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

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# Η παραοικονομία στην Κύπρο: Εμπειρική ανάλυση χρησιμοποιώντας τις μεθόδους κατανάλωσης ηλεκτρικής ενέργειας και ζήτησης για μετρητά

**Χριστόφορος Ανδρέου, Έλενα Ανδρέου, Στέφανη Μιχαήλ, Γιώργος Συρίχας**

## ΠΕΡΙΛΗΨΗ

Η πανδημία έχει αναζωπυρώσει το ενδιαφέρον για την εκτίμηση του μεγέθους της παραοικονομίας, καθώς οι κυβερνήσεις προσπαθούν απεγνωσμένα να βρουν πρόσθετα έσοδα για να στηρίξουν τη μειωμένη οικονομική δραστηριότητα και να χρηματοδοτήσουν τα δημοσιονομικά ελλείμματά τους. Αυτό το άρθρο παρέχει νέες εκτιμήσεις για την παραοικονομία στην Κύπρο χρησιμοποιώντας δύο διαφορετικές μακροοικονομικές προσεγγίσεις, τη μέθοδο κατανάλωσης ενέργειας (ECM (Kaliberda and Kaufmann, 1996) και τη μέθοδο της ζήτησης μετρητών (Tanzi, 1980, 1983). Από όσα γνωρίζουμε, αυτή είναι η πρώτη ερευνητική εργασία που εφαρμόζει την προσέγγιση κατανάλωσης ενέργειας για την εκτίμηση της παραοικονομίας που επικεντρώνεται αποκλειστικά στην κυπριακή οικονομία. Η εμπειρική ανάλυση καλύπτει μια πρόσφατη περίοδο, χρησιμοποιώντας τριμηνιαία στοιχεία για την περίοδο 1995-2018, κατά τη διάρκεια της οποίας η κυπριακή οικονομία έχει υποστεί σημαντικές διαρθρωτικές αλλαγές όπως η χρηματοοικονομική φιλελευθεροποίηση, η κατάργηση των κεφαλαιακών περιορισμών, η ένταξη στην Ευρωπαϊκή Ένωση, η υιοθέτηση του ευρώ καθώς και η πρόσφατη τραπεζική κρίση. Κατά τη διάρκεια αυτής της περιόδου το μέσο μέγεθος της σκιώδους οικονομίας στην Κύπρο βάσει της νομισματικής προσέγγισης εκτιμάται σε περίπου 11-18% του ΑΕΠ, ενώ για την κατανάλωση ηλεκτρικής ενέργειας οι αντίστοιχες εκτιμήσεις είναι κατά μέσο όρο μεταξύ 25% - 34% του ΑΕΠ.

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

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## Abstract

The 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%.

## *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 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.

[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".

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 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 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,

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

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:

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

where $OA\_GDP_t$ has a base year in 1995 with a value equal to 100. $\Delta EC_t$ 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 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:

$$\Delta EC_t=\beta_0+\beta_1\Delta EP_t+\beta_2\Delta EU_t+\beta_3\Delta IAV_t+\beta_5\Delta PROIL_t+u_t \quad (2)$$

where $\Delta EC_t$ is the percentage change in electricity consumption, $\Delta EP_t$ is the change in electricity prices, $\Delta EU_t$ is the percentage change of energy use per *GDP*, $\Delta IAV_t$ 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)

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

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 ($\beta_0$). 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:

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

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:

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

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:

$$X = ln\left(\frac{C}{M_2}\right) \Rightarrow X = ln(C) - ln(M_2) \ or\ C_e = exp[X + ln(M_2)] \quad (5)$$

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 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

[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.

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.

[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

[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.

(1996) *and* the *Modified Electricity Consumption Method* of Eilat and Zinnes (2002) as well as the *Currency Demand Approach* of Tanzi (1980, 1983). This study estimates 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 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 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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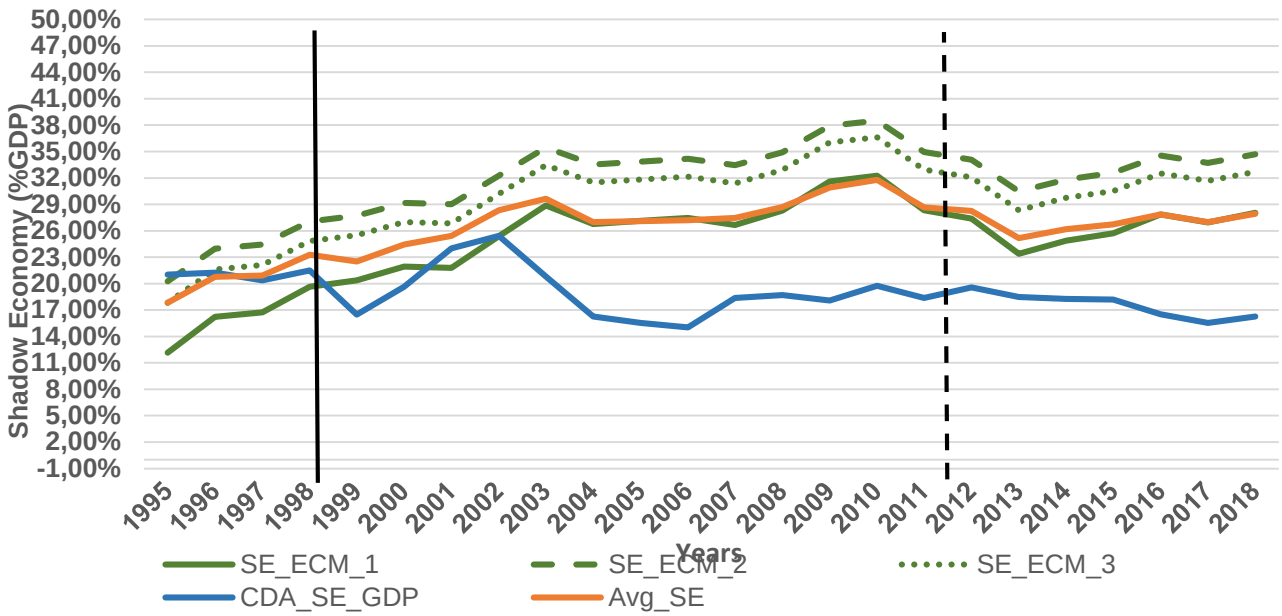
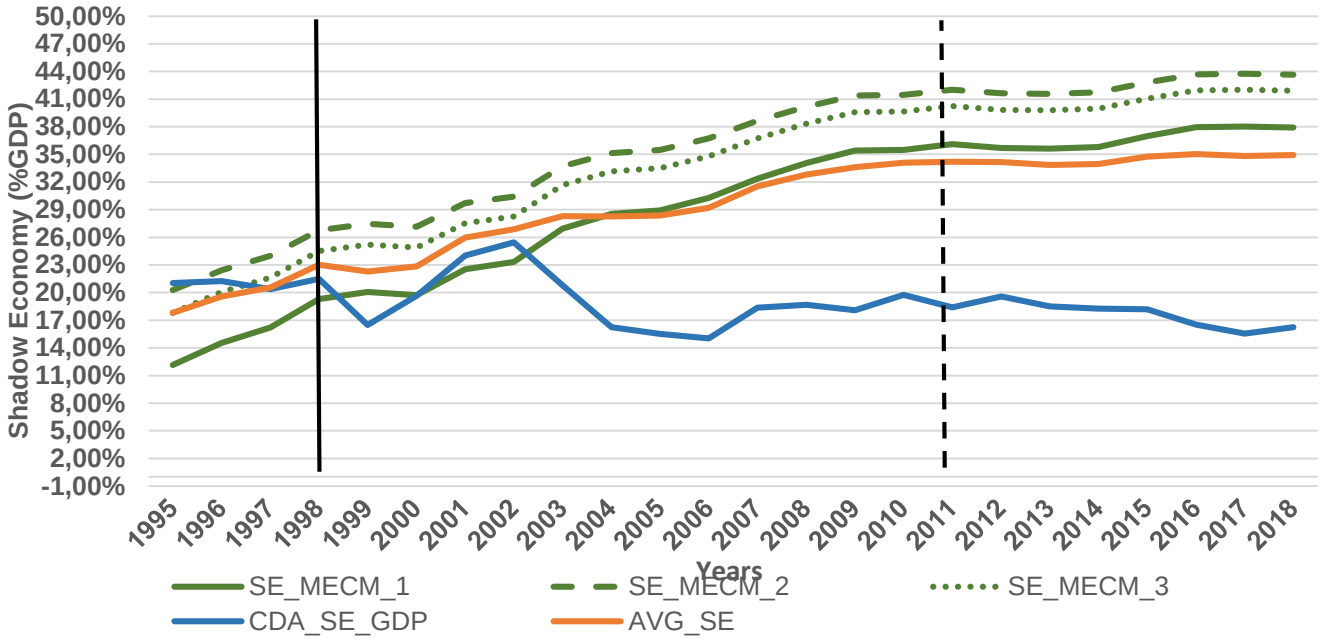
**Figure 1: Evolution of SE in Cyprus (ECM & CDA)**




**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**

| | | | | | | Panel B1. ECM | | | Panel B2. MECM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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%)*** | ***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*. ∆*EP* is the change in electricity prices, ∆*EU* is the percentage change of energy use per GDP, ∆*IAV* the percentage change of industrial added value in GDP, and *ΔPROIL* 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. *t*-statistics are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

| | **Quarterly Data** | **Annual Data** |
|---|---|---|
| ***Constant*** | 0.038*** | 0.0417** |
| | (6.52) | (3.34) |
| ∆***EP*** | -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 |

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

| | **(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 |

## 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 |
| *ΔEGDP* | The percentage change of the share of electricity consumption to GDP. | Statistical Service of Cyprus |
| *ΔOILP* | 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<br>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% |