from 96.4 in Japan to 1.225 in New Zealand, while Greece counted to 112.5. Medium incomes are burdened by reducing competitiveness and incentives for formal employment of skilled workers (Pissarides et al., 2020). This raised shadow economy from 35% up to 42% (Schneider and Williams, 2013). Regarding the extent of tax and social security burden, we use real tax revenue as a percentage of real GDP and hypothesize that:

Hypothesis 1: The larger the tax and social security burdens, the larger shadow economy.

3.1.2. Quality of institutions and corruption.

Institutions include formal rules and unwritten laws shaping human behavior (North, 1991), based on trust assuring good governance (European Commission, 2001; Canh et al., 2021). With high bureaucracy and selective regulation application (Buehn and Schneider, 2013) their quality is at stake (Medina and Schneider, 2018). In the meantime, proper law implementation assures less corruption and lower shadow economy (Medina and Schneider, 2017) promotes healthy entrepreneurship and clearly growth (Berdiev and Saunoris, 2020; Owusu-Nantwi and Owusu-Nantwi, 2021). This affects the shadow economy from 10% to 17% (Schneider and Williams, 2013). Focusing on the quality of institutions effectiveness and corruption relationship, we use 4 of 6 of the World Governance Indicators (voice and accountability, political stability and absence of violence/terrorism, government effectiveness, control of corruption) and hypothesize that:

Hypothesis 2: The higher the degree of corruption, the lower is the institutional quality which means a larger shadow economy size.

3.1.3. Regulations.

The regulatory framework consists of a set of rules and decisions shaping society's function. Its implementation is delayed (Johnson et al., 1998) when corruption increases (Friedman et al., 2000; Mazhar, 2015) with a larger share of GDP absorbed by the shadow economy (Schneider, 2018). However, there is a possibility that excessive regulation can increase labor costs by facilitating shadow work (Hassan, 2011). That is why perhaps the cost of starting a business exceeds tax and social security burden, being the initial step of their official operation. Extent of regulatory framework in a country, interprets shadow economic activities size (Russo, 2018) estimating them from 7% and 15.88% (Schneider and Williams, 2013; Schneider, 2000). Willing to locate the degree of the effect of the regulatory framework to the shadow economy, we use 2 of 6 of the World Governance Indicators (regulatory quality, rule of law) and hypothesize that:

Hypothesis 3: Many regulations are associated with a larger shadow economy.

Hypothesis 4: Lower degree of regulations increases shadow economy.

3.1.4. Public services.

Public services affect shadow economy size mostly through tax administration function and business organization, with tax evasion reduction. Tax collection power determines identification and imposition of offenders' sanctions and fines (Manolas et al., 2013a) with multiplied tax rates on it by shadow economy (Schneider, 2010). Johnson et al. (1998) found increased corruption and shadow economy in Latin America as in former Soviet Union countries, characterized by fiscal instability and weak rule of law. Countries under fiscal surveillance, is appropriate to public sector size elimination (Giles, 1998) in order to reduce public spending. A recent study proved that Greece (Gwartney et al., 2020) is one of the 15 countries with the largest state mechanism size. Contributes to shadow economy size from 5% to 9% (Schneider, 2009). In order to ascertain the extent of public services to shadow economy in Greece, we use government spending as a percentage to GDP hypothesized that:

Hypothesis 5: An excellent public services organization eliminates shadow economy size.

3.1.5. Tax morale.

One of the most decisive shadow economy factors is tax morale (Schneider, 2019) measuring taxpayer's attitude towards their tax obligations (Torgler, 2012) related to social development (Manolas et al., 2013b). This captures a social contract between citizens and state based on high tax compliance (Torgler, 2007). It is due to demographic (Bunescu and Comaniciu, 2011) and additional costs with lost reputation (Schneider, 2018). Slippery slope approach explains tax morale focusing on competitive or cooperative relation of taxpayers and state, within the context of mandatory or voluntary compliance (Kastlunger et al., 2013). Taxpayer's costs and benefits determine the paid amounts, through their marginal tax rate and income (Allingham and Sandmo, 1972). Offenders' detection is increased by controls and fines' imposition via determination of non – compliance cost. Additionally, is achieved by estimating tax gap between the tax capacity and the actual tax revenue (Castro and Ramirez, 2014). In US economy is estimated up to €285 billion, because of the strong tax collection mechanism (Toder, 2007). In Greece reached €19.9 billion (Murphy, 2019) confirming tax morale low level, strong family ties and low trust level (Mare et al., 2020). It is calculated with voluntary compliance level by recording the percentage of tax that is voluntarily paid to the amount of tax that had to be declared, where the latter is equal to declared plus the additional tax, in a scale between 0 and 100 (Kanellopoulos, 2002). Even though public revenue strengthened by Single Property Tax in Greece, it still remains lower than Eurozone average, due to the complicated legislation and the lack of taxpayer's trust to the tax administration (Pissarides et al., 2020). It contributes to shadow economy from 22% to 25%, and it is classified second after tax and insurance burden (Schneider, 2009). Therefore, in order to count for tax morale's significance in shadow economy size we use total tax revenue as a percentage of real GDP hypothesized that:

Hypothesis 6: Tax morale's higher rate assures higher degree of tax compliance and lower shadow economy size.

3.1.6. Deterrence

Deterrence refers to people who satisfy their desires and take into account subjective motives (Pedersen, 2003), costs and benefits by seeking to maximize their usefulness (Paternoster, 2010). Taxpayers are prevented from participating in shadow economy when they are afraid of being identified (Pedersen, 2003). This is due to different fines and sanctions depending on

crime's seriousness and the actual offender's income or ignorance audits' frequency, by tax authorities. Fines and sanctions have negative impact on shadow economy as the risk of identifying offenders is subjective. Shadow economy (based on Granger's causality test) affects deterrence approach more than the other way around (Granger, 1969; Schneider, 2018). Thus, trying to identify the significance of deterrence approach on shadow economy we use tax revenue (current LCU) in billion euros and hypothesize that:

Hypothesis 7: Highest deterrence measures causes highest level of shadow economy.

Hypothesis 8: Lower deterrence measures facilitates shadow economy expansion.

3.1.7. Self – employment

Self - employment favors shadow transactions occurrence including voluntary characteristics in contrast to paid employment with dependency (Bosch and Maloney, 2010). It is difficult for employees to hide their income, as happens with self - employed (Medina and Schneider, 2018). This is inextricably linked to shadow work in a family business with direct production control and taxpayers' remuneration (FEIR, 2012). In Southern Europe, survival is the main concern of self - employed low-income, while better paid Scandinavians have the willingness to participate (Williams et al., 2012). However, willing to estimate the degree of self–employment in shadow transactions we use it as a percentage of the total employment and hypothesize that:

Hypothesis 9: Higher self–employment percentage means shadow economy expansion.

3.1.8. Unemployment

Unemployment reflects economic recession and labor market rigidity, with shadow workforce (Pavlopoulos, 1987) and has a strong causal relationship with shadow economy (Dobre et al., 2010). The shadow economy, affects formal economy positively as 2/3 of its income is spent on formal transactions (Schneider and AT Kearney, 2013, Nguyen et al., 2020). Dobre and Alexandru (2009) studied unemployment effect on Spanish shadow economy through a structural equation model. Ranged from 18% to 22% of GDP, with individuals having privileges but lack of public tax revenues. Intending to evaluate unemployment's contribution to shadow economy's size we use the percentage of unemployment in the total labor participation and hypothesize that:

Hypothesis 10: Highest unemployment level means higher shadow economy size.

3.1.9. Agricultural sector

Rural societies have abysmal resistance to shadow trade (Conroy, 2013) with increased employment (Angel–Urdinola and Tanabe, 2012) as a result of the industrial pressures for reduced cost (Williams, 2018). The higher is the share of agricultural sector in GDP (Schneider et al., 2021), the more likely is for someone to participate in shadow economy (Vuletin, 2008) as in Jamaica where 45% of agricultural activity is conducted illegal (Wedderburn et al., 2012). Regarding agricultural sector affection in Greece, we use agricultural employment as a percentage of the total employment and hypothesize that:

Hypothesis 11: Higher level of agricultural employment means higher shadow economy size.

3.1.10. Cash use

Extensively use of cash, especially outside of banks, consists an indicator of high shadow economy, although many shadow transactions take place inside the formal sector (Medina and Schneider, 2018; Chan et al., 2021; Marmora and Brenden, 2021). A remarkable study of Esselink and Hernandez (2017) focused on the use of cash in EU. They found that Greece,

Cyprus and Malta (72%-75%), Lithuania, Slovakia, Austria, Spain, Italy and Slovenia lead in cash transactions (62%-68%). Cards and other means of payment by consumers in 2016 were used by 45%-54% less in Netherlands, Estonia and Finland. Since, most of transactions in shadow economy are payed with cash we use a number of cards with a cash function–issued by resident PSPs and hypothesize that:

Hypothesis 12: Highest cash use, means increased card use and higher shadow economy size.

3.1.11. Migration

Migration affects shadow economy (Kasimati and Panagiotopoulou, 2018). In a European Commission study was found that it is a positive effect on destination country's GDP by 0.1%-0.2% yearly, however the real wage was reduced by 0.1% due to the lower wages of immigrants compared to locals. It is sufficient that migration improves native's skills, immigrants' business activity and their homeland economic growth (European Commission, 2016). For example, economic growth in Ethiopia ranged between 8.8% 12.4% (Foged and Peri, 2016) and in Greece, social security system has changed (BoG, 2016). Regarding shadow economy size we use data about inflows of asylum seekers by nationality and hypothesize that:

Hypothesis 13: Highest migration level, without regulations, increase shadow economy.

3.1.12. Education

Education and shadow economy are interconnected (Ela, 2013; Buehn and Farzanegan, 2013) emphasizing on overall attitude towards life and knowledge acquisition. Children's inadequate education motivates them to engage in shadow and criminal activities (Guloglu et al., 2003). Unfortunately, education stimulates shadow economy with increased opportunity costs (Gerxhani and Van de Werthorstm, 2013). According to Stefoni and Draghia (2020) education and government efficiency have direct impact on shadow economy, since the higher level of education obstruct people from acting informally. It has been noticed that shadow economy has estimated with higher rates in countries where the implemented general educational programs were based on the educational system. Private is superior to public sector in specialized staff and vocational education contributes negatively to students' shadow employment (Keneck–Massil and Noah, 2019). Public education expenditures and higher education policies have negative impact on shadow economy (Berritella, 2015) but sometimes not spreading the phenomenon (Kodila–Tedika and Mutascu, 2014). We use data from Gross Domestic Spending on research and development as a percentage of GDP and hypothesize that:

Hypothesis 14: Lower educational level fuels shadow economy due to weak political institutions.

3.1.13. Social transfers.

Benefits (pensions, unemployment benefits, etc.) although stimulate consumption in formal economy, give to participants a strong incentive to enter in shadow activities (Bajada and Scheinder, 2009; Kemal, 2007; Schneider, 2000; Ulus, 2002; Almenar et al., 2020). Unemployed persons are vulnerable having low incomes, based on tax returns and accept to participate in shadow actions deprived of labor rights (lower, tax-free and uninsured remuneration) (Palaiologos and Kassar, 2003). They contribute to shadow economy from 5% to 9% (Schneider, 2009). In an era of pandemic crisis we would like to examine the relation between social transfers and shadow economy so we use data about family benefits as a percentage of GDP and hypothesize that:

Hypothesis 15: Increased allowance of family benefits means shadow economy highest size.

3.1.14. Epidemic.

Shadow sector workers (ILO, 2020) have been greatly affected by the COVID - 19 pandemic. Developing world has shadow economic activities up to 80% of the population (Narula, 2020) redefining goods and services demand (Bracci et al., 2020). Berdiev et al. (2020) found that a 10% increase in epidemic intensity leads to a 2.1% increase in the shadow economy. One of the sectors absorbing vibrations is health care with increased out of pocket healthcare expenditures, as it happens in Greece (Kousi et al., 2021; Mariolis et al., 2021; Peppou et al., 2020; Giannopoulou and Tsobanoglou, 2020). Based on this phenomenon, we use data of out of pocket expenditure as a percentage of current health expenditure and hypothesize that:

Hypothesis 16: Highest health out of pocket payments, highest likelihood for shadow economy.

Table 1: Shadow economy variables and effect to the official economy

Variables	Effect	Variables	Effect
Tax and social security burden	+	Unemployment	+
Quality of institutions and corruption	+	Agricultural sector	+
Regulation	+	Cash use	+/-
Public services	+	Migration	+/-
Tax morale	-	Education	-
Deterrence	+/-	Social transfers	+
Self – employment	+	Epidemic	+

Source: Own remarks, based on Chen et al. (2020).
Note: "+" means the variable has positive effect on the shadow economy, "-" means the variable has negative effects on the shadow economy and "+/-" means that is still unclear the effects of these variables to shadow economy.

3.2. Indicators of shadow economy

3.2.1. Official economy

Basic means of capturing the economy's function is GDP (Easton and Veldhuis, 2001). There exists a positive correlation between the formal and the shadow GDP (Dell 'Anno, 2008; Afonso et al., 2020; Mansour and Zaki, 2020; Yuvali and Yildiz–Contuk, 2020) and the shadow economy enhances growth otherwise it is restricted (Feld and Schneider, 2010). It demolishes statistics reliability (Negreponti-Delivani, 1991) and causes national economy uncertainty, us false data were used on Greece's EMU entrance (Vavouras and Manolas, 1999). Business activity is paused as monetary policy is limited to deal with changes in the business cycle (Pavlopoulos, 2002) with financial system malfunctions (Tatsos et al., 2001), secret transactions, precarious operation of capital markets and credit restriction (Danopoulos and Znidaric, 2007). Another case is the total debt effect on it. Berger et al. (2014) argued that formal economy's total debt in Greece feeds shadow economy, which increased since the country entered EMU positively related to debt-to-GDP ratio stabilizing economy. Moreover, banking system has a positive affect to shadow economy (Lui–Evans and Mitra, 2019; Affandi and Malik 2020), high lending rates (Patrick and Akanbi, 2017), flexible working, shadow work and unemployment (Tatsos et al., 2001). Evasion of social security contributions has a negative effect in flexible labor market prolonging working life and reducing benefits in social security system (Petrakis, 2012). Seeking to explore the reaction

of official and shadow economy we use data, as a percentage of Gross Domestic Product and hypothesize:

Hypothesis 17: Better regulated official economy assures lower size of public debt, better economic development and lower shadow economy size.

3.2.2. Energy consumption.

Energy consumption is a shadow economy indicator (Schneider and Buehn, 2018; Schneider and Enste, 2000, Wiseman, 2013; Suslov and Ageeva, 2009). Energy sum of formal and shadow sector consumption, and energy consumption output is defined for a specific period when productivity is stagnant, so an increase in shadow economy size will expand energy consumption (Novkovska and Novkovski, 2018). Hence, we use the growth rate of total energy consumption as a proxy for energy consumption. Since Greece is energy node we use data about total energy consumption, as ktep via Interactive chart and hypothesize that:

Hypothesis 18: Higher energy consumption growth means an increased shadow economy size.

3.2.3. Income inequality and poverty.

Income inequality and poverty are shadow activities culmination for vulnerable groups such as flexibly employed, sick, large and single-parent households, minor children (Kanellopoulos, 2015). Low income pushes people to act informally (Ocran, 2018; Alanon and Gomez-Antonio, 2005) and living in absolute or relative poverty. Absolute means lack of basic means of subsistence (Mitrakos and Tsakloglou, 2012) while relative one focuses on household living with an income below 60% of the average European income (Matsaganis and Leventi, 2011). In Greece, due to high tax burdens and social security contributions insurance (Vassiliades et al., 2018) relative poverty reached up to 25.5% in years 2009-2010 (Mitrakos, 2014). Subsequently, increase in the average income widens wage gap between men and women by 13% (OECD, 2020; Avraam and Popova, 2020). Elgin and Elveren (2019) besides positive they argued for a negative one between poorer and lower income countries with higher participation of women in employment. Income inequality promotes shadow economy but at the same time its expansion contributes to income inequality (Berdiev and Saunoris, 2019) being the culmination for poverty spread in developing and transition countries (Elijah and Uffort, 2007). Shadow economy is a mechanism against poverty with produced income to occupy a small part of family income, as demonstrated by Nguyen et al. (2013). They found that in Vietnam 1/3 of the respondents were poor without additional income from shadow activities while 10.34% of them are poor even though they have shadow income. Undoubtedly, the Greek economy is affected by poverty and shadow economy as a result of the economic crisis worsening income distribution (Gasteratos et al., 2016) and that's why we use data about income inequality via Gini Index and hypothesize that:

Hypothesis 19: Higher income inequality level causes higher poverty level and highest shadow economy size.

3.2.4. Labor force participation.

Low labor force participation rate means high shadow economy (Medina and Schneider, 2018). Labor market is inelastic, so those with minimal employment opportunities in the formal labor market are entering to shadow economy evading taxes and social contributions. According to Arsic et al. (2015) Serbian unemployment in 2015 rise up to 26.1% with similar rates in Spain, Italy, Republic of Northern Macedonia and Greece. In Greek case over the period 2000-2018 unemployment rate was 15.86%. In our paper we use data about labor

participation rate, as a percentage from the ratio of people participating in the economy divided by the number of people of working age and hypothesize that:

Hypothesis 20: Lower labor force participation rate is caused by high shadow economy size.

Table 2: Shadow economy indicators and effect to the official economy

Variables	Effect	Variables	Effect
Official economy	+/-	Income inequality and poverty	+
Energy consumption	+	Labour force participation	-

Source: Own remarks, based on Chen et al. (2020).

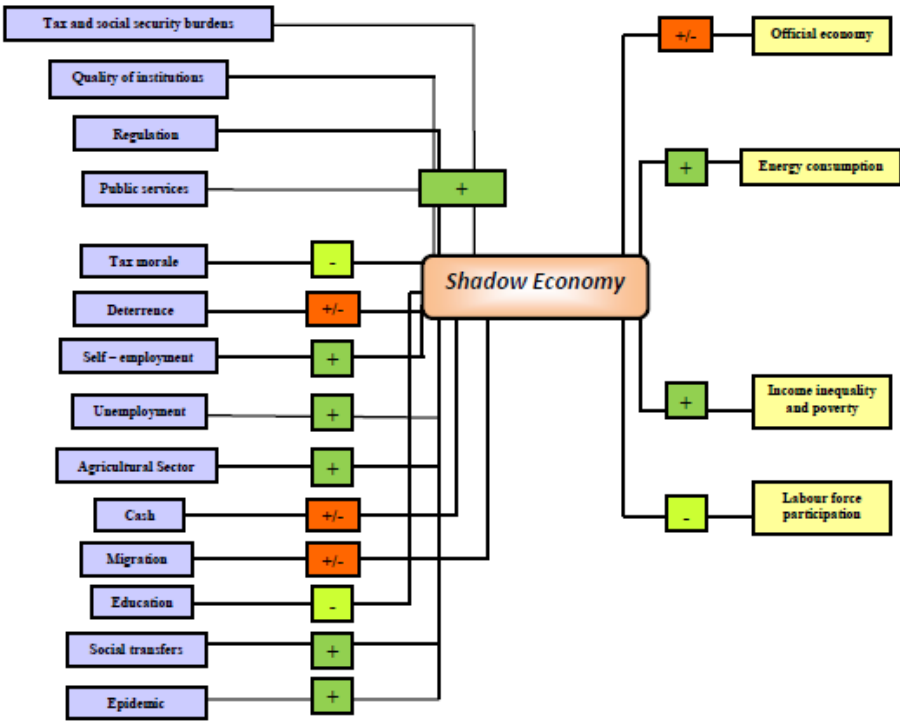
Note: "+" means the variable has positive effect on the shadow economy, "-" means the variable has negative effects on the shadow economy and "+/-" means that is still unclear the effects of these variables to shadow economy.

4. The MIMIC Analysis of the shadow economy in Greece.

4.1. Variables and data.

According to the theoretical analysis of causes and indicators of the shadow economy, 14 causes and 4 indicators are considered in this paper, and all variables and their expected signs are presented in Figure 2.

Figure 2: Flexible multiple indicators and multiple causes (MIMIC) model for shadow economy in Greece.



Since we check out the stationarity of all variables we use Equation (1) to put all variables to series with an expected mean value of 0 in order to meet the requirements of MIMIC analysis.

$$x^*_{jit} = (x_{jit} - \bar{x}_{ji}); y^*_{jit} = (y_{jit} - \bar{y}_{ji}) \quad (1)$$

when,

j, represents Greece

i, represents 18 variables

t, represents the year base (2004).

4.2. Empirical results of MIMIC analysis on the Greek shadow economy.

We apply SPSS Amos 23 about MIMIC analysis of Greece's shadow economy and best estimations are presented in Table 3. Furthermore, we report five MIMIC estimation models in Table 3, Model 1 is the baseline model, and the coefficients of most variables have the theoretical expected signs although their fitness is not good, except for the variable of energy consumption *(ENER)*. For the indicator variable of *TBURD*, we confirm its significant positive effect on shadow economy size. Also, in Models 2, 3 and 4zze, the positive affection of *ENER* to shadow economy closely to *SOTRA* contribution with growing significance of *SELF* and *TBURD*.

According to the fit indices of these MIMIC estimation models, there is no doubt that model 5 is the best one; however, χ^2 should be used carefully because it only works for large samples and multinomial distributions, and RMSEA is a more reliable fit index (Dell' Anno and Mourao, 2012; Dell' Anno and Dollery, 2014). With respect to calculating the size of the shadow economy in Greece; we use model 5, which has the best fitness, to construct the shadow economy index. Equation (2) represents the estimation model of shadow economy in Greece for the period 2000-2018.

SE = -0.064**TBURD* – 0.093**QUIC* + 0.000**REG* + 0.093**PSERV* + 0.942**SELF* - 0.032**UNEMP* - 0.325**EMPA* + 0.647**SOTRA* *(2)*

Table 3. "MIMIC Model shadow economy estimation results for Greece"

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Causal variables					
TBURD	0.543 (***)	0.367 (***)	0.605 (***)	0.575 (***)	**-0.064 (0.002)**
QUIC	-0.041 (***)	-0.057 (***)	-0.050 (***)	-0.053 (***)	**-0.093 (***)**
REG	-0.063 (***)	-0.040 (***)	-0.075 (***)	-0.070 (***)	**0.000 (0.569)**
PSERV					**0.093 (0.038)**
TMOR	-0.872 (***)	-0.522 (***)	-0.991 (***)	-0.996 (***)	
DETT	0.000 (***)	0.000 (***)	0.000 (***)	0.000 (***)	**0.000 (***)**
SELF	0.412 (***)	0.466 (***)	0.702 (***)	0.696 (***)	**0.942 (***)**
UNEMP	-0.055 (***)	-0.061 (***)	-0.052 (***)	-0.042 (***)	**-0.032 (***)**
EMPA	-0.126 (***)	-0.296 (***)	-0.184 (***)	-0.176 (***)	**-0.325 (***)**
CASH	0.000 (***)	0.000 (***)	0.000 (***)	0.000 (***)	**0.000 (***)**
MIGR	0.000 (0.144)	0.000 (0.263)	0.000 (0.027)		
EDU	-2.517 (***)	-4.181 (***)			
SOTRA		0.854 (***)	0.434 (***)	0.383 (***)	**0.647 (***)**
EPID	0.027 (0.035)				
Indicators					
OFF	-5.798 (0.211)	-5.798 (***)	-5.798 (0.139)	-5.798 (0.143)	**-5.798 (0.263)**
ENER	0.894 (***)	0.894 (0.282)	0.894 (***)	0.894 (***)	**0.894 (***)**
INEUR	-0.034 (0.511)	-0.034 (0.571)	-0.034 (0.436)	-0.034 (0.441)	**-0.034 (0.556)**
LPR	0.165 (***)	0.165 (***)	0.165 (***)	0.165 (***)	**0.165 (***)**
Fit indices					
χ^2	791.544	804.974	720.760	611.801	**579.140**
(p)	0.000	0.000	0.000	0.000	**0.000**
RMSEA	0.558	0.563	0.571	0.564	**0.164**
CFI	0.139	0.141	0.148	0.172	**0.546**

Note: The multiple indicators and multiple causes (MIMIC) estimation in Greece was made using SPSS Amos 23.0 and model 5 in the final model used to estimate the size of the shadow economy in Greece. The coefficient of variables, degree of significance and Z-statistics are reported in the table, and *, ** and *** denote significance at 1%, 5% and 10% significance levels. For the fit indices, the model is acceptable when p is higher than 0.05, the root mean square error of approximation (RMSEA) is smaller than 0.2, the comparative fit index (CFI) is higher than 0.5.

4.3. The size of the shadow economy in Greece.

We need two steps to calculate the size of the shadow economy using the MIMIC model: first, obtain a shadow economy index by using Equation (2); second, calibrate the size of the shadow economy using a specific value obtained from other methods or other's research. In our paper we use the latest estimation result on the size of Greece's shadow economy in 2004, from Schneider (2015), to make the calibration. Furthermore, equation (3) will be used to undertake the calibration:

$$SE_{i,t} = \eta_{i,t} \frac{SE^*_{2004}}{\eta^*_{2004}} \quad (3)$$

In Equation (3), $SE_{i,t}$ is the size of shadow economy in Greece i in year t, η_t is the value of shadow economy index in Greece i in year t, η^*_{2004} is the average value of the shadow economy index in Greece in 2004, and SE^*_{2004} is the size of Greece's whole shadow economy in 2004 as estimated by Schneider (2015); its value is 28.1%. Taking into account all determinants in model 5 as causes, we can estimate the size of the shadow economy in Greece presented in Table 4. A general remark is that shadow economy in Greece for all period of 2000-2018 is over 37.63%, above all official estimations due to shadow economy underestimation since there is no strict registration of shadow economic activities by official authorities. Two years before Greece entered in EMU (2000–2001) shadow economy was 38.46%. Also, the period 2002–2003, just before the Olympic Games showed that shadow economy was around 38.99% and reached at the highest level, of the survey period, in 2004 gathering 39.54% of GDP. It means that the real size of shadow economy is higher due to false registration of economic activities in public authorities along leading Greece's EMU entrance. The next fourteen years (2005–2018) shadow economy is estimated around 37.11%, with slow decreasing tense and an exception in 2009 showing 39.12%. The last year of surveyed period in 2018 shadow economy size in Greece was 34.74% of GDP.

Table 4.

"Size of shadow economy in Greece using flexible MIMIC model"

Year	% of GDP	Year	% of GDP
2000	38.55	2010	38.15
2001	38.38	2011	37.3
2002	38.87	2012	37.29
2003	39.11	2013	36.18
2004	39.54	2014	35.85
2005	39.4	2015	35.62
2006	39	2016	35.26
2007	38.67	2017	35.23
2008	38.68	2018	34.74
2009	39.12		

Note: This result is calculated using the MIMIC model 5, and is represented by the percentage of shadow economy to GDP. The values in the table are the average size of shadow economy for the period 2000-2018.

Furthermore, we attempt to forecast shadow economy size (Kdiladze and Metrevelli, 2016) in Greece from 2019 to 2028. We use a time-series forecasting model (Stock, 2001a, b) showed by equation (4):

$$y_{t+h} = g(X_t, \theta) + \varepsilon_{t+h} \quad (4)$$

Where y_t, denotes shadow economy variable to be forecast, t denotes the present year 2021, h is about the forecast horizon from 2019 until 2028, X_t denotes the variables are used in 2021 to make the forecast, θ is a vector of parameters of the function g and ε_{t+h} refers to the forecast error. Usually, the variables in X_t include current and large values of y_t . It is appropriate to define the forecast error in equation (4) such that it has conditional mean zero, which is:

$$E(\varepsilon_{t+h}|X_t) = 0$$

Thus given the predictor variables X_t, under mean squared error loss the optimal forecast of y_{t+h} is its conditional mean, $g(X_t, \theta)$. So, this forecast model is infeasible, since neither g and θ are known. The task of the time-series forecast model of shadow economy is to select the predictors X_t to approximate g, and to estimate θ in a way that the resulting forecasts are reliable and have mean-squared forecast errors as close as possible to that of the optimal infeasible forecast.

Our shadow economy forecasting model is multivariate time-series model (Stock, 2001a, b) when X_t includes multiple time-series that usefully contribute to forecasting y_{t+h}. We chose this model type, due to empirical experience and by theory, eg shadow economy theory is based in multiple causes of its existence. The multivariate extension of the univariate autoregression is the vector autoregression (VAR), in which a vector of time-series variables, Y_{t+1}, is presented as a linear function of $Y_t,\ldots, Y_{t-p+1}$, perhaps with deterministic terms (an intercept or trends). Also, our model contains a large number of unknown parameters, a problem which is grandly exacerbated when nonlinearities are introduced. Conceptually, the extension of univariate nonlinear models to the multivariate setting is straight-forward. In practice, however, because of the relatively small number of time-series observations available to economic forecasters, it is unclear how best to implement nonlinear multivariate models and there are currently no definite conclusions in this area. By 2028, the average size of shadow economy in Greece will be 33.04%, instead of 34.74% in 2018 (Table 5).

Table 5. "Shadow economy size in Greece based on forecasting model, 2019-2028"

Year	% of GDP
2019	**34.66**
2020	**34.37**
2021	**34.09**
2022	**33.81**
2023	**33.54**
2024	**33.26**
2025	**32.99**
2026	**32.72**
2027	**32.45**
2028	**32.18**

5. Discussion & Conclusions.

Shadow economic activities attract scientific interest for almost seven decades (Koufopoulou et al., 2019). Regarding Greek economy's particularity with many structural problems (Katsikas and Bazoti, 2021) it was the trigger for the shadow economy study (Pavlopoulos, 1987; Schneider, 2019). Its size is estimated via direct and indirect methods (Schneider, 2019; Dell' Anno et al., 2007). Scholars, latest years, mostly used flexible multifunctional models by taking into account more than one cause regarding shadow economy as a latent variable (Rocque et al., 2019) instead of direct methods that use one cause (Schneider, 2019).

We chose MIMIC model because its flexible, containing causes and indicators (Schneider, 2015) of Greek economy's situation over the period 2000-2018. Its determinants focused on domestic problems (tax and social security burden, corruption and institutional quality, regulations, official economy, income inequality and poverty, self-employment etc) as well as data about epidemic crisis. The results show an average size around 37.63% ranging from 38.55% in 2000 to 34.74% in 2018, reflecting a false data that official estimations has taken into account the previous years. According to our forecasting model, shadow economy size on average rises up to 33.04%. This is much higher than average size of 23.35% in other studies, for six decades. Conducted studies, previous years revealed different shadow economy size, based on various estimation methods. Initially, researchers used Currency Demand Approach (Vavouras et al., 1990; Negreponti-Delivani, 1991; Tatsos et al., 2001; Schneider and Enste, 2000) with average size of 24.38% for the period 1958 – 1997. In the following years, the mostly used method is MIMIC model (Dell' Anno et al., 2007; Buehn and Schneider, 2012; Schneider, Buehn, 2012, Schneider, 2015, 2018, 2019, Reimers et al., 2020) with size ranged from 22.4% to 29%, over the period 1968-2019. In few studies (Pavlopoulos, 1987; Dellas et al., 2017; Kanellopoulos et al., 1995; Manolas and Vavouras, 2001; Schneider, 2004; Medina and Schneider, 2017, Alarcon-Garcia et al. 2020, Szulc-Obloza, 2020; Remeikiene et al., 2019; Remeikiene et al., 2014) was found an increase average size up to 34,95%. Most likely this is due to many different study periods and Greek's case determinants. Public services have a lack of credible data causing a false shadow economy estimation such as misregistration of unemployed individuals. Analyzing Greece's shadow economy causes using MIMIC model, we found 14 causes. Most of them *SOTRA, SELF* and *PSERV* have a total positive effect on shadow economy size. As far as 4 indicators, the highest impact on shadow economy's size had *ENER* and *LPR.*

Our research provides policy implications for shadow economy prevention, management and combating strategies. First, tax system is one of shadow economy most important driving forces. To prevent shad ow economic activities, the government should try to lighten the tax burden and at the same time, lessen residents' awareness of taxation through tax system simplification, as happens in US and Australian economy. Also, expanding the proportion of direct tax in total tax revenue is crucial for achieving effective tax regulation, which is conducive to preventing shadow economic activity. Second, the government should also try to improve institutions quality and public services, strengthening the rule of law and reducing corruption to provide an excellent environment for official economy development. Thirdly, public authorities should develop practices tax morale improvement through education and awareness raising campaigns on the benefit on a legal basis operating. Also, government should adopt a strategy against unemployment, multiply official agricultural employment in order to increase regional growth and simplify labor and tax laws for the self-employed in order eliminate tax evasion. Furthermore, cash usage must be disincentivized and the use of debit and credit cards promoted. Additionally, a new digital system should be created in order to detect the offenders before the illegal action combining with stricter Penal Code's sanctions, with no suspensive character so as offenders to be punished. Regarding the above,

public authorities must apply internal audit (Rodosthenous et al., 2016) and risk management (Stiglitz, Pieth, 2016) practices in order to eliminate shadow economic activities.

In sum, this paper has provided an estimation of the shadow economy. The flexible method adopted here allows special characteristics of the Greek economy to be taken into account. Given the size of the shadow economy identified, the need for action is revealed. Here, the determinants that need to be tackled have been identified. If this stimulates government action, then the intention of this paper will have been fulfilled.

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Appendix

VARIABLES AND DATA

Table 1: "Definition and sources of variables"

Variable	Definition	Source
TBUR	Tax burden, real tax revenue as a % of real GDP	1
QUIC	World Governance Indicators (voice and accountability, political stability and absence of violence/terrorism, government effectiveness, control of corruption)	2
REG	World Governance Indicators (regulatory quality, rule of law)	2
PSERV	Government spending as % to GDP	3
TMOR	Total tax revenue, as % of real GDP	4
DETT	Deterrence, as tax revenue (current LCU) Greece in billion euros	4
SELF	Self-employment, as a % of total employment	4
UNEMP	Unemployment, as a % of total labour participation	5
EMPA	Employment in agricultural sector as a percentage of total employment	3
CASH	Number of cards with a cash function - issued by resident PSPs – from Greece	6
MIGR	Migration flows, as inflows of asylum seekers by nationality	1
EDU	Education, as Gross Domestic Spending on R&D (% of GDP)	1
SOTRA	Social transfers, as family benefits (% of GDP)	1
EPID	Epidemic data, through out of pocket expenditure (% of current health expenditure).	7
OFF	Official economy, as % of Gross Domestic Product (GDP)	8
ENER	Total Energy Consumption, as ktep via Interactive chart	9
INEUR	Income inequality via Gini Index.	10
LPR	Labour participation rate, as a % from the ratio of people participating in the economy divided by the number of people of working age.	3

Sources: 1. OECD Database. **2.** World Bank Database (2000, 2002-2018), Kaufmann et al. (2002): Governance Matters II: Updated Indicators for 2000-2001, Policy Research Working Paper No. 2772, World Bank (2001). **3.** Global Economics. **4.** World Bank Database. **5.** Hellenic Statistical Authority. **6.** European Central Bank Database. **7.** WHO Database. **8.** Statista (2000-2011), Trading Economics (2012-2018). **9.** Enerdata. **10.** Eurostat, EU-SILC.

Table 2: "Shadow economy size in Greece, 2000-2018"

Year	% to GDP
2000	**28,7**
2001	**28,2**
2002	**28**
2003	**28,2**
2004	**28,1**
2005	**27,6**
2006	**26,2**
2007	**25,1**
2008	**24,3**
2009	**25**
2010	**25,4**
2011	**24,3**
2012	**24**
2013	**23,6**
2014	**23,3**
2015	**22,4**
2016	**22**
2017	**21,5**
2018	**20,81**

Sources: Buehn, Schneider (2012), Schneider (2015, 2019).