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Estimating the size of the shadow economy in EU countries using the electricity consumption method

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Abstract

The shadow economy is a common phenomenon, primarily in developing countries but also in developed ones, causing most often distortions in the economy. In this paper we provide a literature review of the methods used in estimating the shadow economy over the years and a detailed description of the electrical consumption method. In this paper we estimate the size of the shadow economy in 25 EU countries, by implementing a variation of the physical input approach, where instead of the electric power consumption we use as a dependent variable the total final energy consumption, which includes all forms of energy used in the economy. Estimates show that Western European countries have smaller informal sector, whereas in Eastern European countries the percentage of the shadow economy in the official GDP is higher. The results also show a flourishing shadow economy in the European Union, the unweighted average size of the shadow economy ranging from 23,7% of the official GDP in 2007.to 21,3 % of the official GDP in 2013.

Keywords: shadow economy, energy consumption, estimation methods

Jel Codes: E26, O17, D69, H53, C23

1. Introduction

The Shadow Economy is a common phenomenon of all economies around the world, causing distortions in economy and in society. Over the years, numerous definitions of the term and its synonyms (informal, hidden, illegal, parallel, underground, unrecorded, etc) have been proposed in the literature, none of which is universally accepted.

In 2002, the OECD (2002) provided a standard definition for the non-observed economy (NOE). According to OECD the NOE includes the following five activities: 1) Underground production – those activities that are both productive and legal but which are concealed from the authorities to avoid the payment of taxes (for example, when enterprises decide not to declare all their income to the authorities to avoid taxation); 2) Illegal production – these are activities that are forbidden by law (for example, production and distribution of illegal drugs); 3) Informal sector production – those productive activities conducted by unincorporated enterprises in the household sector that are unregistered; 4) Household production for own final use – those productive activities undertaken by household unincorporated enterprises exclusively for own final use by owners (for example, production of crops, construction of own houses); 5) Production missed due to deficiencies in data collection program – defined as all the productive activities that should be accounted for by the basic data collection program but are missed due to statistical deficiencies.

A similar definition is given also by EUROSTAT in 2014 (EUROSTAT, 2014), who considers that "the non – observed" part of the economy refers to activities such as: 1) underground activities, which include those activities that are productive and legal but are concealed from tax authorities to avoid payment of income, payment of social security contributions, having to meet certain legal standards (minimum wages, maximum hours, safety standards), or complying with certain administrative procedures (for example, completing statistical questionnaires); 2) illegal activities, which are those productive activities specifically covered by SNA production boundary that generate goods and services forbidden by law (production or distribution of drugs), or are unlawful when carried out by unauthorized producers (e. g. unlicensed practice of medicine); 3) household production for own use (e.g. production of crops, construction of own houses); 4) non observed informal activities which are those productive

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activities conducted by unincorporated enterprises in the household sector that are not registered and that have some market production.

In a more recent study, Medina and Schneider (2019) define the shadow or informal economy as " all economic activities which are hidden from official authorities for monetary, regulatory, and institutional reasons. Monetary reasons include avoiding paying taxes and all social security contributions, regulatory reasons include avoiding governmental bureaucracy or the burden of a regulatory framework, while institutional reasons include corruption law, the quality of political institutions and weak rule of law." The shadow economy, in their paper, reflects mostly legal economic, and productive activities that, if recorded, would contribute to national GDP. Therefore, the definition of the shadow economy in the study tries to avoid illegal or criminal activities, do-it-yourself, or other household activities.

It is useful to say that the shadow economy estimated with the physical input method reveals data regarding all unofficial activities (legal and illegal), whereas in the MIMIC model proposed by Schneider and his collaborators, the estimations do not include illegal activities or do – it – yourself activities, as described above.

In the literature we identified various drivers of the shadow economy that can be clustered into three categories: (1) economic factors, (2) political and institutional variables, and (3) social factors. (Clement et al, 2021).

Among the economic factors we can enumerate just a few: economic development, GDP per capita, economic growth, economic complexity, trade openness, inflation, employment rate, income.

Regarding the political determinants of the shadow economy, we can distinguish between: tax morale, tax burden, tax level, tax complexity, tax policy, public governance, institutional quality, rule of law, etc.

And finally, among social factors we can identify the following: gender, happiness, religion, inequality.

Reviewing the literature, we identified three main groups of methods used in estimating the shadow economy: 1) Direct methods or microeconomic approaches (surveys, tax auditing); 2) Indirect methods, which are also called indicator approaches – these are mostly macroeconomic; 3) The model approach, which considers multiple causes that lead to the existence and growth of the shadow economy, and its multiple effects over time (MIMIC).

Among these methods, a physical input method is used due to its advantages, among them being: the method has a model free nature in contrast with other methods where the results are conditioned by strong assumptions and complex econometric models and the most important is the availability of data required by the method resulting in the minimization of estimation errors.

The contribution of this study to the existing literature would be: firstly, the analysis provides model – free estimations of the shadow economy in 27 EU countries over the period 2001-2020. As a result, we provide a new reference point for the size of the shadow economy across countries, as an alternative to the existing estimates; secondly, we compute estimates based on total energy consumption, not only electricity consumption as the initial method was constructed, addressing the main criticism to the method, that not all economic activities require electricity consumption.

The remaining of the paper is organized as follows: Section 2 consist of a review of the literature; Section 3 describes the methodology used; Section 4 presents the results and discussion; and Section 5 contains the conclusions.

2. Literature review on shadow economy estimation methods

A reliable estimation of the size of the shadow economy is a difficult task, and although, in recent years it was intensively investigated, to day it is still an open issue. The difficulties of the measurement of the shadow economy lies mainly in its hidden nature, and as a result, all methods attempt to capture an unobserved variable. In addition data used for the estimates are not always available, and if they are , they are not always reliable. Also, the lack of a clear and universally accepted definition of the shadow economy produces results that are not always comparable across studies. (Psycoyios, et al , 2019).

Reviewing the literature, we identified three main groups of methods used in estimating the shadow economy: 1) Direct methods or microeconomic approaches (surveys, tax auditing); 2) Indirect methods, which are also called indicator approaches – these are mostly macroeconomic; 3) The model approach, which considers multiple causes that lead to the existence and growth of the shadow economy, and its multiple effects over time (MIMIC).

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In the direct methods category, we can distinguish two types of estimation methods: survey based and tax audit based methods. These are not widely used because of the costs that imply such a procedure and the biased results that might be obtained by not answering honestly to the questions by the respondents. They exploit the micro-level data obtained from tax audits and surveys. Because tax audits are not always random, this could lead to biased results as well. (Postea, Achim, 2022). These types of methods may underestimate the level of the shadow economy because it is very likely that individuals do not declare during the polls what they intend to hide from authorities (Achim and Borlea, 2020, p.33).

Indirect approaches are mostly macro-economic, they are also called "indicator" approaches. In the literature we identified four groups of methods: 1) the discrepancy between national expenditure and income statistics; 2) Estimating the shadow economy using employment statistics; 3) Monetary methods; 4) The physical input approach (energy consumption).

The discrepancy between national expenditure and income statistics approach is based on the idea that if those hiding their income cannot hide their expenditure, the difference between the two indicators leads to the estimation of the shadow economy. (Franz, 1983; O'Higgins, 1989; Smith, 1994; MacAfee, 1980; Petersen, 1982; Dell Boca & Forte, 1982; Park, 1979; Yoo & Hyun, 1998).

The advantage of this method is that in many countries, the national accounts provide both income based and expenditure based estimates, lending themselves very well to discrepancy analysis (OECD 2002). If the estimate of the income does not include the part that has been concealed from the authorities for tax reasons, the second estimate, relating to the expenditure, includes those too. Consequently, the difference between the two estimates can partly be attributed to the shadow economy or tax evasion.

There are a few disadvantages to using this method, among them being: 1) there can be other causes for the discrepancy, such as errors in timing and statistical errors (OECD, 2002); 2) There are some activities that might be omitted from the expenditure-based estimates, such as the expenditure on narcotics, gambling, alcohol, or even prostitution. Consequently, with this method's help, the part of the shadow economy that is estimated is the one that interacts with the legal one, other segments couldn't be estimated. (OECD 2002, Bashlakova, Bashlakov, 2020).

In the literature, we identified three different types of methods used to *estimate the shadow economy based on the employment statistics*. These are: 1) The discrepancy between the official and the actual labor force. This method assumes that a decline in labor force participation in the formal sector can be assumed to be constant and a decrease in the official rate of participation can be seen as an indicator of an increasing informal sector. Over the years, there have been a few studies regarding this method, such as for Italy, Contini (1981) and Del Boca (1981), and for the United States, O'Neill (1983). Several flaws in this method were identified, including: a) differences in the rate of participation may have other causes, such as an economic crisis (Schneider and Buehn 2018); b) there can be the possibility that people participate simultaneously in both sectors. For example, individuals can have a main job in the formal sector and have a second job in the informal one: c) this method doesn't include wages granted but not declared to the authorities, the so called "envelop" wages. 2) The use of labor versus supply of labor. This method is based on the idea that wages and employment measured from the employer side and from the employee side can be compared. These measures should be the same, with allowance for conceptual differences. Analyzing the discrepancies between the two measures can provide an indication of the size of the activities missing from the enterprise data (OECD 2002). This approach is so effective that analysis of labor inputs is one of the mechanisms specified by the European Commission, according to the OECD handbook (2002); 3) The employment rate method. The Italian Statistical Service (ISTAT) has focused on surveys of labor costs. The main data is obtained by conducting a specially organized sample survey of households. The question asked in the survey is related to the hours worked in a specific sector. Then the information is extrapolated to the entire population and converted to the average number of hours worked (Bashlakova and Bashlakov 2020). The method has various disadvantages, such as: 1) a high number of respondents understand the difference between official labor hours and informal or shadow labor hours, which can lead to distorted answers; 2) the shadow economy, in different sectors of the economy, has a different labor intensity, the structure of the official and the shadow activities being different, which can lead to drawing unreasonable conclusions about the quantitative and qualitative parameters of the shadow economy. (Bashlakova and Bashlakov 2020).

The *Monetary methods are* based on the idea that usually, shadow economic activities are settled by paying cash, so that few traces or none are left. Consequently, if the demand for cash rises above a specific value, this can be explained by the increase of shadow economic activities. This idea was developed in two distinct methods elaborated to estimate the shadow economy based on monetary transactions:

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1*) The transaction approach*. Feige developed this approach in 1979, and it is based on the assumption that the relationship between the volume of transactions and the official GNP is constant, as highlighted by the Fisher quantity equation: M*V=p*T (where M is money, V is velocity, p- prices and T is total transactions). In other words, the total stock money (M) multiplied by the velocity of circulation equals the number of transactions paid for with M multiplied by the price of the transactions. Also, one has to assume that there is a constant relationship between the money flows related to the transactions and the total value added (P*T = k *Ytotal, where Ytotal = Yofficial + Yunder). Consequently, Mt * Vt = k* (Yofficial + Yunder) over the years t=0,1, … In the equation, the stock of money is measurable, money velocity can be estimated, and the value-added estimates are known. Therefore, if one knows the size of the shadow economy as a ratio of the official economy for a base year, then the shadow economy can be computed for all subsequent years (OECD 2002, Feige 1979, 1996). The main disadvantage of the method is the assumption of the value of the shadow economy for the base year. There are also other disadvantages, such as: a) the assumption of a constant ratio of transactions to official GDP seems unrealistic. Cramer (1980) argued that there is a high probability that monetary transactions that are not related to income generation will be included in the calculation; b) increased facilities for and use of cheques and credit cards can also have an impact; c) part of the money in circulation, such as bills of large denomination, is not actually in circulation but kept by the owners as a store of wealth; d) the fact that the method requires a large amount of empirical research and data, makes the results doubtful; e) another criticism regarding this method was given by Blades (1982), who pointed out that the US dollar circulates throughout the world, either as official currency (Virgin Islands, Puerto Rico) or as an accepted alternative to local currency (South East Asia, Central America). For these reasons, there is no point in relating dollars in circulation to domestic activity in the US.

2) *The currency demand approach.* This approach was first used by Cagan (1958), who highlighted the correlation between currency demand and tax pressure as a cause of the shadow economy, in the US over the period 1919 to 1955. Later, in 1977, Gutmann adopted a similar approach, but examining only the ratio between currency and demand deposits over the years 1937 to 1976. Cagan's approach was further developed by Tanzi (1980, 1983), who econometrically estimated a currency demand function to calculate the shadow economy in the United States from 1929 to 1980. His assumption is that shadow transactions are settled in the form of cash payments in order to leave few traces of the transaction. He deduced then that an increase in the shadow economy would lead to an increase in the demand for currency. There are several disadvantages and criticisms in the literature regarding this method, among them being: a) The main and obvious objection is that not all shadow economy transactions are paid with cash (Takala, Viren 2010); b) When applying this method, most researchers consider only one factor influencing the shadow economy (tax burden, for example). Other factors such as state regulation, the strength of law enforcement, the taxpayers' attitude towards the state and tax morale are not considered because in most countries, data available for these factors cannot be reliable (Schneider, Buehn 2018); c) The assumption that the velocity of money in both sectors (official and shadow) is the same can occur only when the elasticity of income is the same (Ahumada et al. 2009); 4) Considering that in the base year there is no shadow economy is unrealistic.

The physical input approach is based on the consumption of electricity when quantifying the size of the shadow economy. In the literature, a distinction can be made between two different methods used in this approach: 1) Kaliberda and Kaufmann method and 2) The Lacko method. The first one makes use of total electricity consumption for the entire economy, and the second one uses the consumption of electricity in the residential sector when estimating the size of the shadow economy. (Psychoyios, et al, 2021).

1)*The Kaliberda and Kaufmann method.* This method was used first by Lizzeri (1979), Del Boca and Forte (1982), and then later used by Portes (1996), Kaliberda and Kaufmann (1996), and Johnson et al. (1998). In the literature the Kaliberda and Kaufmann method remained as a landmark.

Kaliberda and Kaufmann (1996) assume that electric power consumption is the single best physical indicator of overall (official and unofficial) economic activity. An important role in using this method is the electricity – to – GDP elasticity, which is close to one. This means that the growth of total electricity consumption can be a good indicator for the growth of overall GDP (official and unofficial). Having this overall GDP estimate, we can then subtract the estimates of the official GDP and estimate the size of the shadow economy. However, the constant elasticity assumption can be unrealistic. As a result, Johnson et al. (1998) use different elasticities for different countries in order for cross – country comparison to be feasible. This method seems to be very simple and easy to apply, but has also been the subject of some criticism. For example: 1) the main criticism is related to the fact that not all informal activities require electricity (for example, personal services), and for those that do require energy consumption, there are other sources of energy that can be used (gas, oil) (Schneider, Buehn, 2018); 2) in recent years there has been considerable progress regarding the efficiency of electricity consumption, leading to a modification of this indicator not related to the actual economic activities; 3) the constant elasticity assumption is

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rather unrealistic (Eilat, Zinnes, 2002); 4) For some sectors, like agriculture, the relationship between electricity consumption and output will not be stable since output is mostly determined by the weather (OECD 2002); 5) In many developing and transition countries, electricity is not a major source of energy in industrial production (OECD 2002).

2)*The Lacko method*. The second method for the physical input approach estimates the shadow economy based on residential electricity consumption (or household consumption). One has to assume that energy efficiency is constant over the years. Lacko (1998) was the first researcher that described this method, and she suggested that residential electricity consumption is correlated with the overall shadow economy activities. In her opinion, a high value of the households' shadow economy suggests a high value of the overall shadow economy

This method has drawn some criticism in the literature, the main objections being: 1) As in the Kaliberda and Kaufmann method, there is a known fact that not all shadow economy activities need a great amount of electricity (for example, services) and if there is a need for energy consumption, there are other alternative energy sources that can be used (renewable energy sources, coal, gas); 2) the obvious objection is that not all shadow activities take place in the household sector; 3) it is questionable which is the best base value for the shadow economy used to calculate the shadow economy for all other countries;

The indirect methods described in the previous paragraphs assume that the shadow economy can be modelled with the aid of a small number of variables. Most of them consider just one indicator to capture the size of the shadow economy. They ignore other background information and variables that lead to shadow economy activities. Frey and Weck (1983) address this issue by proposing a latent variable method which considers a wide range of explanatory variables. The size of the shadow economy is estimated based on variables that affect its size, on the one hand, and variables that are traces of the phenomenon, on the other. According to Frey and Weck, the size of the shadow economy can be explained by variables such as the tax burden, the perception of tax burden, the number of laws, the unemployment rate, tax morale, and per capita income. On the other hand, traces of the shadow economy can be considered some indicators such as the labor force participation rate of the male population, the number of weekly hours worked, or the growth of GNP.

The model was seriously criticized in the literature, mainly by Helberger and Knepel (1988), who argued that the results of this method are very unstable. They showed that even a small change in the countries used leads to different results. They concluded that the ambiguity of the data used can severely limit the model's utility. Also, another criticism is regarding the variables used for the model.

The standard MIMIC model has been used quite widely in the literature for many years (see, Frey & Weck-Hannemann, 1984; Quintano & Mazzocchi, 2013; Ruge, 2010; Schneider and Enste (2000), Buehn and Schneider (2007), Dell Anno and Schneider (2009), Dell Anno and Schneider (2006), Schneider, et al (2010), Williams and Schneider (2013), Schneider et al (2015), Hassan and Schneider (2016), Schneider and Buehn (2018), Medina and Schneider (2018), Schneider (2019)). It has also been the subject of criticism, mainly on the use of GDP (GDP per capita and growth of GDP per capita) as cause and indicator variables. Medina and Schneider (2019) addressed this issue by using the night lights approach by Henderson, Storeygard, and Weil (2012) to independently capture economic activity. As the authors themselves recognized, this method used to estimate economic activities has its shortcomings as well. For example, in rural areas the economic activity can be independent on the use of light. And this is the case in the agricultural sector in general.

There are other criticisms regarding using the MIMIC method to estimating the size of the shadow economy. (Ahumada, Alvaredo, & Canavese, 2009; Helberger & Knepel, 1988; Organization for Economic Cooperation & Development (OECD), 2002, Feige, 2016). The most obvious criticism is the fact that the results are highly dependent on the proper selection of the variables used as causes and indicators. If indicators and causes are not unique one may ask which are the appropriate variables to use in the model?

The electricity consumption method will be described in detail in the following paragraphs.

2.1. The simple electricity consumption method

The simple electricity consumption method (ECMS) assumes that the growth rate of total electricity consumption is the best single proxy for the growth of the overall economy (real and shadow). In this method, the actual growth rate of electricity consumption is utilized to approximate economic growth. Kaliberda and Kaufman (1996) claim that the electricity /output elasticity is constant and close to one. In our study, we also assume a unitary elasticity between the two variables, considering that all EU countries have almost the same energy efficiency. In other words, we consider that the growth rate of electric power consumption is the same as the growth rate of the overall

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GDP. Then we proceed to estimate the overall GDP (GDP_T) and the official GDP (GDP_0) indices. Taking the first observations as the base of the index every subsequent observation is obtained by a simple chain – multiplication ($GDP_{Tt} = GDP_{Tt} – 1\ (1+ g_{t,e})$), where g_e is the growth rate of total electricity consumption. In a similar manner the GDP_0 index is constructed. The initial shadow economy level is obtained from the estimations of Schneider and Medina (2019). Once the initial values are set, every subsequent value is derived by invoking the observed growth rate of the official GDP. Therefore, the difference between the GDP_0 index and the GDP_T index implies the size of the shadow economy.

2.2. The modified electricity consumption method (ECMM)

The ECMS method, despite it's attractiveness, shows some weaknesses. For example, variations in electricity consumption may have other reasons than economic factors. Eilat and Zinnes (2002) modify the method in an attempt to overcome this limitation. The modified electricity consumption method implies implementing a panel regression specification, obtaining the growth of electricity consumption through the respective residuals of the panel regression.

In their study, Psycoyios et al (2021), use the following panel specification:

$$C_{it}^{Ele,c} = a_0 + a_1 P_{it}^{Ele,c} + a_2 U_{it}^{Ele,c} + a_3\ I_{it}^{Add,c} + a_4\ H_{it}^{Dd,c} + a_5\ P_{it}^{Oil,c} + u_{it} \quad \text{Eq (1)}$$

Where**,**

$C_{it}^{Ele,c}$ is the growth in electricity consumption for country i at time t,

$P_{it}^{Ele,c}$ is the change in the electricity prices,

$U_{it}^{Ele,c}$ Is the change in energy use per $1000 of GDP,

$I_{it}^{Add,c}$ is the change in industry's value added in GDP

$H_{it}^{Dd,c}$ is the change in the Heating Degrees Days index,

$P_{it}^{Oil,c}$ is the growth rate of the real crude oil price,

a_k (k = 1, .., 5) are parameters to be estimated

u_{it} is the error term assuming the usual properties.

After estimating the equation, the residuals consist of the growth rate of electricity consumption related to the total economic activity.

Once the residuals are obtained, then by following the principles from ECMS, both the overall GDP (GDP_T) index as well as the official GDP (GDP_0) index can be constructed. The difference between GDP_0 index and the GDP_T index represents the shadow economy.

2.3. The final energy consumption method (ECMF).

A limitation of both ECMS and ECMM is the assumption that electricity is the only for of energy used in the economy. In reality, some shadow activities can use other forms of energy as natural gas, oil, renewable energy. This is the reason why in this study we use ECMF method, which is similar to the ECMM, but instead of the electricity consumption we use the total final energy consumption growth ($CFE_{c,it}$) as a dependent variable.

3. Methodology

3.1. Variable and data

The data of this study consist of annual observations on the period 2001-2020 in 27 EU countries. The data for GDP per capita (euros), the industry value added (% of GDP), population, the energy use (kg of oil equivalent per capita), electric power consumption per capita (in kWh) all come from WDI database of the World Bank. The Heating Degree Days (HDD) index, The Cooling Degree Days (CDD) index, the total final energy consumption (thousands of tons of oil equivalent), and electricity prices (including taxes and levies) were collected from Eurostat database. We should mention that the electricity price was calculated as the average of industrial and other domestic consumer price. And finally, the crude oil price was collected from www.macrotrends.net.

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3.2. Method

The method used in this study is the final energy consumption method, which is similar to the ECMM, but instead of the electricity consumption we use the total final energy consumption growth ($CFE_{c,it}$) as a dependent variable. As a result, the panel regression will have the following specification:

$$C_{it}^{FE,c} = a_0 + a_1 P_{it}^{Ele,c} + a_2 I_{it}^{Add,c} + a_3 H_{it}^{Dd,c} + a_4 C_{it}^{Dd,c} + a_5 P_{it}^{Oil,c} + u_{it} \quad \text{Eq(2)}$$

Where,

$C_{it}^{FE,c}$ is the growth in final energy consumption for country i at time t,

$P_{it}^{Ele,c}$ is the change in the electricity prices,

$I_{it}^{Add,c}$ is the change in industry's value added in GDP

$H_{it}^{Dd,c}$ is the change in the Heating Degrees Days index

$C_{it}^{Dd,c}$ is the change in the Cooling Degrees Days index

$P_{it}^{Oil,c}$ is the growth rate of the real crude oil price,

a_k (k = 1, .., 5) are parameters to be estimated

u_{it} is the error term assuming the usual properties

4. Results and discussions

4.1. Preliminary results

The panel variables were all tested for unit roots with the aid of Fisher test. The results of the tests for each variable are illustrated in Table 1. For all the variables, the respective null hypothesis of non – stationarity is rejected at the conventional levels of significance.

Table 1. Panel unit root test (Fisher)

	$C_{it}^{FE,c}$	$P_{it}^{Ele,c}$	$I_{it}^{Add,c}$	$H_{it}^{Dd,c}$	$C_{it}^{Dd,c}$	$P_{it}^{Oil,c}$
Inverse chi-squared (54) P	472.0823 P(0.000)	272.8773 P(0.000)	364.5935 P(0.000)	1039.1535 P(0.000)	826.7213 P(0.000)	263.4978 P(0.000)
Inverse normal Z	-16.5147 P(0.000)	-12.1965 P(0.000)	-15.0171 P(0.000)	-29.5347 P(0.000)	25.6297 P(0.000)	-12.6115 P(0.000)
Inverse logit t(139) L*	-24.9672 P(0.000)	-14.4120 P(0.000)	-19.2626 P(0.000)	-55.3292 P(0.000)	-44.8577 P(0.000)	-14.0077 P(0.000)
Modified inv. chi-squared Pm	40.2300 P(0.000)	21.0615 P(0.000)	29.8869 P(0.000)	94.7964 P(0.000)	75.9677 P(0.000)	20.1589 P(0.000)

4.2. Empirical results

For the implementation of the ECMF we estimate a balanced panel specification, with cross-sectional fixed effects. The estimated coefficients along with the respective p-values in parentheses are illustrated in Eq. () below:

$$C_{it}^{FE,c} = -0.451 \; -0.0137 P_{it}^{Ele,c} + 0.13 I_{it}^{Add,c} + 0.116 H_{it}^{Dd,c} + 0.0002 C_{it}^{Dd,c} + 0.059 P_{it}^{Oil,c} + u_{it} \quad \text{Eq(3)}$$

P values: (0.000)(0.012)(0.049)(0.006)(0.031)(0.000)

All the coefficients are statistically significant at the 0.05 significance level, having at the same time the theoretically expected sign. Based on Eq. (3), we recover the residuals, and by following the steps described in Section 3.1. we estimate the share of the SE for each country. Table 2 presents the size of the SE as a percentage

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of the official GDP for 25 EU countries. Two countries were eliminated from the study because of the lack of data. (Estonia and Lithuania)

Table 2 . Shadow economy (% of official GDP) based on ECMF method

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	9.3	9.5	9.9	9.8	9.9	9.8	9.8	9.6	9.4	9.8
Belgium	20.4	19.5	19.9	19.4	18.6	18.5	17.9	18	17.5	18.2
Bulgaria	36	37.2	39.1	39.3	40.4	41.8	41.9	40	35.5	36.5
Croatia	34.9	36.1	37.4	37.7	38.2	38.6	39.3	39.4	39.3	38.7
Cyprus	30.8	30.1	30.9	29.8	29.4	29.1	29.6	29.3	29.4	29.5
Czech Rep	17.2	17.2	17.8	17.6	17	17.2	17	16.5	16.3	15.8
Denmark	15	14.9	15	15	14.9	14.9	15.1	14.5	14.2	14.2
Finland	12.8	13.2	13.1	13	12.4	12.6	12.6	12	11.5	12.3
France	14.2	14.2	14	13.8	13.4	13.2	12.9	12.6	12.5	12.5
Germany	13.1	13.1	13.1	12.8	12.5	12.8	12.2	12.4	12.2	12.5
Greece	27.1	30.7	40	47.5	48.8	53.7	62.4	69.5	64.5	57.8
Hungary	26.3	26.9	27.5	27.1	28.4	27.9	27	26.8	27	26.8
Ireland	13.8	13.7	13.9	13.8	14.3	14.4	14.3	13.7	12.5	12.3
Italy	23.2	23.5	24.2	23.8	23.7	23.5	23.3	22.5	21.9	21.7
Latvia	29.9	31	32.6	33.4	34.6	35.5	37.2	35.5	35.9	34.8
Luxemburg	10.2	10.4	10.7	11.6	11.6	11.4	11	10.7	10.3	10.4
Malta	25.4	22.9	23.3	26.4	25.8	27.3	29	27	27.5	29.2
Netherlands	10.6	10.6	10.6	10.6	10.5	10.4	10.3	9.8	10	10.2
Poland	26.5	26.8	26.8	27.2	27	28.3	29	28.8	28.7	30.2
Portugal	21.9	22.7	22.3	21.9	21.6	22	22.1	21.1	21.8	21
Romania	35.8	36.7	37.6	38.8	38.6	39	39	39.1	36.7	36.3
Slovakia	18.4	19	17.9	17.3	17.7	17.3	17.2	17.4	16.8	17.7
Slovenia	26.4	26.3	26.5	26.4	26.9	26.8	27.1	28.4	26	26.3
Spain	24.1	24.3	25.1	25.2	25.2	24.5	24.7	22.9	22.1	21.8
Sweden	12.4	12.5	12.3	12	11.6	11.5	11.5	11	10.9	11.1
EU average	21.4	21.7	22.5	22.8	22.9	23.3	23.7	23.5	22.8	22.7

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	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average 2001-2020
Austria	9.5	9.5	9.7	9.4	9.8	10	10	9.7	9.9	9.3	9.7
Belgium	17	16.9	17.3	16.8	17.7	18.1	17.9	17.8	17.6	16.9	18.1
Bulgaria	37.7	37.1	37.4	38.7	42.4	43.7	44.9	45.3	46.5	46.4	39.9
Croatia	37.5	36.2	36	35.4	38.3	39.2	41	40.7	42	40.2	37.9
Cyprus	26.9	24.8	23.4	24.7	25.1	26.8	27.3	27.6	26.3	22.5	28
Czech Rep	15.4	15.4	15.2	15.2	15.9	16.4	16.7	16.5	16.7	16.6	16.5
Denmark	13.7	13.1	12.9	12.8	13.5	13.8	13.7	13.5	13.2	12.6	14.1
Finland	11.9	11.9	11.8	11.8	12	12.5	12.3	12.5	12.4	11.8	12.4
France	12.3	12.4	12.5	11.9	12.4	12.6	12.5	12.2	12.1	11.3	12.9
Germany	12.3	12.4	12.6	12.3	12.7	12.9	12.9	12.6	12.6	12.2	12.6
Greece	55.1	47.4	47.1	46.7	39.1	38.7	40.1	42.7	41.4	38.2	46.3
Hungary	26.9	25.7	26.1	26	28.4	29.4	30.4	30.5	31.1	30.9	27.6
Ireland	11.4	11.1	11.2	11.3	11.1	11.6	11.5	11.7	11.8	10.7	12.6
Italy	20.9	20.7	20	19.4	20.4	20.6	20.1	20.3	20.5	19	21.9
Latvia	33.8	35.3	34.7	35.9	36.9	37.7	39.4	40.9	40.9	40.1	35.1
Luxemburg	10.3	9.7	9.3	9.1	8.9	8.9	9	9.1	9	8.1	10.1
Malta	27	27.5	29.2	31.2	31.6	32.7	31.3	32.9	32.4	25.8	28.4
Netherlands	9.7	9.6	9.5	9.1	9.5	9.7	9.7	9.6	9.5	9	10
Poland	29.7	29.4	29.1	28.9	30.1	32.4	34.5	36.1	36.3	36	29.6
Portugal	20.4	18.5	18.5	19.1	20	20.4	21.1	20.6	21.6	19.6	21
Romania	36.5	37.5	36.7	37.2	39	40.3	42.3	42.9	44.8	45.5	38.5
Slovakia	16.4	15.8	16.4	15.7	16.1	16.9	17.9	17.7	18	17.2	17.3
Slovenia	26.3	25.5	25	24.6	25.4	26.6	26.7	26.5	25.9	23.9	26.2
Spain	21.6	20.6	20.1	20.4	21.2	21.8	22.4	22.2	22.4	19.8	22.8
Sweden	10.5	10.6	10.5	10.4	10.6	10.4	10.4	10.1	10.3	10.3	11.2
EU average	22	21.4	21.3	21.4	21.9	22.6	23	23.3	23.4	22.2	22.4

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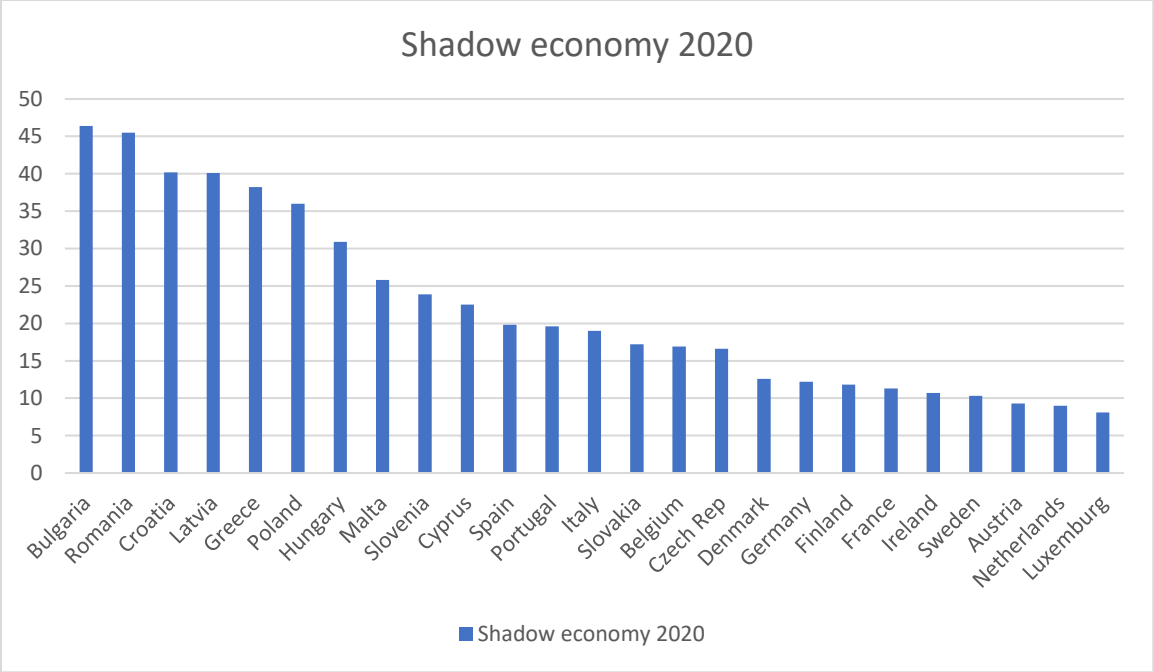

Fig 1. Shadow economy in Europe 2020

Source: own computation

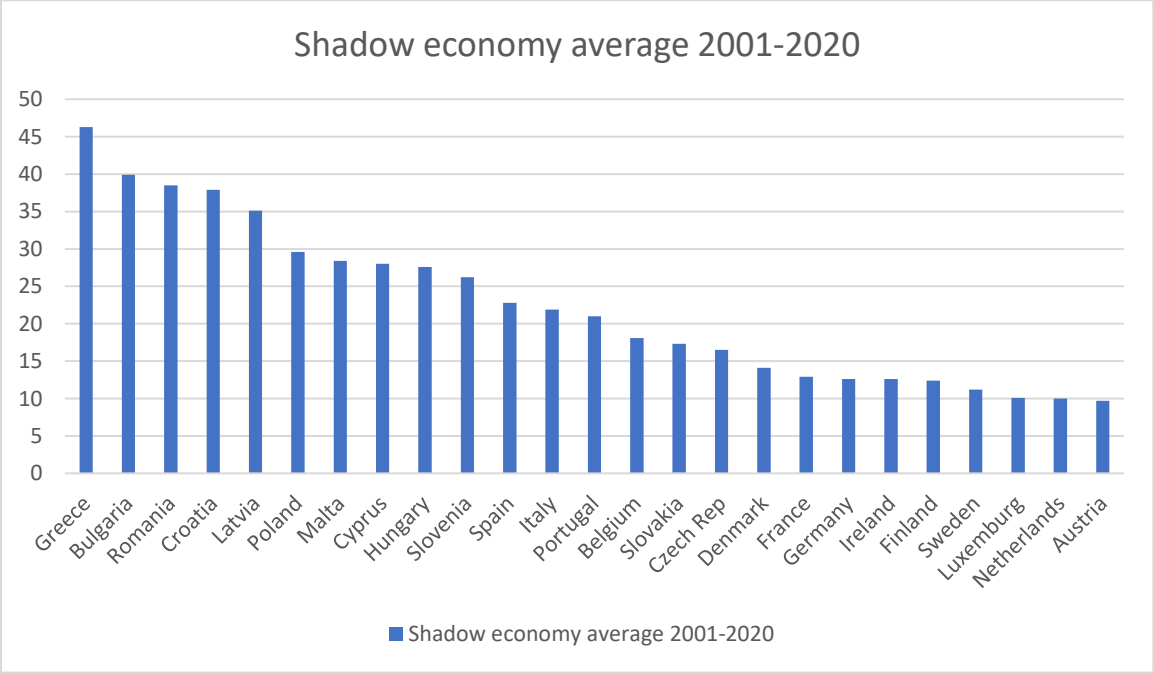

Fig 2. Shadow economy in Europe average 2001-2020

Source: Own calculation

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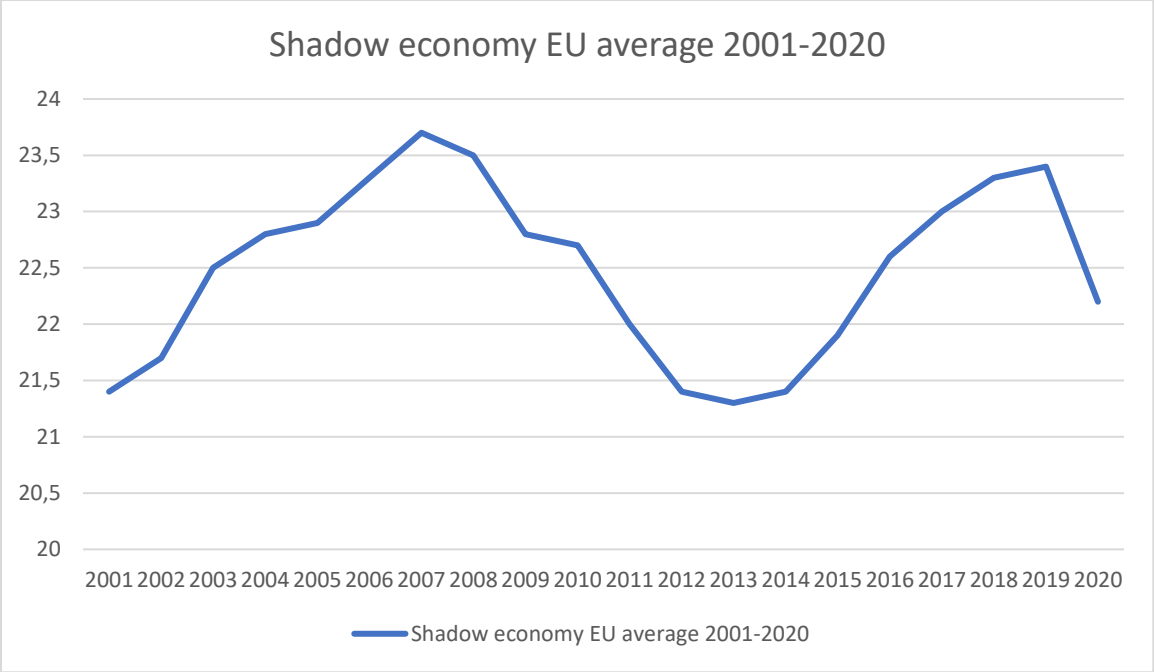

Fig 3. Shadow economy EU average in the period 2001-2020

Source: own computation

The results show, on average, higher percentage of shadow economy in GDP in countries like Bulgaria, Croatia, Greece, Latvia and Romania (above 35%) and a lower percentage in countries like Austria, Luxemburg, Netherlands (at about 10%).(fig 2)

The results also show a flourishing shadow economy in the European Union, the unweighted average size of the shadow economy ranging from 23,7% of the official GDP in 2007.to 21,3 % of the official GDP in 2013. (fig 3)

5. Conclusions

In the first part the paper focuses on describing the methods identified in the literature used for estimating the shadow economy. We described the methods used and presented their advantages and shortcomings. Then the paper focused on explaining in detail the electricity consumption method, describing three different approaches to this method: the simple electricity consumption method, the modified electricity consumption method and the final electricity consumption method.

The paper focused on measuring the size of the shadow economy using the final electricity consumption method, extending the standard electricity consumption method, by incorporating alternative forms of energy. It provides estimates for 25 EU countries. The results show a flourishing shadow economy in the European Union, the unweighted average size of the shadow economy ranging from 23,7% of the official GDP in 2007.to 21,3 % of the official GDP in 2013. The results also show that better performing economies (Western European countries) are associated with smaller informal sector, whereas in Eastern European countries the percentage of shadow economy in the official GDP is higher.

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References

Achim, M.V. & Borlea N.S. (2020). Economic and financial crime. Corruption, shadow economy and money laundering. Springer Nature Switzerland AG 2020.

Ahumada, H., Alvaredo, F., & Canavese, A. (2009). The monetary method to measure the size of the shadow economy. *Revue Économique,* 60, 1069–1078.

Bashlakova, V., & Bashlakov, H. (2021). The study of the shadow economy in modern conditions: Theory, methodology, practice. *The Quarterly Review of Economics and Finance*, 81, 468-480.

Buehn, A. & Schneider, F. (2007). Shadow economies and corruption all over the world: Revised estimates for 120 countries. *Economics,* 1(9), 1–66.

Cagan, P. (1958). The demand for currency relative to the total money supply. *Journal of Political Economy*, 67, 303-328.

Clement S , Mara E. R. , Achim V. M. , Postea M. (2021) Determinants of shadow economy: A bibliometric approach, 23rd RSEP International Economics, Finance & Business Conference

Contini, B. (1981), Labor market segmentation and the development of the parallel economy: the Italian experience, *Oxford Economic Papers*, 33, pp. 401–412.

Dell'Anno, R., & Schneider, F. G. (2006). Estimating the underground economy by using MIMIC models: A Response to T. Breusch's critique (No. 0607). *Working paper.*

Dell'Anno, R., & Schneider, F. (2009). A complex approach to estimate shadow economy: the structural equation modelling. In Coping with the Complexity of Economics (pp. 111-130). *Springer*, Milano.

Del Boca, D., & Forte, F. (1982). Recent empirical surveys and theoretical interpretations of the parallel economy in Italy. *The underground economy in the United States and abroad, Lexington (Mass.), Lexington*, 160-178.

Eurostat, & EUROSTAT. (2014). Essential SNA: Building the basics.

Eilat, Y., & Zinnes, C. (2002). The shadow economy in transition countries: Friend or foe? A policy perspective. *World Development*, 30(7), 1233-1254.

Feige, E. L. (1979). How big is the irregular economy? *Challenge*, 22(1), 5–13.

Feige, E. L. (1996). Overseas holdings of US currency and the underground economy. Exploring the Underground Economy. *Kalamazoo*, Michigan, 5-62.

Feige, E. L. (2016). Professor Schneider's shadow economy: what do we really know? A rejoinder. Forthcoming in *the Journal of Tax Administration*, 2(2).

Feige, E. L. (2016). Reflections on the Meaning and Measurement of Unobserved Economies: What Do We Really Know About the'Shadow Economy'. *Journal of Tax Administration* (2016) Vol, 2.

Frey, B.S. and H. Weck (1983a), Bureaucracy and the shadow economy: a macro-approach, in: Hanusch, H. (ed.), Anatomy of Government Deficiencies, *Springer*, Berlin, pp. 89–109.

Frey, B.S. and H. Weck (1983b), Estimating the shadow economy: a "naïve" approach, *Oxford Economic Papers*, 35, pp. 23–44.

Frey, B.S. and H. Weck-Hannemann (1984), The hidden economy as an "unobserved" variable, *European Economic Review*, 26, pp. 33–53.

Franz, A. (1983), Wie groß ist die „schwarze" Wirtschaft?, Mitteilungsblatt der Österreichischen *Statistischen Gesellschaft*, 49, pp. 1–6.

Gutmann, P.M. (1977), The subterranean economy, *Financial Analysts Journal*, 34/1, pp. 24– 27.

Hassan, M., & Schneider, F. (2016). Size and development of the shadow economies of 157 countries worldwide: Updated and new measures from 1999 to 2013. Available at SSRN 2861026.

Helberger, C., & Knepel, H. (1988). How big is the shadow economy? A re-analysis of the unobserved-variable approach of B.S. Frey and H. Weck-Hannemann. *European Economic Review*, 32, 965–976.

Henderson, J. V., Storeygard, A., & Weil, D. N. (2012). Measuring economic growth from outer space. *American economic review*, 102(2), 994-1028.

Johnson, S., Kaufmann, D. and P. Zoido-Lobatón (1998a), Regulatory discretion and the unofficial economy, *The American Economic Review*, 88/2, pp. 387–392.

Johnson, S., Kaufmann D. and P. Zoido-Lobatón (1998b), Corruption, Public Finances and the Unofficial Economy, *World Bank Policy Research Working Paper Series No. 2169, The World Bank*, Washington, D.C.

Kaliberda, A., & Kaufmann, D. (1996). Integrating the unofficial economy into the dynamics of post-socialist economies: A framework of analysis and evidence. *The World Bank.*015 p5

Lackó, M. (1996). Hidden economy in East-European countries in international comparison. International Institute for Applied Systems Analysis (IIASA), Laxenburg.

Lizzeri, C. (1979), Mezzogiorno in Controluce. *Enel*, Naples.

MacAfee, K. (1980), A glimpse of the hidden economy in the national accounts, *Economic Trends*, 136, pp. 81–87

Medina, L. & Schneider, F., (2018). Shadow economies around the world: what did we learn over the last 20 years? International *Monetary Fund working papers. African Department,* Washington, DC doi: 10.5089/9781484338636.001.

Medina, L., & Schneider, F. (2019). Shedding light on the shadow economy: A global database and the interaction with the official one. *CESifo Working Paper No. 7981*

OECD. (2002). Measuring the Non-Observed Economy.

O'Higgins, M. (1989), Assessing the underground economy in the United Kingdom, in: Feige, E.L. (ed.), The Underground Economies: Tax Evasion and Information Distortion, *Cambridge University Press*, Cambridge, UK, pp. 175–195.

O'Neill, D.M. (1983), Growth of the underground economy 1950–81: some evidence from the current population survey, Study for the Joint Economic Committee, U.S. *Congress Joint Committee Print*, U.S. Gov. Printing Office, Washington, DC, pp. 98–122.

Quintano, C., & Mazzocchi, P. (2013). The shadow economy beyond European public governance. *Economic Systems*, 37, 650–670.

Park, T. (1979), Reconciliation Between Personal Income and Taxable Income, *Bureau of Economic Analysis*, Washington, DC, pp. 1947–1977.

Petersen, H.G. (1982), Size of the public sector, economic growth and the informal economy: development trends in the Federal Republic of Germany, *Review of Income and Wealth*, 28, pp. 191–215

Postea M.M. , Achim M. V., (2022), Estimation methods for the shadow economy. A systematic literature review. 24th RSEP International Economics, Finance & Business Conference.

Portes, A. (1996), The informal economy, in: Pozo, S. (ed.), Exploring the Underground Economy, W.E. *Upjohn Institute for Employment Research*, Kalamazoo, pp. 147–165

Psychoyios, D., Missiou, O., & Dergiades, T. (2021). Energy based estimation of the shadow economy: The role of governance quality. *The Quarterly Review of Economics and Finance*, 80, 797-808.

Psychoyios, D., et al. Energy based estimation of the shadow economy: The role of governance quality. The Quarterly Review of Economics and Finance (2019)

Ruge, M. (2010). Determinants and size of the shadow economy – A structural equation model. International *Economic Journal*, 24, 511–524

www.rsepconferences.com CONFERENCE PROCEEDINGS/FULL PAPERS ISBN: 978-605-70583-8-6/July 2022

Postea, M.M. & Achim, M.V.pp.137-150

Schneider, F. (2019). Size of the shadow economies of 28 European Union countries from 2003 to 2018. In European Union (pp. 111-121). *Palgrave Macmillan*, Cham.

Schneider, F. & Enste, D. (2000). Shadow economies: size, causes, and consequences. *J. Econ.* Lit. 38, 77–114.

Schneider, F., Buehn, A., & Montenegro, C.E. (2010). New estimates for shadow economies all over the world. *Int. Econ. J.* 24(4), 443–461.

Schneider, F., Raczkowski K., Mróz, B., (2015),"Shadow economy and tax evasion in the EU", *Journal of Money Laundering Control*, Vol. 18 Iss 1 pp. 34 – 51

Schneider, F., & Buehn, A. (2018). Shadow economy: Estimation methods, problems, results and open questions. *Open Economics*, 1(1), 1-29.

Schneider, F., Linsbauer, K., & Heinemann, F. (2015). Religion and the Shadow Economy. *Kyklos*, 68(1), 111–41.

Smith, P. (1994), Assessing the size of the underground economy: the Canadian statistical perspectives, *Canadian Economic Observer*, 11, pp. 16–33.

Takala, K., & Viren, M. (2010). Is Cash Used Only in the Shadow Economy? *International Economic Journal*, 24, 525–540.

Tanzi, V. (1980), The underground economy in the United States: estimates and implications, *Banca Nazionale del Lavoro*, 135, pp. 427–453.

Tanzi, V. (1983), The underground economy in the United States: annual estimates, 1930–1980, *IMF Staff Papers*, 30, pp. 283–305

Williams, C.C. (2004), Cash-in-hand Work: The Underground Sector and the Hidden Economy of Favours, *Palgrave-Macmillan*, London.

Williams, C. C., & Schneider, F. (2013). The shadow economy. London: *Institute of Economic Affairs.*

Yoo, T., & Hyun, J. K. (1998). International comparison of the black economy: Empirical evidence using micro-level data. Paper Presented at 1998 *Congress of Int. Institute Public Finance*