Estimation methods for the shadow economy: A systematic literature review

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Abstract

Estimating the shadow economy is by no means a simple task. The hidden nature of the phenomenon makes it difficult to measure. In the literature, there are various methods used in estimating the shadow economy, each of which has its strengths and weaknesses. This paper aims to be a detailed literature review of the different types of methods existing at the current time. The review can be a good reference in deciding which of the methods is best to serve one's purpose when measuring the underground economy. Analyzing the advantages and shortcomings of each method, as well as the methodology used, can lead to a rational decision regarding the estimation of the shadow economy. Reviewing the literature, we identified three main groups of methods for estimating the shadow economy: 1) Direct methods; 2) Indirect methods; and 3) Model approach. Over the years, there has been an increasing interest in developing estimation models for the shadow economy, but, to date, there is no universally accepted definition for the concept, nor a universally accepted type of model used. However, the most frequently used method to estimate the shadow economy, in recent years has been the model approach (MIMIC), despite its limitations. When deciding which model to use to estimate the shadow economy, one has to consider the definition of the concept (what kinds of activities will be included), the availability of data necessary, and the methodology used. Our paper is useful both for academical purposes but also for policy makers in order to find the best tool of measuring the shadow economy around the world countries.

Keywords: shadow economy, underground economy, estimation methods

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1. Introduction

Estimating the shadow economy is by no means a simple task. The hidden nature of the phenomenon makes it difficult to measure. In the literature, there are various methods used in estimating the shadow economy, each of which has its strengths and weaknesses.

The definition of the shadow economy plays an important role in trying to estimate its size. 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 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 very important to know what component of the unobserved economy is estimated by the model used. For example, 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.

It is useful to say that most of the methods used to estimate the shadow economy, in the existing literature, refer to "underground production" according to NOE classification given by the OECD (2002), or "underground activities" defined by EUROSTAT (2014).

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).

The aim of the paper is to provide a detailed literature review of the existing methods used to estimate the shadow economy. We will describe the methods, highlight the weaknesses and advantages of using them, and compare the values of different estimates made using the methods described, in a specific year for a specific country.

2. Methods used in estimating the shadow economy
2.1. Direct methods
In this 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.

Until 2006, there were not many studies regarding the estimates of the shadow economy using the survey method. Until now, the vast majority of direct surveys were small-scale intensive surveys, usually conducted on specific localities (Barthe, 1985; Fortin et al., 1996; Howe, 1988; Lemieux et al., 1994; Leonard, 1994; McCrohan et al., 1991; Pahl, 1984; Warde, 1990; Williams, 2004, 2006; Williams and Windebank, 2001). The first direct survey of business perceptions of the magnitude of the shadow economy was conducted by Collin C. Williams in 2006. The survey was conducted in the UK, at the national level and highlighted the perception of enterprise management about the shadow economy in the sector in which they activate. The result is that businesses perceive that about 8 per cent of the activities in their sector are in the informal sector. The study also emphasized the fact that there are marked variations in the prevalence of the shadow economy in different sectors, regions, and businesses.

Regarding tax audit methods, the best example would be the one used by the US Internal Revenue Service (IRS), which conducted detailed line by line audits for the period 1965 – 1988 in the US. They considered a stratified random sample of 50.000 individual tax returns on a 3-year cycle. These audits have led to an IRS estimate of the

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taxpayer's true income, which led the IRS to the real tax gap existing in the economy. The reality is that few other countries have systematic audit – based programs (OECD, 2002).

The direct methods have the obvious advantage that they can deliver results in specific sectors or regions. Meanwhile, the drawbacks are related to the potentially biased sample of the population or to the fact that the selection of taxpayers for a tax audit is not random, and thus the sample is not representative for the entire population. Also, tax audit-based estimates reflect the portion of informal activities that the authorities succeed in discovering, this being a fraction of the real informal activity. Consequently, this would be the main disadvantage of both the survey and tax audit-based methods; the fact that they don't capture all shadow activities. In addition, 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). Furthermore, these methods are unable to evaluate the development and growth of the shadow economy over a long period of time. Following these estimates for a long-term period can be very expensive.

2.2 Indirect methods

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).

In the following paragraphs we will describe in depth these methods based on the existing research studies that uses them.

2.2.1 The discrepancy between national expenditure and income statistics

This 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).

2.2.2. Estimating the shadow economy using employment statistics.

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; 2) The use of labor versus supply of labor; 3) The employment rate method.

In the following paragraphs, we will detail these methods along with their strengths and weaknesses when measuring the shadow economy.

   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: 1) differences in the rate of participation may have other causes, such as an economic crisis (Schneider and Buehn 2018); 2) 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: 3) this method doesn't include wages granted but not declared to the authorities, the so called "envelop" wages.

   2)   Use of labor versus supply of labor

This method is best described in the OECD handbook titled "Measuring the non-observed economy" from 2002. 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).

The steps of the method are the following: 1) estimate the labor input underlying GDP estimates – deriving the labor input that is included in the GDP estimates; 2) estimate the labor input based on household survey data – typically obtained from a labor force survey; 3) standardize the labor input estimates – converting the two labor estimates to the same units of labor input, such as hours worked so that they can be meaningfully compared; 4) compare the two sets of estimates – analyzing the discrepancies. A surplus of labor input derived from the employee source over the enterprise source can be an indication of non-observed production. 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 or the Italian 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).

2.2.3 Monetary methods

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: 1) The transaction approach and 2) The currency demand approach.

   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).

Feige applied the method to the United States. He assumed that the shadow economy was zero in the year 1939, and he calculated the shadow economy to be 27% in the year 1979.

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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: 1) 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 (for example, the repurchase agreements, euro – dollars deposits); 2) increased facilities for and use of cheques and credit cards can also have an impact; 3) 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; 4) the fact that the method requires a large amount of empirical research and data, makes the results doubtful; 5) 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.

Applied to the Netherlands, the transaction method revealed implausible results. To address this problem, Boeschoten and Fase (1984) modified the transaction method, creating a new base method and several other variants. However, they obtained significantly different results, and there is no way to know which could be closest to the truth (OECD 2002).

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. The regression equation for the proposed currency demand is:

$$(1) \quad \ln (C / M2)\, t = \beta O + \beta 1 \ln (1 + TW)\, t + \beta 2 \ln (WS / Y)\, t + \beta 3 \ln Rt + \beta 4 \ln (Y / N)\, t + ut,$$
$$\text{with } \beta 1 > 0, \beta 2 > 0, \beta 3 < 0, \beta 4 > 0,$$

where ln denotes natural logarithms, C/M2 cash holdings ratio to current and deposit accounts, TW is a weighted average tax rate, WS/Y is the proportion of wages in national income, R is the interest paid on savings deposits and Y/N is per capita income.

Any "excess" increase in currency will then be attributed to the rising tax burden and other reasons leading people to work in the shadow economy. The size and development of the shadow economy can be computed by comparing the difference between the development of the currency when the tax burden and government regulation are held at their lowest value and the development of the currency at their actual value. Assuming the same income velocity for currency used in the shadow economy as well as in the official economy, the size of the shadow economy can be computed.

There are several disadvantages and criticisms in the literature regarding this method, among them being: 1) The main and obvious objection is that not all shadow economy transactions are paid with cash (Takala, Viren 2010); 2) 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); 3) 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.

In conclusion, monetary methods are unsuitable for estimating the shadow economy, firstly because they are based on assumptions that cannot be justified. The main assumption of the currency demand approach is that a change in the size of the shadow economy is caused by a change in taxation and/or government regulation and that this will be visible in the change in the demand for currency because informal transactions are mainly paid with cash. This assumption could not be tested and it is probably not true (OECD, 2002). In contrast, the transaction approach is not based on any assumed relation between monetary transactions and GDP, which likewise cannot be justified.

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The main argument against these models is given by the sensitivity of the results to the base year assumptions, most of which are not even close to reality. Consequently, the results obtained by making these assumptions are questionable.

2.2.4 The physical input approach (energy consumption)

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). In the following paragraphs, we will describe each one of them.

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 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, 2000) 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. In explaining the method, Lacko (1998) uses two regression specifications. In the first one, the shadow economy appears as the dependent variable, and in the second one, the shadow economy is the explanatory variable:

$$(1) \quad \ln E_i = \alpha_1 \ln C_i + \alpha_2 \ln PR_i + \alpha_3 G_i + \alpha_4 Q_i + \alpha_5 H_i + u_i \quad \text{with } \alpha_1 > 0, \alpha_2 < 0, \alpha_3 > 0, \alpha_4 < 0, \alpha_5 > 0$$

$$(2) \quad H_i = \beta_1 T_i + \beta_2 (S_i - T_i) + \beta_3 D_i \quad \text{with } \beta_1 > 0, \beta_2 < 0, \beta_3 > 0$$

where i indicates the number assigned to the country,
E_i is per capita household electricity consumption in country i,
C_i is per capita real consumption of households without the consumption of electricity in country i in US dollars (at purchasing power parity),
PR_i is the real price of consumption of 1 kWh of residential electricity in US dollars (at purchasing power parity),
G_i is the relative frequency of months requiring heating in houses in country i,

Qi is the ratio of energy sources other than electricity energy to all energy sources in household energy consumption,

Hi is the per capita output of the hidden economy,

Ti is the ratio of the sum of paid personal income, corporate profit and taxes on goods and services to GDP,

Si is the ratio of public social welfare expenditures to GDP,

Di is the sum of the number of dependents over 14 years of age and inactive earners, both per 100 active earners. She then estimates the first equation by substituting Hi with the second one. Further, there is the need to know how much GDP is produced by one unit of electricity consumption in the shadow economy for each country. This data is not known, as a result she uses the estimates of the shadow economy obtained by another approach. She used the estimates of the shadow economy for the United States as a base (10,5% of GDP obtained by Morris (1993)) for calculating the shadow economy for other countries.

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 physical input method is very simple and can appear appealing to use it in estimating the shadow economy. However, it is subject of criticism mainly for three major reasons. First, the fact that there are shadow economy activities that do not use energy or can use alternative energy sources. Second, the method requires the estimation of different elasticities of electricity/GDP across countries and over time, and it is a known fact that variations in elasticities do occur and are due to factors that could not be related to shadow economy activities of households or businesses. Also, the two approaches described here rely on a broad definition of the shadow economy, because they include all activities (legal and illegal) that require electric power consumption.

In the literature, in the recent years, there have been variations of the physical input method that tried to address the shortcomings of the initial methods. For example, in their research, Psychoyios, D., et al. (2021) make the distinction between two different methods.

First, there is the simple electricity consumption method (ECMs), which assumes that the growth rate of total electricity consumption is the best single proxy for the growth of overall (real and shadow) economic activity. And second, the authors propose a modified electricity consumption method (ECMm) which considers the fact that variations in electricity consumption may be attributed to factors other than economic. In this modified version, Psychoyios, D., et al. (2021) propose the following regression:

$$C_{it}^{Ele,c} = a_0 + a_1 P_{it}^{Ele,c} + a_2 U_{it}^{Ele,c} + a_3 I_{it}^{Add,c} + a_4 H_{it}^{Dd,c} + a_5 P_{it}^{Oil,c} + u_{it}$$

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.

Going further, the authors proposed a model in which the final energy consumption growth is used, instead of the electricity consumption growth, addressing the issue regarding the forms of energy that can be used in economic activities (other than electricity). The total final energy consumption variable aggregates several forms of energy.

In our opinion, this could be a starting point for updating the research of Kaliberda and Kaufmann (1996), Lacko (1998), and Eilat and Zinnes (2002). Some of the shortcomings of the two standard methods were addressed. Future research in this field should address the other ones as well.

2.3 The model approach
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. The model uses a technique (known as LISREL – Linear Structural Relations) that enables a cross-sectional analysis of the relationship between a dependent variable and one or more explanatory variables. The results are estimates of the relative size of the non-observed variable in each of the countries, or time periods. 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. Frey and Weck calculated the relative sizes of the shadow economy in a large number of countries and then generated estimates of the actual sizes, using monetary method estimates for Sweden and Norway as benchmarks.

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. For example, the variable tax morale can be very difficult to quantify in an objective manner. Or the number of weekly working hours, is it a trace of the shadow economy? Or is it rather a consequence? (OECD, 2002). And lastly, the reliability of the model is based entirely on the reliability of the benchmarks used.

Over the years, this latent variable model was used and modified several times by researchers that wanted to benefit from the advantage of explaining the shadow economy with the aid of multiple variables. A remarkable contribution had professor Schneider (Schneider and Enste (2000), Buehn and Schneider (2007), Dell Anno and Schneider (2009), 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)), who, over the years, perfected this method.

The model proposed by Medina and Schneider (2019) is based on three steps:

1) Modeling the shadow economy as an unobservable variable;
2) Description of the relationship between the latent variable and its causes in a structural model:
$$SE = \Gamma X + \xi$$

3) The link between the latent variable and its indicators, represented in the measurement model:
$$Y = \Lambda SE + \varepsilon$$

Where, SE represents the shadow economy, X represents the variables used as causes, and Y represents the variables used for indicators.

The estimation, as explained by Medina and Schneider (2019), relies on the following drivers of the shadow economy: a measure of the tax burden on the economy, institutional quality, and openness, proxied by trade openness and unemployment. The model also uses the following indicators: currency as a fraction of broad money, labour force participation, and a measure of the size of the economy. It should be noted that different studies use different variables as causes and indicators (Elgin and Erturk, 2019).

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?

Some harsher criticisms of the method can be found in the literature regarding the use of the MIMIC method in estimating the shadow economy. For example, in the papers of Breusch (2005) and later of Feige (2016), the proper use of variables, the definition itself given by Schneider for the term "shadow economy", and the proper use of econometrical modelling were questioned. Feige, in his paper, concluded that "MIMIC model applications treating the "shadow economy" as a latent variable purport to measure the underground component of the NOE. Analyses of these applications reveal that the statistical and economic assumptions of the MIMIC model are typically violated and that resulting latent variable bears little relationship to any unobserved economy. The methodology has been shown to be so malleable that it can be readily manipulated to obtain virtually any desired result, however the complexity of the procedure often obscures these manipulations."

Even so, to date, the estimations obtained by Schneider and his collaborators are widely used and considered a starting point when it comes to quantifying the non - observed economy in many countries worldwide.

Summarizing, in Table 1, we made a short recap of the methods used for estimating the shadow economy, with references from the literature and highlighting the main advantages and disadvantages of using each one of them.

Table 1. Estimation methods of the shadow economy. Literature review

Estimation method		References in the literature	Advantage	Disadvantage
Direct methods	Survey based methods	Barthe, 1985; Fortin et al., 1996; Howe, 1988; Lemieux et al., 1994; Leonard, 1994; McCrohan et al., 1991; Pahl, 1984; Warde, 1990; Williams, 2004, 2006; Williams and Windebank, 2001	They can deliver estimations to specific sectors and regions;	High costs; Biased sample of the population The honesty of the respondents can be questionable; They offer point estimates at a certain time.
	Tax audit-based methods	US IRS	They can deliver estimation regarding a specific sector or region;	They are not always random; They reveal a fraction of the informal activity
Indirect methods	The discrepancy between national expenditure and income statistics	Franz, 1983; O'Higgins, 1989; Smith, 1994; MacAfee, 1980; Petersen, 1982; Del Boca & Forte, 1982; Park, 1979; Yoo & Hyun, 1998	The national accounts provide both income based and expenditure based estimates;	There can be other causes for the discrepancy; Some activities might be omitted from the expenditure - based estimates
	Estimating the shadow economy using employment statistics	Contini,1981; Del Boca, 1981; O'Neill, 1983.	They can reveal the structure of workforce at different times, sectors and regions.	Differences can have other causes, such as an economic crisis; People can have both formal and informal jobs at a time; They don't include "envelop" wages
	Monetary methods	Feige in 1979; Boeschoten and Fase, 1984; Cagan, 1958; Gutmann, 1977; Tanzi, 1980, 1983; Alm, Embaye, 2013; Chen, Schneider, 2018	They can reveal useful information regarding the shadow economy activities settled with cash	Not all shadow economy transactions are paid with cash; The sensitivity of the results to the base year assumptions
	The physical input approach	Lizzeri, 1979; Del Boca and Forte, 1982; Portes, 1996; Kaliberda and Kaufmann, 1996; Johnson et al,1997; Lacko, 1998, 2000; Johnson et al, 1998; Eilat, Zinnes, 2002; Psychoyios, D., et al, 2021;	Very simple and can appear appealing	There are shadow economy activities that do not use energy; They rely on a broad definition of the shadow economy
The model approach	MIMIC	Frey and Weck, 1983; Quintano & Mazzocchi, 2013; Ruge, 2010; Schneider and Enste, 2000; Buehn and Schneider, 2007; Dell Anno and Schneider, 2009; 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.	The use of multiple variables to explain the shadow economy	The results are highly dependent on proper selection of the variables

Source: Own compilation.

3. Conclusions

Reviewing the literature related to research on the shadow economy, we realized that at the present moment, there is no deffinition universally accepted for this concept. Such a deffinition is necessary to be able to compare estimates from different countries and also to conceptualize the phenomenon before trying to estimate it.

In the literature, we identified three broad classes of methods used in estimating the shadow economy. Analysing the methods, we identified several advantages and shortcomings for each one of them. For example, the direct approach can be very useful for gathering information regarding a specific sector of the economy at a specific time, but the disadvantage is that these methods deliver information only at a specific period, thus, the evolution of the indicator can't be obtained. Also, the method comes with high costs.

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A major issue regarding indirect approaches is that they consider one factor as an indicator of the shadow economy (e.g, the consumption of electricity, employment rate or currency demand). Also, many estimation methods are dependent of simplistic assumptions that cannot be justified. For example, the monetary models assume that changes in the evolution of currency demand can be attributed entirely to changes in missing economic activities. Similarly, the physical input method assumes that variations in the consumption of electricity can be explained by the evolution of the informal sector. The advantage of all these methods would be the simplicity of the methodology used and the availability of data.

The model approach adresses the issue of having just one factor influencing the shadow economy by considering various variables in describing the concept, but these models tend to be unstable and very complicated at times, as some researchers have proven it.

At the present, we can state that there is no estimation better than the other. Each method, with no exception, has its limitations. When estimating the shadow economy, it is advised to use different types of estimation methods.

Our future research would be concentrated on perfecting the physical input method, addresing the issues that are related to this method, and maybe combining it with other methods identified in the literature to obtain a more reliable estimation for the shadow economy in Romania and other EU countries.

The review of the literature has demonstrated, once again, that the link between theory and empirical estimation of the shadow economy is still unsatisfactory. Therefore, research in this area is necessary and would be very useful. Also, developing a good method that could help validate the empirical results and determine their plausibility is mandatory in this field. In future studies, we will be concerned with combining both the advantages and disadvantages in order to elaborate on the best possible method that optimizes their advantages and disadvantages.

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The authors of this paper certify that there is no financial or personal interest that could have appeared to influence the work reported in this paper.

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