The Shadow Economy in Cyprus: Evidence from the Electricity Consumption and Currency Demand Methods

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Abstract

The recent pandemic has brought about a renewed interest in estimating the size of the shadow economy as governments are striving to find additional revenues to support the fast declining economic activity and finance their substantial public deficits. This paper provides new estimates of the shadow economy in Cyprus using two different macro approaches; the energy consumption method (ECM) (Kaliberda and Kaufmann, 1996) and the currency demand approach (Tanzi, 1980, 1983). To the best of our knowledge, this is the first paper that applies the energy consumption approach for estimating the shadow economy focusing only on Cyprus. The empirical analysis covers a more recent period, using quarterly data for the period 1995-2018, during which the Cypriot economy has undergone significant structural changes such as financial liberalization, the abolition of capital controls, accession to the European Union, the adoption of the Euro as well as the recent banking crisis. During this period the average size of the shadow economy in Cyprus based on the currency approach is estimated around 11-18% of GDP while for the electricity consumption the respective estimates are on average between 25%-34%.

Keywords: black economy, underground economy, macroeconomic approach, time-series methods

1. Introduction

In the last decades, there has been a renewed interest in estimating the size of the shadow economy in many countries around the globe. The extent of the shadow economy is undoubted of interest to governments, researchers and policymakers.[1]

The shadow economy results, among other things, in reduced tax revenues and lower quantity and quality of public goods and services available to the society. Economic indicators like growth, unemployment and other key indicators do not reflect the actual socioeconomic situation in a country. Thus, decisions made by public authorities may not be the optimal ones. The recent

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[1]The shadow economy is known under different names such as black, hidden or informal economy (Schneider & Dell'Anno, 2003; Schneider, 2016; Smith, 1994). For instance, Dell'Anno (2003) defines the shadow economy as "those economic activities and the income derived from them that circumvent government regulation, taxation or observation". Another definition given by Smith (1994) is "the market-based goods and services, whether legal or illegal that escape detection in the official estimates of GDP".

pandemic and its devastating effects on global economic activity provide a renewed impetus on shadow economies. Public finances are under tremendous pressures in an environment of heightened public expenditures and reduced revenues. As a result, governments have a vested interest in knowing the size of the shadow economy and the additional revenue that can be extracted. In light of the above, this study aims to re-estimate the size of the shadow economy in Cyprus.

The shadow economy, being the unobservable part of the economy, is challenging to estimate. In fact, there is no universal agreement on what exactly constitutes a shadow economy. Disagreements go beyond the definition of the shadow economy into estimation methods. The literature presents alternative definitions of the underground economy, without specifying the specific activities of the shadow economy as well as their measurements. The broader definition of the shadow economy, according to Feige (1979) includes all the activities that are not registered. In other words, these are activities that are not captured by the definition of GDP and could be illegal or legal activities for monetary or non-monetary transactions. Examples of illegal activities include drug dealing, barter of drugs, or producing drugs for own use. On the legal side, examples include unreported income from self-employment, wages from unreported work, barter of legal services and goods, doing-your-self (DIY) activities or neighbour help. Other researchers use a narrow definition of the shadow economy (e.g. Tanzi 1980, Macafee 1980, Schneider and Buehn, 2017) where criminal activities are excluded. According to this definition, shadow economy consists of a series of market-based activities which, however, escape detection in the official estimates of GDP. In this paper, the definition adopted refers to market-based activities that are hidden from the authorities, and therefore are neither taxed nor included in national statistics.

Several studies have tried to estimate the shadow economy in Cyprus (Georgiou & Syrichas, 1994; Pashardes and Polycarpou, 2008, Fethi, and Katircioglu, 2006). Particularly, Georgiou and Syrichas (1994) utilized the currency approach similar to Tanzi (1980, 1983) to estimate the shadow economy in Cyprus for the period 1960-1990. Pashardes and Polycarpou (2008) used the micro household approach to uncover the extent to which Cypriot households underreport their income and which sources of income (e.g., self-employment, capital income, agriculture) are more prone to tax evasion. Fethi et al. (2006) employed monetary and non-monetary methods (employment discrepancy; simple currency ratio; transaction and currency demand) over the period 1960-2003 to investigate the size of the Cypriot underground economy empirically. Other studies provide estimates of the shadow economy in Cyprus using multi-country estimation methods. These are derived from cross-sectional analyses using indirect approaches such as multiple indicators, multiple causes estimation (Buehn and Schneider, 2012; Dell'Anno et al., 2007; Medina, Jonelis, and Cangul, 2018; Hassan and Schneider, 2016; Wang, Lin, and Yu, 2006).[2]

This paper provides new estimates of the level of the shadow economy in Cyprus using two different macro approaches; the energy consumption method (ECM) of Kaliberda and Kaufmann (1996) and the currency demand approach of Tanzi (1980, 1983) for the recent period 1995-2018. To the best of our knowledge, this is the first paper that applies the energy consumption approach for estimating the shadow economy in Cyprus. The empirical analysis aims to cover the more recent period, using annual and quarterly data for the period 1995-2018, during which the Cypriot economy has undergone significant structural changes such as financial liberalization, the

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[2] A brief overview for each approach and method used for the estimation of the shadow economy is given in the Section 2.

abolition of capital controls, accession to the European Union, the adoption of the Euro as well as the recent banking crisis. We find that during this period the average size of the shadow economy in Cyprus based on the currency approach is estimated around 13-20% of GDP while for the electricity consumption the respective estimates are on average between 25%-34%.

The rest of the paper is organized as follows: Section 2 briefly reviews the relevant literature and Section 3 describes the data, measurement, and methodology. Section 4 discusses the empirical results of the shadow economy in Cyprus, and Section 5 concludes the paper.

2. Literature Review

Estimation of the shadow economy is challenging due to its unobservable nature. Alternative methods try to quantify the size of the shadow economy broadly divided into two main categories, the micro (direct) and macro (indirect) approaches. Direct methods are based on surveys and tax audits that allow insights into the characteristics and structure of the shadow economy. These methods, however, are static preventing in most cases comparisons over time as well as across different countries. In contrast, indirect methods rely on macro variables and indicators to capture the shadow economy, allowing such comparisons. This paper focuses on macro approaches.

2.1 Indirect (Macro) Approaches

The advantage of the indirect methods vis-a-vis direct methods is their dynamic nature as well as their cross-country comparability. Such methods include the currency demand, electricity consumption, and national income versus national expenditure, official versus real labour force, the transaction and the model approach.

The currency demand approach (CDA) assumes that all transactions in the shadow economy are paid in cash so that authorities cannot detect them. In that case, an increase in the size of the shadow economy will increase the demand for a currency. Tanzi (1980, 1983) uses a currency demand equation estimated over time controlling for all the common factors of the preference for liquidity plus a variable, such as tax burden, which is assumed to be the sole factor inducing people to work in the shadow economy. *CDA* has been criticized on several grounds. For instance, not all transactions in the shadow economy are carried out in cash and the assumption that the tax burden is considered as the sole determinant of the shadow economy is very restrictive. Moreover, in some countries like the US, increases in the currency are mostly the result of a slowdown in the demand of deposits and not the increase in currency (Feige (1996)). Finally, the assumption of no shadow economy in the base year is not realistic.

The physical input (electricity consumption) method (or ECM) is a widely used approach for the estimation of the underground economy. Kaliberda and Kaufmann (1996) assumed that electricity consumption is among the best physical indicators of overall economic activity. This assumption is supported by empirical evidence in Burke and Csereklyei (2016) that suggests that the electricity to GDP elasticity is usually close to one in all EU countries which are considered to have the same energy efficiency. This study includes EU countries that have similar characteristics to the Cyprus economy. By assuming that this elasticity is equal to one, electricity consumption growth can be used as a proxy for the overall GDP growth. The difference between the growth of electricity consumption and the growth of official GDP is a proxy for the growth of

the informal economy. Despite the simplicity of Kaliberda and Kaufmann (1996) approach, it has many drawbacks as some shadow activities probably do not require a considerable amount of energy (*e.g.*, services) or require other energy sources (*i.e.* gas) (Medina and Schneider, 2018). In addition, the assumption of constant elasticity over time has also been criticized. In response to some of these drawbacks, Eilat and Zinnes (2002) and Missiou and Psychoyios (2017), among others, use a modified ECM (MECM) version of Kaliberda and Kaufmann (1996) to get estimates of the unofficial GDP. However, MECM continues to be subject to scepticism since not all unofficial economic activities require a considerable amount of electricity.

Another variant method that uses electricity consumption to measure the size of the shadow economy is the Lacko method (Lackó, 1998). It assumes that only a part of the shadow economy is associated with household consumption of electricity. This method takes into account DIY and home production activities, so it refers to the broad definition of the shadow economy. Some of the criticisms of this method include the fact that shadow activities do not take place only in the household sector, and that not all activities require electricity. Further, Lacko method uses the ratio of social welfare expenditures as an explanatory factor for the shadow economy, which may not apply for some developing countries. Lastly, Lacko using the size of the US shadow economy to estimate the shadow economy for the other countries has received criticism because this base value is not the most representative, especially for smaller and developing countries.

Another method proposed by Feige (1989) uses the *transaction approach* in the estimation of the shadow economy, which is based on Fischer's quantity equation, $M{\times}V{=}P{\times}T$. Any discrepancy between the two estimates is attributed to the shadow economy. In the case of no shadow economy, the ratio of $P{\times}T$ to GNP is constant over time. By subtracting the official GNP from total nominal GNP, an estimate of the shadow economy is derived. To get reliable estimates of the shadow economy, one needs precise figures of the total volume of transactions, which is quite tricky for cash transactions. One of the main weaknesses of this method is that it ignores fundamental factors that affect the desired amount of cash and velocity, such as the development of checks and credit cards.

Finally, the multiple indicators, multiple causes estimation (MIMIC) is a widely used approach for the estimation of the shadow economy (*e.g.* Buehn and Schneider, 2012; Dell'Anno, 2007; Medina, Jonelis, and Cangul, 2018; Hassan and Schneider, 2016; Wang, Lin, and Yu, 2006). The MIMIC model is a particular type of structural equation modelling (SEM) which is based on the statistical theory of unobserved variables, and it was first used to estimate the size of the shadow economy by Frey and Weck-Hanneman (1984). At first, a theoretical model needs to be established that explains the impact of a set of exogenous causal variables on the latent variable (shadow economy), and also the effect of the shadow economy on macroeconomic indicator variables. One advantage of the model approach is the inclusion of multiple causes and effects for the existence of a shadow economy compared to other methods that only use one indicator. It is also a flexible method because it allows us to choose the causal or indicator variables according to the features of the shadow economy under study. Some criticism of this method relates to the interpretation of the latent variable (Breusch, 2005). MIMIC provides estimates of coefficients that are used to calculate an index of a latent variable for which its unit and measurement are not observed. The calibration procedure is also an open debate because most of the time it is arbitrary. Moreover, if the scope of the researcher was to measure the shadow economy in its narrower definition, the model may capture activities that need to be excluded from the analysis like criminal activities. Lastly, this is a method that leads to stable estimated coefficients for large

samples, which is however empirically challenging for the case of Cyprus especially for annual frequency and for a country that has undergone so many structural changes.

3. Data, measurement and models

Our empirical investigation utilizes both quarterly and annual data. Specifically, our sample covers the recent period 1995-2018 for both yearly and quarterly data. The data used in this study are collected from various databases described in Table A1 in Appendices.

To measure the shadow economy (*SE*), we use two different approaches. The first approach is the energy consumption method (ECM) of Kaliberda and Kaufmann (1996). The second approach is the currency demand approach of Tanzi (1980, 1983). Below is a detailed description of how each method was applied to the Cyprus economy.

3.1 Kaliberta and Kaufman Approach (ECM and Modified ECM)

The approach of Kaliberda and Kaufmann (1996) (or ECM) assumes that the growth rate of electricity consumption is the best proxy for the growth rate of the country's total economic activity. ECM relies on the assumption that electricity consumption is converted to the growth of the overall economy, having electricity/GDP elasticity close to one. The percentage of changes in electricity consumption is similar to the percentage changes or growth rate of the overall *GDP*. ECM requires two primary estimations: 1) the overall *GDP* Index (*OA_GDP*) derived from electricity growth rate and 2) the official *GDP* (*OFL_GDP*).

To proceed to the estimation of *OA_GDP*, we define 1995 as the base year of GDP and the electricity growth rate. Particularly, *OA_GDP* is given by chain-multiplications of the following equation:

$$OA\_GDP_t = OA\_GDP_{t-1}^{base:1995} \times (1 + \Delta EC_t) \qquad (1)$$

where OA_GDP_t has a base year in 1995 with a value equal to 100. ΔEC_t is the electricity consumption growth rate at year *t*. To estimate the shadow economy through ECM, we also need the initial value of the shadow economy (*SE*) to GDP, *SE_GDP*, that will be used in the calculation of *OFL_GDP*. *OFL_GDP* is equal to *OA_GDP* minus the initial value of Shadow economy for the base year of 1995. In this paper we consider three different base values of *SE_GDP* that are derived from prior studies investigated the Shadow economy in Cyprus.[3] This approach aims to report a more comprehensive and representative range of the shadow economy in Cyprus given the importance of initial values in the method, but also evaluate the robustness of the time series behaviour of the shadow economy estimates. In particular, the first initial value of *SE_GDP* is equal to 12.15% which is the average value of *SE_GDP* derived from studies that investigate the shadow economy only for Cyprus (Georgiou and Syrichas, 1994; Fethi, Fethi, and Katircioglu, 2006; Pashardes and Polycarpou, 2008). The second initial value of *SE_GDP* is the average value (20.28%) of *SE_GDP* taken from cross-sectional studies for the year of 1995 where Cyprus is included (Fethi *et al.*, 2006; Alm and Embaye, 2013; Medina, Jonelis, and Cangul, 2018). The last

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[3] All the values of the Cyprus shadow economy derived by prior studies are presented in Appendices in Table A1.

initial value of *SE_GDP* is the average value (17.82%) of *SE_GDP* based on other studies that provide values of *SE_GDP* close to 1995.

The ECM received criticism by various scholars (*e.g.*, Eilat and Zinnes, 2002; Medina and Schneider, 2018; Missiou and Psychoyios, 2017) on several grounds such as the fact that (i) some shadow activities do not require electricity; (ii) there are alternative energy sources other than electricity; (iii) the electricity/GDP elasticity can be time-varying breaching the basic premise (of unitary elasticity) assumed in this method. Therefore, similar to Eilat and Zinnes (2002) and Missiou and Psychoyios (2017) we proceed with a modified energy consumption method (MECM) which is based on a regression model to control for economic factors that are expected to affect electricity consumption. Our regression model specification is given by:

$$\Delta EC_t = \beta_0 + \beta_1 \Delta EP_t + \beta_2 \Delta EU_t + \beta_3 \Delta IAV_t + \beta_5 \Delta PROIL_t + u_t \tag{2}$$

where ΔEC_t is the percentage change in electricity consumption, ΔEP_t is the change in electricity prices, ΔEU_t is the percentage change of energy use per *GDP*, ΔIAV_t the percentage change of industrial added value in *GDP*, and $\Delta PROIL_t$ the percentage change of the real price of crude oil. u_t is the residual component which captures the percentage of changes in electricity consumption that cannot be explained by the total economic activity. The difference between our *Eq.* (2) with the Eilat and Zinnes (2002) model refers to the growth rate of the Heating Degrees Days (HDD) variable which is not included in our final model as it is not found to be significant in case of Cyprus. In estimated *Eq.* (2) we focus on the residuals ($\hat{u}_t$) and the constant (β_0). Their summation is assumed to be the new overall *GDP* growth rate ($\Delta EC_t^{residuals}$). In particular, the new overall *GDP* index (***OA_RES_GDP**_t*) is given by the following expression:

$$OA\_RES\_GDP_t = \text{overall } GDP_{t-1}^{base} \times (1 + \Delta EC_t^{residuals}) \tag{3}$$

Given the estimated ***OA_RES_GDP**_t* we follow the same process as in ECM approach to estimate the shadow economy.

3.2. Currency Demand Approach

The Currency Demand Approach (*CDA*) relies on the assumption that the demand for currency is a function of, inter alia, taxes. Particularly, *CDA* assumes that the participants of the shadow economy engage in practices to avoid or manipulate their tax obligations, where the tax elasticity of currency demand can be used to estimate the currency held in the shadow economy. Tanzi (1980, 1983) using the following equation tries to capture the informal economic activity attributed to the tax evasion:

$$\ln\left(\frac{C}{M_2}\right)_t = \beta_0 + \beta_1 \ln\left(\frac{WS}{GDP}\right)_t + \beta_2 \ln\left(1 + \frac{T}{GDP}\right)_t + \beta_3 \ln(R_t) + \beta_4 \ln\left(\frac{GDP}{N}\right)_t + u_t \tag{4}$$

where *C* is the currency in circulation, M_2 is money supply measure that includes current accounts plus deposits accounts, *T* is the total tax income, *WS/GDP* is the ratio of wages and salaries over

GDP, *R* is the deposit rate on saving deposits, and *GDP/N* is GDP per capita. Eq. (4) represents the estimated logarithmic value of currency ratio for every year. Thus, given M2 we can measure the estimated currency in circulation (C_e). Particularly, C_e is given by the following modification:

$$X = ln\left(\frac{C}{M_2}\right) => X = ln(C) - ln(M_2) \text{ or } C_{e=exp[X+ ln(M_2)]} \tag{5}$$

The actual currency in circulation (*C*) and the estimated one (C_e) are presented in the first two columns of Table 4. By setting the tax variable equal to 0 and following the same procedure as in C_e a new estimation of currency in circulation (C_x) net of taxation is obtained. The difference between C_e and C_x captures the excess amount of money (or "illegal money") that is held by people, presumably to avoid taxation. The value of "illegal money" is presented in the fourth column of Table 4, *IM*. The "legal money" is shown in the fifth column (*LM*), and it is defined as the difference between *M1* (money supply) and *IM*. *VLM* in column 6 presents the income velocity of legal money that is measured as the ratio of GDP over legal money ("*LM*"). The value of the shadow economy for each year is given by the multiplication of *VLM* with *IM and* relies on the assumption that the velocities of the observed and the hidden economy are the same. The last column of Table 4 shows the ratio of the shadow economy over GDP.

4. Empirical results

This section discusses the estimation results of the shadow economy for Cyprus following the two approaches discussed in section 3.

4.1 Shadow Economy estimates based on ECM and MECM

Panel A1 in Table 1 presents the annual results of the shadow economy estimates derived from Kaliberda and Kaufmann (1996) approach, ECM. The Cyprus shadow economy estimate (column 1) starts with the initial value of 12.15% in 1995 peaks to 32.26% in 2010 and comes down to 28.06% in 2018. As expected, the results depend on the initial value assumed for the shadow economy which follows a number of different studies as detailed in section 3.1. Assuming that the initial size of the shadow economy is 20.28%, the derived values are now higher, ranging between 20.28% to 41.45%. A similar picture is obtained with the quarterly data with the size of the shadow economy under the conservative initial value is between 12.15% and 33.62%.

We now turn to the modified energy consumption method (MECM) of Eilat and Zinnes (2002) in *Eq.* (2) which controls for other factors that affect the electricity consumption growth. The regression coefficients of this model are presented in Table 2. Notably, the model in Eq (2) is estimated using annual and quarterly time series. However, due to the small sample size of the annual figures, the focus of the econometric analysis will be on the quarterly estimates.[4] *ΔEP* is significant at the 5% significance level and negatively related to electricity consumption, while *ΔEU* is positive and significant at 1%. Therefore, including *ΔEP* and *ΔEU* in Eq. (2) is crucial because they offset the effects derived from oil price changes and the sensitivity of electricity

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[4] Despite the small sample size of the shadow economy estimates based on the annual data are very similar to those of the quarterly data.

consumption relative to *GDP*, *ΔEU*. The variables *ΔIAV* and *ΔPROIL* turn out to be statistically insignificant in our sample period.

Panel B2 in Table 1 presents the results derived from *MECM*. The new quarterly estimations of the shadow economy for each of the three initial values (in 1995) of the shadow economy ranges as follows: *SE_MECM_1*: 12.15% in 1995 to 32.67% in 2018; *SE_MECM_2*: 20.28% in 1995 to 38.98.74% in 2018; and *SE_MECM_3*: 17.82% in 1995 to 37.73.01% in 2018. As with the simple energy consumption method, the final results depend on the initial value of *SE* and a higher initial value of *SE* yields higher values of the estimated *SE*. Nevertheless, regardless of the initial value of SE used, the behaviour of the estimated shadow economy for all three values (*SE_MECM_1, SE_MECM_2, SE_MECM_3*) turns out to be similar. The size of the shadow economy broadly follows an upward trend up to 2012 interrupted by a few years of declining shadow activities and in 2015 it resumes its upward trend. In recent years Cyprus has suffered two major financial crises. The Stock exchange crisis in 1999, where the overall index rose by almost nine times before its collapse. In 2013 following the global financial crisis, Cyprus was forced to ask for a bailout while the banking sector suffered a haircut on deposits. Unlike other studies (Bitzenis *et al.*, 2016; Colombo *et al.*, 2016; Schneider, 2010; Buehn and Schneider, 2013) which show that after financial crises the level of the shadow economy tends to increase[5] we find no empirical evidence to support this hypothesis in Cyprus using this method.

4.2 Shadow Economy estimates based on Currency Demand Approach

Table 3 presents the regression coefficients reported in *Eq.* (4) of the currency demand approach for two different time frequencies, quarterly and annual. The coefficient of the natural logarithm of one plus the ratio of T/GDP (ln(1+T/GDP)) is positive and significant (at the 5% significance level). This result is consistent with prior studies (*e.g.* Georgiou and Syrichas, 1994; Tanzi, 1980, 1983). An increase in the tax ratio presumably through tax evasion leads to greater use of currency. The interest rate and GDP per capita are negative and highly significant (at the 1% significance level) which are also consistent with Georgiou and Syrichas (1994) who estimate the same model for Cyprus covering the period 1960 to 1990. In contrast to Georgiou and Syrichas (1994), the salary ratio (WS/GDP) turns out to be insignificant.[6] The adjusted R^2 of the model is very high, exceeding 82%, indicating that the model can explain most of the variance in the dependent variable, ln(C/M2).

The estimation results of the shadow economy in Cyprus based on CDA are presented in Table 4. According to CDA based on quarterly data, the shadow economy in Cyprus ranges from about annual average 11%% to 18% in 2002. We find that the size of the shadow economy estimated by the currency method is considerably lower than the size derived from the energy method. Further, the size of the shadow economy seems to decline over time a finding that is consistent with other studies utilizing the MIMIC approach.

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[5] Buehn and Schneider (2013) show that the shadow economy increases after the world financial crisis in the countries under investigation (e.g. Canada, Chile, Norway). Consistent with Buehn and Schneider (2013) findings is the Schneider (2010) study which shows that by the beginning of the global economic crisis the shadow economy rose in all 21 OECD countries that are examined.

[6] We consider both the quarterly and annual samples to estimate the model in *Eq.* (4) (96 quarterly observations compared to 24 observations in the annual frequency) and the results are quantitatively similar.

4.3 Shadow Economy estimates in Cyprus – MCEM & CDA

In this sub-section, we compare the SE estimates derived from the MCEM and CDA. The SE value differs across alternative approaches, especially if we change a piece of vital information like the initial SE value in MCEM. Figure 1 provides additional evidence on this argument by illustrating the results derived from MECM and CDA and the average SE value from both approaches. The green lines (solid, dash and dot line) present the SE values obtained from MECM while the blue line present the SE derived from CDA. Comparing the two approaches, they have many differences in their estimations as expected, but it would be arbitrary to choose one of the two approaches as superior. For that reason, we take the average value (*AVG_SE*) of these two approaches (*SE_MECM_1, SE_MECM_2,* and *SE_MECM_3,* and CDA *CDA_SE_GDP*) to have the most conservative view about the shadow economy in Cyprus. *AVG_SE* is the orange line in Figure 1, and it starts from around 17% in 1995 ending to 27.9% in 2018. The average value of the shadow economy over the whole period is approximately 26% of GDP.[7]

To have a better understanding of the size of the shadow economy in Cyprus, we also look at other studies estimates not just for Cyprus but also other EU countries. According to currency demand approach, the size of the shadow economy in Cyprus is around 16% below the EU average over the period 1996-97 and significantly lower of that of Greece and Italy estimated at 30.1% and 27,2 respectively(Schneider and Enste 2000). However, a different picture arises in the case of the electricity methodology, simple and modified, with Cyprus topping the list of the EU countries during 2008-2013(Missiou and Psychoyios 2017). It should be noted that the only study as far as we know that uses the electricity approach and includes estimates of Cyprus is the Schneider and Enste 2000. This study gives an estimated size of the shadow economy of 21% of GDP of Cyprus during the period 1989-1990 which is very close to our estimates for the same period. Based on a MIMIC dynamic model (Medina and Schneider 2018) Cyprus has on average shadow economy of around 31% over the period 1991-2018 compared with 27,06% in Greece, 24,95% in Italy and 21,88% in Portugal. Malta has 29.8% and Slovenia 24.09.[8]

5. Conclusion

In this paper, we re-estimate the shadow economy in Cyprus from 1995 to 2018 using two macro or indirect approaches, the *Electricity Consumption Method* based on Kaliberda and Kaufmann (1996) *and* the *Modified Electricity Consumption Method* of Eilat and Zinnes (2002) as well as the *Currency Demand Approach* of Tanzi (1980, 1983). We estimate the size of the shadow economy during the period 1995-2018 in Cyprus to be in the range between 11% and 18 % of GDP according to the currency demand approach. These estimates are higher than those found in earlier studies using the same method for Cyprus. However, Alm and Embaye (2013) estimates of the shadow economy for 111 countries using the currency approach came up with even higher estimates for Cyprus in the range of 27% - 37% of GDP over the shorter sample of 1985-2006. Turning to the electricity method, our study also estimates a higher range for the size of the shadow economy in Cyprus of 26% - 34% of GDP compared to that of the currency method. The same applies when

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[7] The average value of the shadow economy as well as the Figures 1 and 2 are derived from the annual figures. Similar picture can be obtained from the quarterly data.

[8] Tongler and Schneider have shown that countries with lower per capita income tend to show higher size for shadow economy. This could partly explain the difference between Cyprus, Greece Portugal Spain and all the eastern European countries where average value of shadow economy exceeds 20% official GDP.

we compare the Cyprus estimates derived from electricity consumption approach with those of other EU Mediterranean countries for a subperiod. In particular, Missiou and Psychoyios (2017) utilizing the electricity approach over the period 2008-2013 estimated the size of the shadow economy between 20%-30% in Greece, 18%-21% in Portugal and 12%-18% in Spain. Summarizing, during the quarterly period 1995-2018, the two macro methods estimate the range of the shadow economy in Cyprus to be between 11% - 18% of GDP according to the currency demand approach and between 26% - 34% of GDP following the energy consumption approach.

In terms of future work, model averaging using alternative model specifications would be one approach (Steel, 2020) to follow for a comprehensive empirical analysis of the estimates of the shadow economy given its unobserved nature, the alternative direct and indirect methods and to deal with model uncertainty.

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FIGURE 1

Evolution of SE in Cyprus (ECM & CDA)
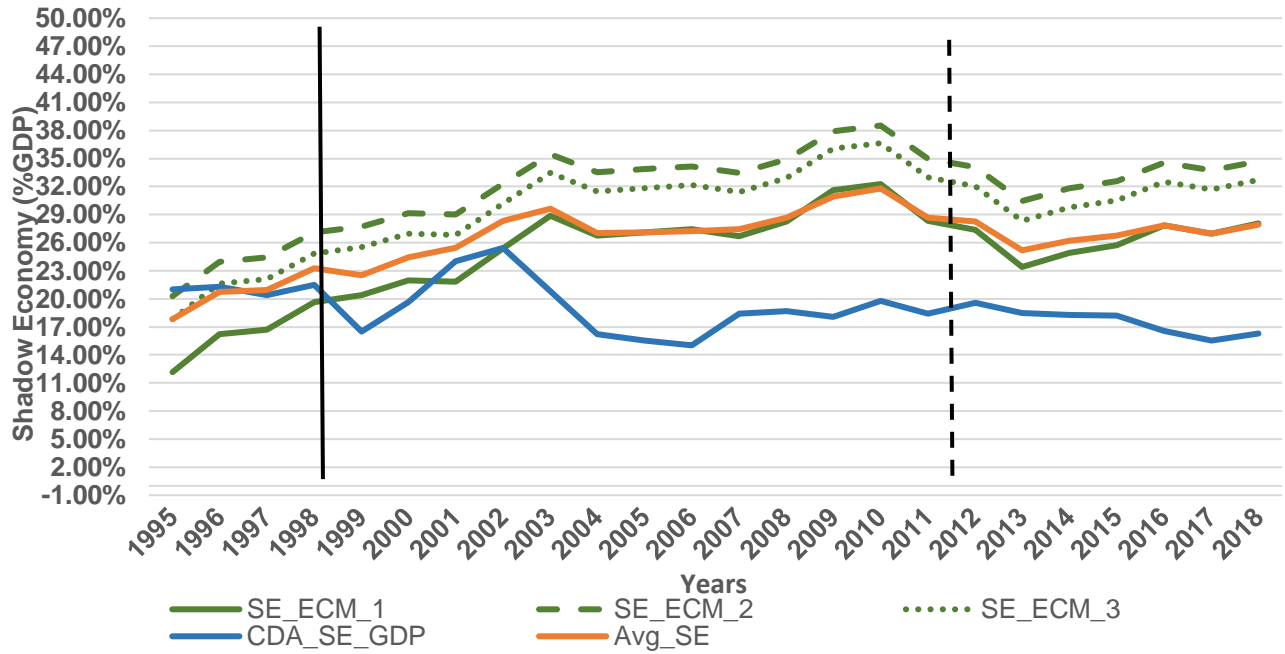
Note: This figure illustrates the estimated shadow economic values derived from ECM and CDA approaches. Particularly, the green lines represent the shadow economy derived from ECM based on three different initial values of Shadow economy (see section 3.1 for more information); the blue line shows the estimated shadow economy in Cyprus derived from CDA approach (see section 3.2), and the orange line represent the average shadow economy value from all four estimated values. The vertical black lines indicate the local financial crisis in 1999 and 2013 while the black vertical dash line presents the local banking financial crisis in 2013.
Source: Authors' Calculations

FIGURE 2

Evolution of SE in Cyprus (MECM & CDA)
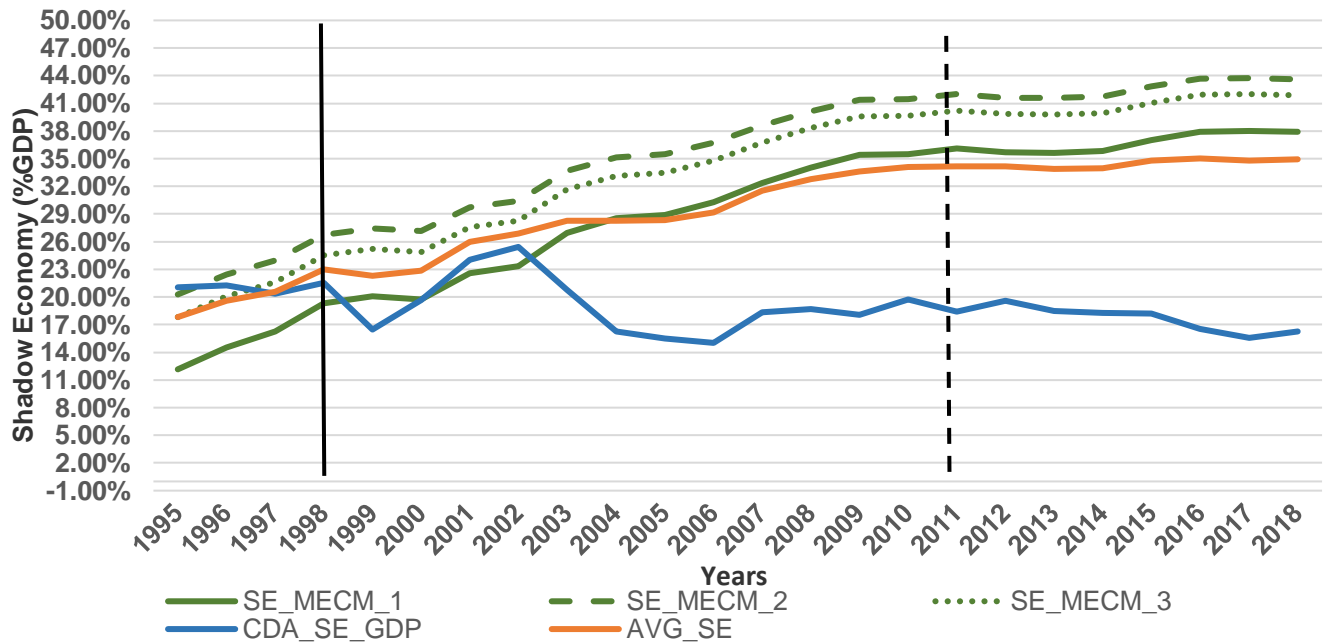
Note: This figure illustrates the estimated shadow economic values derived from MECM and CDA approaches. Particularly, the green lines represent the shadow economy derived from MECM based on three different initial values of Shadow economy (see section 3.1 for more information); the blue line shows the estimated shadow economy in Cyprus derived from CDA approach (see section 3.2), and the orange line represent the average shadow economy value from all four estimated values. The vertical black lines indicate the local financial crisis in 1999 and 2013 while the black vertical dash line presents the local banking financial crisis in 2013.

Source: Authors' Calculations

TABLE 1

Estimates of Shadow Economy - Energy Consumption Method

This table presents the annual and quarterly estimations of the Shadow economy for Cyprus in Panel A and Panel B, respectively, derived from the energy consumption method (ECM) of Kaliberda and Kaufmann (1996) and the modified energy consumption method (MECM) of Eilat and Zinnes (2002). *OA_GDP* represents the overall GDP Index estimated by Eq. (1) and using 1995 as the base year of the index. *OA_RES_GDP* is the alternative overall GDP measure derived from Eq. (3). *OFL_GDP 1, OFL_GDP 2, OFL_GDP 3* are the values of Cyprus official GDP subtracting for three different initial levels of the shadow economy in 1995. *SE_ECM_1, SE_ECM_2, and SE_ECM_3* represent the ratios of the Shadow Economy of Cyprus over *OA_GDP* given by ECM based on the three different levels of *OFL_GDP* (1, 2, and 3). Whereas SE_MECM_1, SE_MECM_2, and SE_MECM_3 are the percentage values of the Shadow economy derived from MECM.

Panel A. Annual Estimates

						Panel A1. ECM			Panel A2. MECM		
Year	OA_GDP	OA_RES_GDP	OFL_GDP 1 (SE 1995: 12.15%)	OFL_GDP 2 (SE 1995: 20.28%)	OFL_GDP 3 (SE 1995: 17.82%)	SE_ECM_1	SE_ECM_2	SE_ECM_3	SE_MECM_1	SE_MECM_2	SE_MECM_3
1995	100.000	100.000	87.846	79.724	82.180	12.15%	20.28%	17.82%	12.15%	20.28%	17.82%
1996	106.161	104.072	88.941	80.718	83.205	16.22%	23.97%	21.62%	14.54%	22.44%	20.05%
1997	109.632	108.974	91.290	82.850	85.402	16.73%	24.43%	22.10%	16.23%	23.97%	21.63%
1998	120.546	120.054	96.869	87.913	90.621	19.64%	27.07%	24.82%	19.31%	26.77%	24.52%
1999	127.717	127.230	101.710	92.307	95.150	20.36%	27.73%	25.50%	20.06%	27.45%	25.21%
2000	138.071	134.259	107.778	97.813	100.827	21.94%	29.16%	26.97%	19.72%	27.15%	24.90%
2001	143.276	144.656	112.038	101.679	104.812	21.80%	29.03%	26.85%	22.55%	29.71%	27.54%
2002	155.720	151.546	116.208	105.464	108.713	25.37%	32.27%	30.19%	23.32%	30.41%	28.26%
2003	167.636	163.268	119.257	108.231	111.565	28.86%	35.44%	33.45%	26.96%	33.71%	31.67%
2004	170.996	175.268	125.252	113.671	117.173	26.75%	33.52%	31.48%	28.54%	35.14%	33.15%
2005	180.230	184.774	131.330	119.187	122.859	27.13%	33.87%	31.83%	28.92%	35.50%	33.51%
2006	189.599	197.266	137.519	124.805	128.649	27.47%	34.17%	32.15%	30.29%	36.73%	34.78%
2007	197.087	213.727	144.532	131.169	135.210	26.67%	33.45%	31.40%	32.38%	38.63%	36.74%
2008	208.894	227.196	149.804	135.953	140.141	28.29%	34.92%	32.91%	34.06%	40.16%	38.32%
2009	214.655	227.250	146.785	133.214	137.317	31.62%	37.94%	36.03%	35.41%	41.38%	39.57%

2010	219.585	230.555	148.743	134.991	139.149	32.26%	38.52%	36.63%	35.48%	41.45%	39.65%
2011	208.401	233.781	149.346	135.538	139.713	28.34%	34.96%	32.96%	36.12%	42.02%	40.24%
2012	199.713	225.520	145.045	131.635	135.690	27.37%	34.09%	32.06%	35.68%	41.63%	39.83%
2013	178.355	212.255	136.634	124.001	127.821	23.39%	30.48%	28.33%	35.63%	41.58%	39.78%
2014	179.533	210.057	134.842	122.375	126.145	24.89%	31.84%	29.74%	35.81%	41.74%	39.95%
2015	185.063	218.205	137.488	124.776	128.620	25.71%	32.58%	30.50%	36.99%	42.82%	41.06%
2016	199.763	232.238	144.104	130.781	134.810	27.86%	34.53%	32.52%	37.95%	43.69%	41.95%
2017	206.131	242.849	150.543	136.624	140.833	26.97%	33.72%	31.68%	38.01%	43.74%	42.01%
2018	217.370	251.836	156.381	141.922	146.295	28.06%	34.71%	32.70%	37.90%	43.64%	41.91%

Panel B. Quarterly Estimates

Quarter-Year	OA_GDP	OA_RES_GDP	OFL_GDP 1 (SE 1995: 12.15%)	OFL_GDP 2 (SE 1995: 20.28%)	OFL_GDP 3 (SE 1995: 17.82%)	Panel B1. ECM			Panel B2. MECM		
						SE_ECM_1	SE_ECM_2	SE_ECM_3	SE_MECM_1	SE_MECM_2	SE_MECM_3
Q1-1996	102.466	101.073	88.850	80.520	82.180	13.29%	21.42%	19.80%	12.09%	20.33%	18.69%
Q2-1996	104.599	101.743	88.944	80.605	82.267	14.97%	22.94%	21.35%	12.58%	20.78%	19.14%
Q3-1996	105.790	102.157	89.040	80.692	82.355	15.83%	23.72%	22.15%	12.84%	21.01%	19.38%
Q4-1996	106.328	102.825	89.436	81.051	82.722	15.89%	23.77%	22.20%	13.02%	21.18%	19.55%
Q1-1997	105.730	103.672	89.638	81.234	82.908	15.22%	23.17%	21.59%	13.54%	21.64%	20.03%
Q2-1997	107.305	104.701	90.144	81.692	83.377	15.99%	23.87%	22.30%	13.90%	21.98%	20.37%
Q3-1997	108.235	106.186	90.945	82.419	84.118	15.97%	23.85%	22.28%	14.35%	22.38%	20.78%
Q4-1997	109.971	107.772	91.819	83.210	84.926	16.51%	24.33%	22.77%	14.80%	22.79%	21.20%
Q1-1998	112.397	109.796	93.025	84.304	86.042	17.24%	24.99%	23.45%	15.27%	23.22%	21.63%
Q2-1998	113.911	112.234	94.396	85.546	87.310	17.13%	24.90%	23.35%	15.89%	23.78%	22.21%
Q3-1998	117.654	115.119	95.975	86.977	88.770	18.43%	26.07%	24.55%	16.63%	24.45%	22.89%
Q4-1998	121.242	118.072	97.553	88.407	90.229	19.54%	27.08%	25.58%	17.38%	25.12%	23.58%
Q1-1999	122.333	119.958	98.779	89.518	91.364	19.25%	26.82%	25.32%	17.66%	25.38%	23.84%
Q2-1999	124.106	121.313	100.010	90.634	92.503	19.42%	26.97%	25.46%	17.56%	25.29%	23.75%
Q3-1999	126.409	123.008	101.193	91.706	93.597	19.95%	27.45%	25.96%	17.73%	25.45%	23.91%
Q4-1999	128.537	124.112	102.520	92.908	94.824	20.24%	27.72%	26.23%	17.40%	25.14%	23.60%
Q1-2000	133.008	125.879	104.293	94.515	96.464	21.59%	28.94%	27.48%	17.15%	24.92%	23.37%
Q2-2000	135.130	128.290	106.249	96.288	98.273	21.37%	28.74%	27.27%	17.18%	24.95%	23.40%
Q3-2000	137.766	129.623	107.700	97.603	99.615	21.82%	29.15%	27.69%	16.91%	24.70%	23.15%
Q4-2000	139.318	131.398	108.797	98.597	100.629	21.91%	29.23%	27.77%	17.20%	24.96%	23.42%
Q1-2001	137.849	133.256	109.677	99.395	101.444	20.44%	27.90%	26.41%	17.69%	25.41%	23.87%
Q2-2001	138.177	135.292	110.231	99.896	101.956	20.23%	27.70%	26.21%	18.52%	26.16%	24.64%

Q3-2001	139.421	138.129	111.731	101.256	103.343	19.86%	27.37%	25.88%	19.11%	26.69%	25.18%
Q4-2001	144.711	141.435	113.153	102.545	104.659	21.81%	29.14%	27.68%	20.00%	27.50%	26.00%
Q1-2002	148.459	143.604	114.443	103.714	105.852	22.91%	30.14%	28.70%	20.31%	27.78%	26.29%
Q2-2002	154.044	145.800	116.040	105.161	107.329	24.67%	31.73%	30.33%	20.41%	27.87%	26.39%
Q3-2002	157.486	146.397	116.451	105.533	107.709	26.06%	32.99%	31.61%	20.46%	27.91%	26.43%
Q4-2002	158.058	147.838	117.448	106.437	108.631	25.69%	32.66%	31.27%	20.56%	28.00%	26.52%
Q1-2003	160.876	150.229	118.264	107.177	109.386	26.49%	33.38%	32.01%	21.28%	28.66%	27.19%
Q2-2003	165.700	153.062	118.691	107.563	109.781	28.37%	35.09%	33.75%	22.46%	29.73%	28.28%
Q3-2003	168.767	155.910	119.769	108.540	110.778	29.03%	35.69%	34.36%	23.18%	30.38%	28.95%
Q4-2003	170.536	159.471	120.561	109.258	111.511	29.30%	35.93%	34.61%	24.40%	31.49%	30.07%
Q1-2004	174.610	162.873	121.862	110.437	112.713	30.21%	36.75%	35.45%	25.18%	32.19%	30.80%
Q2-2004	171.303	164.669	123.466	111.891	114.198	27.93%	34.68%	33.34%	25.02%	32.05%	30.65%
Q3-2004	171.322	167.366	125.080	113.353	115.690	26.99%	33.84%	32.47%	25.27%	32.27%	30.88%
Q4-2004	174.322	169.715	126.733	114.851	117.219	27.30%	34.12%	32.76%	25.33%	32.33%	30.93%
Q1-2005	177.086	172.039	128.376	116.340	118.739	27.51%	34.30%	32.95%	25.38%	32.38%	30.98%
Q2-2005	180.468	174.330	129.853	117.679	120.105	28.05%	34.79%	33.45%	25.51%	32.50%	31.11%
Q3-2005	183.426	176.474	131.414	119.093	121.548	28.36%	35.07%	33.73%	25.53%	32.52%	31.12%
Q4-2005	183.943	178.153	132.997	120.528	123.013	27.70%	34.48%	33.12%	25.35%	32.35%	30.95%
Q1-2006	186.150	180.214	134.427	121.824	124.336	27.79%	34.56%	33.21%	25.41%	32.40%	31.01%
Q2-2006	188.055	183.160	136.283	123.506	126.052	27.53%	34.32%	32.97%	25.59%	32.57%	31.18%
Q3-2006	191.345	186.406	137.734	124.821	127.394	28.02%	34.77%	33.42%	26.11%	33.04%	31.66%
Q4-2006	193.529	190.083	139.378	126.311	128.915	27.98%	34.73%	33.39%	26.68%	33.55%	32.18%
Q1-2007	193.725	193.768	141.217	127.977	130.615	27.10%	33.94%	32.58%	27.12%	33.95%	32.59%
Q2-2007	195.891	197.779	142.843	129.451	132.120	27.08%	33.92%	32.55%	27.78%	34.55%	33.20%
Q3-2007	199.514	201.924	144.680	131.115	133.818	27.48%	34.28%	32.93%	28.35%	35.07%	33.73%
Q4-2007	201.031	205.980	146.621	132.875	135.614	27.07%	33.90%	32.54%	28.82%	35.49%	34.16%
Q1-2008	204.863	210.644	148.504	134.581	137.356	27.51%	34.31%	32.95%	29.50%	36.11%	34.79%

Q2-2008	207.949	214.454	150.179	136.099	138.905	27.78%	34.55%	33.20%	29.97%	36.54%	35.23%
Q3-2008	210.672	218.447	151.574	137.364	140.195	28.05%	34.80%	33.45%	30.61%	37.12%	35.82%
Q4-2008	213.419	221.178	152.069	137.812	140.654	28.75%	35.43%	34.10%	31.25%	37.69%	36.41%
Q1-2009	210.425	221.000	151.486	137.284	140.114	28.01%	34.76%	33.41%	31.45%	37.88%	36.60%
Q2-2009	225.239	221.304	150.609	136.489	139.302	33.13%	39.40%	38.15%	31.94%	38.33%	37.05%
Q3-2009	218.002	219.160	149.662	135.631	138.427	31.35%	37.78%	36.50%	31.71%	38.11%	36.84%
Q4-2009	221.415	217.958	149.029	135.057	137.841	32.69%	39.00%	37.75%	31.62%	38.04%	36.76%
Q1-2010	222.581	218.103	149.332	135.332	138.122	32.91%	39.20%	37.95%	31.53%	37.95%	36.67%
Q2-2010	225.430	218.800	149.645	135.616	138.411	33.62%	39.84%	38.60%	31.61%	38.02%	36.74%
Q3-2010	225.908	220.430	150.323	136.229	139.038	33.46%	39.70%	38.45%	31.80%	38.20%	36.92%
Q4-2010	226.259	221.421	151.027	136.868	139.689	33.25%	39.51%	38.26%	31.79%	38.19%	36.91%
Q1-2011	227.130	222.186	151.574	137.364	140.195	33.27%	39.52%	38.28%	31.78%	38.18%	36.90%
Q2-2011	214.946	222.532	152.311	138.031	140.877	29.14%	35.78%	34.46%	31.56%	37.97%	36.69%
Q3-2011	218.760	220.496	151.905	137.664	140.502	30.56%	37.07%	35.77%	31.11%	37.57%	36.28%
Q4-2011	216.713	220.688	151.646	137.429	140.262	30.02%	36.59%	35.28%	31.28%	37.73%	36.44%
Q1-2012	216.573	219.170	151.224	137.046	139.872	30.17%	36.72%	35.42%	31.00%	37.47%	36.18%
Q2-2012	213.492	218.152	150.081	136.010	138.814	29.70%	36.29%	34.98%	31.20%	37.65%	36.37%
Q3-2012	214.332	216.543	149.230	135.239	138.027	30.37%	36.90%	35.60%	31.09%	37.55%	36.26%
Q4-2012	207.279	214.945	147.317	133.506	136.258	28.93%	35.59%	34.26%	31.46%	37.89%	36.61%
Q1-2013	198.664	210.649	144.845	131.265	133.972	27.09%	33.93%	32.56%	31.24%	37.69%	36.40%
Q2-2013	192.997	207.599	142.431	129.078	131.739	26.20%	33.12%	31.74%	31.39%	37.82%	36.54%
Q3-2013	188.083	204.002	140.451	127.283	129.907	25.33%	32.33%	30.93%	31.15%	37.61%	36.32%
Q4-2013	186.317	200.999	138.983	125.952	128.549	25.41%	32.40%	31.01%	30.85%	37.34%	36.04%
Q1-2014	186.178	200.451	138.109	125.161	127.741	25.82%	32.77%	31.39%	31.10%	37.56%	36.27%
Q2-2014	185.107	198.413	137.720	124.808	127.381	25.60%	32.58%	31.19%	30.59%	37.10%	35.80%
Q3-2014	186.356	197.892	137.367	124.488	127.055	26.29%	33.20%	31.82%	30.58%	37.09%	35.80%
Q4-2014	187.311	197.817	137.177	124.316	126.879	26.77%	33.63%	32.26%	30.65%	37.16%	35.86%

Q1-2015	189.195	198.874	137.306	124.433	126.999	27.43%	34.23%	32.87%	30.96%	37.43%	36.14%
Q2-2015	189.291	199.934	137.904	124.975	127.552	27.15%	33.98%	32.62%	31.03%	37.49%	36.20%
Q3-2015	189.990	201.436	138.714	125.709	128.301	26.99%	33.83%	32.47%	31.14%	37.59%	36.31%
Q4-2015	193.300	204.535	139.890	126.775	129.388	27.63%	34.42%	33.06%	31.61%	38.02%	36.74%
Q1-2016	195.977	207.358	141.388	128.133	130.774	27.85%	34.62%	33.27%	31.81%	38.21%	36.93%
Q2-2016	199.677	210.708	142.908	129.510	132.180	28.43%	35.14%	33.80%	32.18%	38.54%	37.27%
Q3-2016	204.610	214.235	144.620	131.061	133.763	29.32%	35.95%	34.63%	32.49%	38.82%	37.56%
Q4-2016	208.833	217.358	146.737	132.980	135.721	29.73%	36.32%	35.01%	32.49%	38.82%	37.56%
Q1-2017	215.093	219.594	148.487	134.566	137.340	30.97%	37.44%	36.15%	32.38%	38.72%	37.46%
Q2-2017	216.908	222.827	150.227	136.143	138.950	30.74%	37.23%	35.94%	32.58%	38.90%	37.64%
Q3-2017	218.312	226.128	151.985	137.736	140.576	30.38%	36.91%	35.61%	32.79%	39.09%	37.83%
Q4-2017	215.912	228.662	153.411	139.029	141.895	28.95%	35.61%	34.28%	32.91%	39.20%	37.95%
Q1-2018	212.045	231.298	154.962	140.434	143.329	26.92%	33.77%	32.41%	33.00%	39.28%	38.03%
Q2-2018	225.156	234.558	156.476	141.806	144.729	30.50%	37.02%	35.72%	33.29%	39.54%	38.30%
Q3-2018	224.757	236.342	157.960	143.151	146.102	29.72%	36.31%	35.00%	33.16%	39.43%	38.18%
Q4-2018	229.482	236.827	159.450	144.501	147.480	30.52%	37.03%	35.73%	32.67%	38.98%	37.73%

TABLE 2

Regression Analysis of Energy Consumption Method

This table presents the coefficients derived from Eq. (2). Our sample covers the period 1996-2018. The dependent variable is the percentage change in electricity consumption, ΔEC. ΔEP is the change in electricity prices, ΔEU is the percentage change of energy use per GDP, ΔIAV the percentage change of industrial added value in GDP, and $\Delta PROIL$ the percentage change of real price of crude oil. Various regression tests (*i.e.,* F-statistic, (Adjusted) R-squared, and Root MSE) and diagnostics tests (*i.e.,* Heteroscedasticity Test, Autocorrelation Tests, and Omitted variables Test) are reported.

	Quarterly Data	**Annual Data**
Constant	0.038***	0.0417**
	(6.52)	(3.34)
ΔEP	-0.937***	-0.804**
	(-11.71)	(-2.03)
ΔEU	0.974***	0.913**
	(13.47)	(2.32)
ΔIAV	-0.084	0.0369
	(-0.78)	(0.13)
ΔPROIL	0.021	0.006
	(1.64)	(0.30)
Obs.	92	23
F(4, 18)	50.78	2.30
Prob > F	0.000	0.098
R-squared	0.700	0.3387
Adjusted R-squared	0.686	0.192
Root MSE	0.042	0.043

Note: t-statistics are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

TABLE 3

Regression Analysis of Currency Demand Approach

This table presents the coefficients derived from *CDA* of Tanzi (1980 and 1983). Our sample covers the period from 1995 to 2018. The dependent variable is the currency in circulation (C) over *M2* money supply, ln(C/M2). *T/GDP* is the ratio of total taxes (*T*) over GDP, *WS/GDP* is the ratio of wages and salaries to GDP. *R* is the deposit rate on saving deposits for one year. *GDP/N* is GDP per capital calculated as GDP divided by the total population. Various regression tests (*i.e.*, *F*-Statistic, (Adjusted) R-squared, and Root MSE) and diagnostics tests (*i.e.* Heteroscedasticity Test, Autocorrelation Tests, and Omitted variables Test) are reported.

	(Annual Data)	(Quarterly Data)
Constant	15.24***	9.802***
	(-4.69)	(11.43)
Ln(WS/GDP)	-0.166	-0.0473
	(-0.49)	(-0.44)
Ln(1+T/GDP)	3.710**	0.603*
	(-2.37)	(1.77)
Ln(R)	-0.260***	-0.324***
	(-8.87)	(-20.59)
Ln(GDP/N)	-1.909***	-1.481***
	(-5.61)	(-14.89)
Obs.	24	96
F(4, 19)	28.670	130.150
Prob > F	0.000	0.000
R-squared	0.858	0.851
Adj R-squared	0.828	0.845
Root MSE	0.083	0.079

Note: t-statistics are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

TABLE 4

Estimates of Shadow Economy - Currency Demand Approach

This table presents the annual and quarterly estimations of Shadow economy in Panel A and Panel B, respectively, which are derived from the Currency Demand approach of Tanzi (1980, 1983) covering the period from 1995 to 2018. C is the currency in circulation. C_e is the estimated currency in circulation given by the *Eq.* (5) while C_x is the estimated currency of circulation net of taxation. *IM* is "illegal money" that is equal to the difference between C_e and C_x. LM is the legal money that is equal to $M1$ (money supply) minus *IM*. VLM is the income velocity of legal money measured as GDP over *LM*. *CDA_SE* is the shadow economy from currency demand approach that is defined as the product of the velocity of money and illegal money. *CDA_SE_GDP* is the ratio of *CDA_SE over GDP*.

Panel A. Annual Estimates

Year	C	C_e	C_x	IM	LM	VLM	CDA_SE	CDA_SE_GDP
1995	488.498	464.861	8103.387	218.921	1040.391	7.380	1615.682	21.04%
1996	509.917	508.955	8928.000	235.094	1106.299	7.213	1695.683	21.25%
1997	534.255	547.624	9874.580	246.889	1212.289	6.907	1705.285	20.37%
1998	564.611	567.331	10481.670	267.164	1242.287	7.293	1948.404	21.51%
1999	614.373	630.830	12010.850	302.254	1834.083	5.306	1603.735	16.48%
2000	652.379	663.403	12474.460	337.615	1717.463	6.169	2082.744	19.66%
2001	698.347	777.894	15120.380	402.242	1675.203	6.815	2741.399	24.01%
2002	747.432	833.495	16216.970	432.216	1699.401	6.989	3020.757	25.43%
2003	839.131	923.571	18362.210	486.660	2339.149	5.491	2672.463	20.80%
2004	974.046	846.358	17187.300	436.969	2689.253	5.153	2251.489	16.25%
2005	1055.770	935.337	18863.110	497.877	3205.778	4.624	2302.009	15.53%
2006	1162.385	1085.952	20913.590	607.888	4046.113	3.954	2403.853	15.02%
2007	1213.110	1332.553	22547.090	812.670	4422.330	3.960	3218.021	18.38%
2008	1388.884	1367.498	23123.750	810.987	4339.013	4.380	3552.370	18.69%
2009	1548.923	1522.137	27590.310	830.672	4596.328	4.063	3374.771	18.07%
2010	1640.006	1726.186	30454.660	942.073	4770.928	4.045	3810.880	19.75%
2011	1707.213	1716.712	29631.010	938.030	5101.970	3.867	3627.655	18.39%
2012	1773.963	1802.389	29957.230	984.620	5029.380	3.875	3815.550	19.58%
2013	1789.913	1883.282	34299.570	1034.723	5596.277	3.242	3354.104	18.49%
2014	2099.329	1901.390	34416.490	1071.818	5864.182	3.003	3218.645	18.28%
2015	2255.267	2110.829	41822.230	1177.931	6474.069	2.741	3228.813	18.19%
2016	2349.172	2135.677	44409.800	1182.824	7154.176	2.585	3057.031	16.53%
2017	2295.306	2193.886	47589.500	1232.232	7923.768	2.480	3055.571	15.55%
2018	2393.992	2690.920	68758.020	1521.465	9355.535	2.216	3371.392	16.26%

Panel B. Quarterly Estimates

Quarter-Year	C	C_e	C_x	IM	LM	VLM	CDA_SE	CDA_SE_GDP
Q1-1995	415.684	396.858	362.863	33.995	1074.290			
Q2-1995	447.986	398.071	366.712	31.359	1133.767			
Q3-1995	449.046	425.915	380.264	45.650	1136.302			
Q4-1995	482.870	456.486	399.897	56.588	1202.724	6.384	361.266	18.52%
Q1-1996	435.178	439.646	399.062	40.583	1133.571	6.840	277.589	14.07%
Q2-1996	465.889	453.342	414.525	38.817	1182.738	6.619	256.943	12.98%
Q3-1996	470.472	477.088	426.446	50.642	1194.102	6.619	335.216	16.80%
Q4-1996	502.808	502.705	441.973	60.732	1280.660	6.231	378.408	18.61%
Q1-1997	468.335	502.221	456.883	45.339	1249.679	6.464	293.070	14.33%
Q2-1997	496.960	503.330	460.510	42.820	1278.258	6.397	273.901	13.28%
Q3-1997	490.445	525.932	472.785	53.147	1289.271	6.418	341.116	16.12%
Q4-1997	523.021	546.362	483.256	63.106	1396.071	5.998	378.499	17.62%
Q1-1998	488.085	526.151	481.207	44.943	1374.015	6.219	279.505	12.78%
Q2-1998	528.646	528.559	484.271	44.289	1410.990	6.178	273.601	12.18%
Q3-1998	520.062	533.535	480.169	53.366	1372.979	6.474	345.479	15.02%
Q4-1998	554.348	551.969	488.000	63.969	1445.482	6.268	400.941	17.23%
Q1-1999	514.932	551.181	500.632	50.548	1478.807	6.240	315.424	13.46%
Q2-1999	566.027	553.932	504.037	49.894	1532.814	6.130	305.836	12.88%
Q3-1999	575.381	569.004	510.120	58.884	1624.987	5.885	346.552	13.95%
Q4-1999	603.220	609.838	539.578	70.260	2066.077	4.710	330.933	13.08%
Q1-2000	549.594	609.794	554.589	55.205	1741.321	5.713	315.359	12.16%
Q2-2000	615.600	602.405	544.556	57.849	2148.462	4.730	273.652	10.37%
Q3-2000	613.360	627.942	556.875	71.067	1958.361	5.300	376.647	14.13%
Q4-2000	643.610	641.055	559.643	81.412	1973.666	5.368	437.036	16.20%
Q1-2001	586.171	619.202	558.037	61.165	1762.037	6.130	374.912	13.53%
Q2-2001	659.102	641.341	576.570	64.771	1890.375	5.822	377.105	13.34%
Q3-2001	663.104	684.023	604.897	79.126	1833.133	6.116	483.939	16.64%
Q4-2001	699.783	748.804	655.441	93.363	1984.082	5.754	537.236	18.46%
Q1-2002	635.453	738.627	660.515	78.112	1749.194	6.593	514.971	17.67%
Q2-2002	699.270	735.474	660.726	74.748	1840.383	6.329	473.052	16.04%
Q3-2002	714.746	779.786	687.873	91.913	1833.479	6.415	589.634	19.94%
Q4-2002	765.516	819.689	716.975	102.713	2028.905	5.854	601.278	19.67%
Q1-2003	703.391	820.559	733.131	87.429	1901.575	6.373	557.201	17.95%

Q2-2003	783.813	862.439	776.174	86.266	2148.772	5.753	496.259	15.56%
Q3-2003	804.110	888.403	783.152	105.251	2528.081	4.985	524.708	16.47%
Q4-2003	901.632	910.284	800.236	110.048	2715.761	4.730	520.517	15.48%
Q1-2004	842.055	903.961	804.940	99.021	2631.370	4.978	492.896	14.61%
Q2-2004	900.931	860.575	768.352	92.223	2764.776	4.829	445.337	13.06%
Q3-2004	918.475	858.191	757.352	100.839	2799.868	4.859	489.943	14.02%
Q4-2004	978.154	857.504	748.600	108.904	3017.318	4.592	500.120	13.97%
Q1-2005	909.002	814.668	728.403	86.265	2795.153	5.044	435.095	12.01%
Q2-2005	988.910	877.094	781.554	95.540	3128.563	4.583	437.895	11.92%
Q3-2005	992.860	899.820	797.643	102.177	3261.667	4.470	456.770	12.23%
Q4-2005	1076.000	940.313	819.504	120.809	3582.845	4.137	499.794	13.17%
Q1-2006	994.000	951.748	843.863	107.884	3788.116	3.991	430.522	11.13%
Q2-2006	1092.000	973.244	870.162	103.082	4124.917	3.736	385.130	9.69%
Q3-2006	1088.000	1015.936	891.893	124.042	4152.958	3.782	469.104	11.65%
Q4-2006	1178.000	1049.829	909.462	140.367	4513.633	3.545	497.579	12.04%
Q1-2007	1081.000	1067.795	940.983	126.812	4536.188	3.611	457.857	10.83%
Q2-2007	1157.000	1113.830	981.232	132.598	4793.402	3.496	463.511	10.68%
Q3-2007	1118.000	1164.546	1006.660	157.886	4835.114	3.544	559.487	12.67%
Q4-2007	1071.000	1150.566	983.831	166.735	5068.265	3.455	576.095	12.71%
Q1-2008	1318.000	1111.854	964.077	147.777	5258.223	3.401	502.647	10.74%
Q2-2008	1331.000	1105.685	965.918	139.767	5158.233	3.540	494.742	10.39%
Q3-2008	1324.000	1283.354	1097.160	186.194	4895.806	3.806	708.620	14.73%
Q4-2008	1452.000	1266.342	1070.784	195.558	4954.442	3.836	750.199	15.78%
Q1-2009	1423.000	1417.917	1233.210	184.707	4768.293	3.969	733.010	15.75%
Q2-2009	1461.000	1542.000	1356.955	185.045	4961.955	3.797	702.590	15.10%
Q3-2009	1468.000	1573.208	1342.674	230.534	4877.466	3.846	886.538	19.08%
Q4-2009	1537.000	1560.524	1344.071	216.453	5210.547	3.584	775.721	16.44%
Q1-2010	1522.000	1537.750	1369.169	168.580	5300.420	3.553	598.889	12.52%
Q2-2010	1555.000	1708.449	1518.453	189.996	5494.004	3.456	656.598	13.69%
Q3-2010	1559.000	1697.283	1468.080	229.204	5366.796	3.567	817.551	16.87%
Q4-2010	1607.000	1745.290	1513.681	231.609	5481.391	3.521	815.470	16.74%
Q1-2011	1575.000	1655.168	1470.019	185.148	5413.852	3.585	663.710	13.51%
Q2-2011	1620.000	1663.694	1491.309	172.384	5704.616	3.421	589.716	11.88%
Q3-2011	1639.000	1758.862	1524.553	234.309	5544.690	3.539	829.237	16.95%
Q4-2011	1696.000	1740.422	1504.597	235.825	5804.175	3.399	801.671	16.16%
Q1-2012	1659.000	1700.155	1506.383	193.772	5545.228	3.547	687.367	13.92%
Q2-2012	1704.000	1752.045	1553.779	198.266	5974.734	3.282	650.749	13.29%
Q3-2012	1703.000	1823.302	1571.803	251.499	5626.501	3.475	873.862	18.04%
Q4-2012	1739.000	1856.644	1603.288	253.356	5760.644	3.383	857.162	17.82%

Q1-2013	1709.000	1826.460	1600.944	225.516	5521.484	3.469	782.245	17.25%
Q2-2013	1737.000	1903.265	1711.235	192.030	5684.970	3.310	635.546	13.63%
Q3-2013	1720.000	1930.058	1655.865	274.192	5983.808	3.088	846.699	18.79%
Q4-2013	1787.000	1919.014	1650.095	268.919	6362.081	2.851	766.787	17.29%
Q1-2014	1969.000	1809.600	1594.309	215.291	6590.709	2.732	588.244	13.30%
Q2-2014	2012.000	1791.128	1583.755	207.373	6573.627	2.719	563.898	12.78%
Q3-2014	2037.000	1811.072	1561.250	249.822	6389.178	2.777	693.752	15.72%
Q4-2014	2127.000	1821.163	1553.657	267.506	6668.494	2.641	706.423	16.20%
Q1-2015	2112.000	2006.204	1765.656	240.548	6640.452	2.657	639.149	14.50%
Q2-2015	2166.000	1964.173	1744.164	220.009	6986.991	2.530	556.651	12.57%
Q3-2015	2188.000	2100.244	1815.103	285.140	7025.859	2.521	718.831	16.19%
Q4-2015	2252.000	2086.030	1790.772	295.258	7356.742	2.412	712.225	15.92%
Q1-2016	2228.000	2031.013	1794.141	236.872	7321.128	2.449	580.184	12.86%
Q2-2016	2263.000	2050.274	1826.634	223.640	7604.359	2.383	532.843	11.65%
Q3-2016	2284.000	2135.081	1852.213	282.868	7662.132	2.389	675.743	14.55%
Q4-2016	2225.000	2138.847	1845.761	293.086	8043.914	2.299	673.701	14.15%
Q1-2017	2202.000	2137.453	1893.757	243.696	7938.304	2.366	576.515	12.00%
Q2-2017	2246.000	2074.058	1852.322	221.736	8231.264	2.317	513.695	10.54%
Q3-2017	2263.000	2214.071	1921.517	292.554	8267.446	2.342	685.042	13.84%
Q4-2017	2313.000	2255.472	1945.338	310.133	8845.866	2.221	688.874	13.72%
Q1-2018	2299.000	2200.390	1943.375	257.016	9054.984	2.200	565.383	11.05%
Q2-2018	2334.000	2390.402	2123.142	267.260	9424.740	2.142	572.526	10.93%
Q3-2018	2362.000	2659.323	2278.166	381.158	9790.843	2.090	796.517	15.44%
Q4-2018	2432.000	2994.958	2576.707	418.251	10458.750	1.982	829.036	15.88%

Appendices

TABLE A1

Variables Definitions

Variable Name	Description	Source
GDP	Gross Domestic Products.	Statistical Service of Cyprus
EL_CON	Electricity consumption(€000's).	Statistical Service of Cyprus
ΔEP	The percentage change in electricity prices.	Statistical Service of Cyprus
$\Delta EGDP$	The percentage change of the share of electricity consumption to GDP.	Statistical Service of Cyprus
$\Delta OILP$	The percentage change of the share of electricity consumption to GDP.	Global Financial Data
POP	Cyprus Population	Statistical Service of Cyprus
OVERALL_GDP		
OFFICIAL_GDP		
SE_ECM	The ratio of Shadow Economy value over GDP based on Kaliberta and Kaufman (1996) approach that is relied on energy consumption method	
SE_MECM	The ratio of the shadow economy over GDP derived from the modified energy consumption method similar to Eilat and Zinnes (2002) and Missiou and Psychoyios (2017).	
CUR	Currency in circulation	IMF - International Financial Statistics
M1	M1 money supply includes the physical currency and coin, deposits, negotiable order of withdrawal accounts, travellers' checks, and other checkable deposits	IMF - International Financial Statistics
M2	M2 money supply includes all the elements of M1 plus saving deposits and money market securities.	IMF - International Financial Statistics CBC - Central Bank of Cyprus
WS	Wages and Salaries	Statistical Service of Cyprus

TAX	Total taxes levied by Cyprus Government	Statistical Service of Cyprus
R	Interest rates on euro-denominated deposits with an agreed maturity up to one year	CBC - Central Bank of Cyprus
$Ln(C/M2)$	The logarithmic ratio of currency holdings to M2 money supply	
C_e	Estimated currency in circulation derived from the following equation:	
	$$C_e = \exp(X + \ln(M2))$$	
	where X is the estimated $Ln(C/M2)$ derived from Eq. (1)	
C_x	Estimated currency in circulation net of taxes derived from the same procedure as in C_e with the difference that we set the tax variable in Eq. (1) equal to zero.	
IM	Illegal money is measured as the difference between C_e minus C_x	
LM	Legal money is calculated as the difference between *M1* and *IM*.	
VLM	The velocity of Legal Money is defined as the ratio of GDP to LM.	
SE_CDA	The value of Shadow Economy based on currency demand approach of Tanzi (1980, 1983)	
SE_CDA_GDP	The ratio of *SE_CDA* over GDP.	
Avg. SE	Average shadow economy value of Cyprus derived from MEMC values (*SE_MECM_1, SE_MECM_2,* and *SE_MECM_3*) and *SE_CDA_GDP*	
LBF	Labour Force	IMF

TABLE A2

Estimates of the shadow economy in Cyprus

This table presents the range of SE in Cyprus and the values of SE close to 1995 that are used as initial values of the shadow economy for Cyprus using the Kaliberta and Kaufman Approach (Section 3.1.2). Min-Max is the range of the shadow economy in Cyprus based on each study. *SE_GDP* is the ratio of the shadow economy to GDP.

Study	Year of study	Estimation Method	Estimation year/Period	Estimates (% of GDP)	
			Start-end year	Min-Max	*SE_GDP* close to 1995
Georgiou and Syrichas	1994	Currency Approach	1960-1990	2.71%-10.30%	10.30%
Fethi *et al.*	2006	Currency Ratio (SCR)	1960-2003	0%-50%	21%
		Transaction method	1960-2003	1%-34%	17%
		Currency Approach	1960-2003	3.93%-14.97%	5.77%
Pashardes and Polycarpou	2008	Consumer Expenditure (demand system)	2002- 2003		6.70%
Quintano and Mazzocchi	2010	Latent variable method	1999-2008	5.35%-6.81%	5.35%
Buehn, A. and F.Schneider	2012	MIMIC	1999-2006	26.5%-29.2%	29.20%
Alm and Embaye	2013	Currency Approach (Dynamic panel)	1985-2006	24.6%-37.3%	29.70%
Medina,L. and F.Shneider	2018	MIMIC	1991-2015	27.91%-36.22%	27.91%
Adair	2018	Eurobarometer survey	1999-2013	27.77%-37.26%	29.20%