



Review Article

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Shadow Economy: Estimation Methods, Problems, Results and Open questions

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Abstract: This paper presents various methods used for estimating the size of the shadow economy. Each method is evaluated and its strengths and weaknesses are discussed, as well as results each method yields. The purpose of the paper is threefold: Firstly, to demonstrate that there is no single infallible method for estimating the size and development of the shadow economy and results can differ significantly between different approaches. The MIMIC approach, discussed in greater detail, is often used due to its flexibility. Secondly, the paper discusses the very definition of the shadow economy and factors contributing to its growth. Finally, latest estimations of the size of the shadow economies of 143 countries over the period 1996 to 2014 are presented.

JEL-Classification: D78, E26, H2, H11, H26, K42, O5, O17

Keywords: shadow economy estimates, MIMIC approach, methods to estimate the shadow economy, advantages and disadvantages of the methods, MIMIC-method, calibration procedure, light intensity approach

1 Introduction

Empirical research about the size and development of the shadow economy all over the world has grown rapidly. Nowadays, there are so many studies,¹ which use different methods in order to estimate the size and development of the shadow economy, that it is quite difficult to judge the reliability of various methods. Hence, the goal of this paper is to critically review the various methods for estimating the size of the shadow economy and to discuss their strengths and weaknesses. This will enable an interested reader to evaluate the advantages and disadvantages of the different methods.

The paper is structured as follows: In the next section some theoretical considerations are presented, starting with a definition of the shadow economy and a brief discussion of its main causes. In section 3 the various measurement methods, as well as their strengths and weaknesses, are described. This section also presents estimates of the size of the shadow economy in Germany using different estimation methods. Section 4 presents some latest developments, new measurement methods, the concept of digital shadow economy, and latest results from 143 countries between 1996 and 2014. Finally, section 5 presents a summary and some concluding remarks.

¹ See e.g. Feld and Schneider (2010), Gerxhani (2003), Schneider (2015), and Schneider and Williams (2013), Schneider (2016), Williams and Schneider (2016), and Sauka, Schneider and Williams (2016).

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2 Theoretical considerations

2.1 Defining the shadow economy

Researchers attempting to measure the size of shadow economy face the first and difficult question of how to define it.² One commonly used working definition encompasses all currently unregistered economic activities that would contribute to the officially calculated (or observed) Gross National Product if observed.³ Smith (1994, p. 18) uses the definition “market-based production of goods and services, whether legal or illegal, that escapes detection in the official estimates of GDP.” One of the broadest definitions includes “those economic activities and the income derived from them that circumvent government regulation, taxation or observation”.⁴ As these definitions still leave a lot of questions unanswered, table 1 offers a reasonable consensus for a definition of the underground (or shadow) economy. From table 1, it is clear that a broad definition of the shadow economy includes unreported income from the production of legal goods and services – either from monetary or barter transactions – and so includes all economic activities that would generally be taxable, were they reported to the tax authorities.

Table 1: A taxonomy of types of underground economic activities

Type of activity	Monetary transactions		Non-monetary transactions	
Illegal Activities	Trade with stolen goods; drug dealing and manufacturing; prostitution; gambling; smuggling; fraud; etc.		Barter of drugs, stolen goods, smuggling etc. Producing or growing drugs for own use. Theft for own use.	
	Tax Evasion	Tax Avoidance	Tax Evasion	Tax Avoidance
Legal Activities	Unreported income from self-employment; wages, salaries and assets from unreported work related to legal services and goods	Employee discounts, fringe benefits	Barter of legal services and goods	All do-it-yourself work and neighbor help

Structure of the table is taken from Lippert and Walker (1997, p. 5) with additional remarks provided

This paper uses the following, narrower, definition of the shadow economy.⁵ The shadow economy includes all market-based legal production of goods and services that are deliberately concealed from public authorities for the following reasons:

1. to avoid payment of taxes, e.g. income taxes or value added taxes,
2. to avoid payment of social security contributions,
3. to avoid certain legal labor market standards, such as minimum wages, maximum working hours, safety standards, etc., and
4. to avoid complying with certain administrative procedures, such as completing statistical questionnaires or other administrative forms.

² See Frey and Pommerehne (1984), Thomas (1992), Loayza (1996), Pozo (1996), Lippert and Walker (1997), Schneider (1994a, 1994b, 1997, 1998, 2003, 2005, 2011), Johnson, Kaufmann, and Shleifer (1997), Johnson, Kaufmann and Zoido-Lobatón (1998a), Belev (2003), Gerxhani (2003), and Pedersen (2003). For newer surveys, see Schneider and Enste (2000, 2002), Schneider and Williams (2013), Alm, et al. (2004), Feld and Schneider (2010), Hassan and Schneider (2016a,b) and Williams and Schneider (2016).

³ This definition is used, for example, by Feige (1989, 1994), Schneider (1994a, 2003, 2005, 2011), and Frey and Pommerehne (1984). Do-it-yourself activities are not included. For estimates of the shadow economy and do-it-yourself activities for Germany, see Buehn, Karmann and Schneider (2009). This definition is taken from Dell’Anno (2003), Dell’Anno and Schneider (2004) and Feige (1989). See also Thomas (1999), Fleming, Roman and Farrell (2000).

⁴ This definition is taken from Dell’Anno (2003), Dell’Anno and Schneider (2004) and Feige (1989). See also Thomas (1999), Fleming, Roman and Farrell (2000).

⁵ Compare also the excellent discussion of the definition of the shadow economy in Pedersen (2003, pp. 13–19), who uses a similar definition.

2.2 Theorizing about the shadow economy

A useful starting point for a theoretical discussion of the shadow economy is the famous study by Allingham and Sandmo (1972) on income tax evasion. While the shadow economy and tax evasion are not congruent, in most cases activities in the shadow economy imply the evasion of direct or indirect taxes, such that factors determining tax evasion will most certainly also affect the shadow economy. According to Allingham and Sandmo tax compliance depends on its expected costs and benefits. The benefits of tax non-compliance result from the individual marginal tax rate and true individual income. In the case of the shadow economy the individual marginal tax rate is often roughly calculated using the overall tax burden from indirect and direct taxes including social security contributions. The expected costs of non-compliance derive from deterrence enacted by the state, that is, the state's auditing activities raising the probability of detection and the fines individuals face when they are caught. Individual morality also plays a role in compliance and additional costs may apply beyond the tax administration's pure punishment in the form of psychic costs like shame or regret, but also additional pecuniary costs if, for example, loss of reputation results.

Individuals are rational calculators who weigh up costs and benefits when considering breaking the law. Their decision to partially or completely participate in the shadow economy is a choice under uncertainty, facing a trade-off between gains if their activities are not discovered and losses if discovered and penalized. Shadow economic activities SE thus negatively depend on the probability of detection p and potential fines f , and positively on the opportunity costs of remaining formal denoted as B . The opportunity costs are positively determined by the burden of taxation T and high labor costs W – individual income generated in the shadow economy is usually categorized as labor income rather than capital income – due to labor market regulations. Hence, the higher the tax burden and labor costs, the more incentives individuals have to avoid these costs by working in the shadow economy. The probability of detection p itself depends on enforcement actions A taken by the tax authority and on facilitating activities F accomplished by individuals to reduce detection of shadow economic activities. This discussion suggests the following structural equation:

$$SE = SE \left[p \left(A, F \right); f; B \left(T, W \right) \right]. \quad (1)$$

Hence, shadow economic activities may be defined as those economic activities and income earned that circumvent government regulation, taxation or observation. More narrowly, the shadow economy includes monetary and non-monetary transactions of a legal nature; hence all productive economic activities that would generally be taxable were they reported to the state (tax) authorities. Such activities are deliberately concealed from public authorities to avoid payment of income, value added or other taxes and social security contributions, or to avoid compliance with certain legal labor market standards such as minimum wages, maximum working hours, or safety standards and administrative procedures. The shadow economy thus focuses on productive economic activities that would normally be included in the national accounts but which remain underground due to tax or regulatory burdens.⁶ Although such legal activities would contribute to a country's value added, they are not captured in national accounts because they are produced in illicit ways. Informal household economic activities such as do-it-yourself activities and neighborly help are typically excluded in the analysis of the shadow economy.⁷

Kanniainen, Pääkönen and Schneider (2004) incorporate many of these insights in their model of the shadow economy. They hypothesize that tax hikes unambiguously increase the size of shadow economy, while the availability of public goods financed by taxes moderates participation in the shadow economy. The

⁶ Although classical crime activities such as drug dealing are independent of increasing taxes and the causal variables included in the empirical models are only imperfectly linked (or causal) to classical crime activities, the footprints used to indicate shadow economic activities such as currency in circulation also apply for classic crime. Hence, macroeconomic shadow economy estimates do not typically distinguish legal from illegal underground activities; rather they represent the whole informal economy spectrum.

⁷ From a social perspective, maybe even from an economic one, soft forms of illicit employment such as moonlighting (e.g. construction work in private homes) and its contribution to aggregate value added may be assessed positively. For a discussion of these issues see Thomas (1992) and Buehn, Karmann and Schneider (2009).

latter effect, however, depends on the ability to access these public goods. A shortcoming of this analysis is the neglected endogeneity of tax morale and good governance, as addressed by Feld and Frey (2007), who argue that tax compliance is the result of a complicated interaction between tax morale and deterrence measures. It must be clear to taxpayers what the rules of the game are and as deterrence measures serve as signals for the level of tax morale a society wants to elicit (Posner, 2000), deterrence may also crowd out the intrinsic motivation to pay taxes. Tax morale not only increases if taxpayers acknowledge the public goods received in exchange for their tax payments; it may also decrease if individuals perceive political decisions for public activities or the treatment of taxpayers by the tax authorities to be unfair. Tax morale is thus not exogenously given but influenced by deterrence and the quality of state institutions. Table 2 presents an overview of the most important determinants influencing the shadow economy.

Table 2: The main causes determining the shadow economy

Causal variable/No.	Theoretical reasoning	References
(1) Tax and social security contribution burdens	The distortion of the overall tax burden affects labor-leisure choices and may stimulate labor supply in the shadow economy. The bigger the difference between the total labor cost in the official economy and after-tax earnings (from work), the greater the incentive to reduce the tax wedge and work in the shadow economy. This tax wedge depends on social security burden/ payments and the overall tax burden, making them key determinants in the existence of the shadow economy.	E.g. Thomas (1992), Johnson, Kaufmann, and Zoido-Lobato (1998a,b), Giles (1999a), Tanzi (1999), Schneider (2003, 2005), Dell'Anno (2007), Dell'Anno, Gomez-Antonio and Alanon Pardo (2007)
(2) Quality of institutions or corruption	The quality of public institutions is another key factor in the development of the informal sector. In particular, the efficient and discretionary application of the tax code and regulations by the government plays a crucial role in the decision to work off the books, even more important than the actual burden of taxes and regulations. A bureaucracy with highly corrupt government officials tends to be associated with larger unofficial activity, while good rule of law through securing property rights and contract enforceability increases the benefits of being formal. A certain level of taxation, mostly spent in productive public services, characterizes efficient policies. In fact, production in the formal sector benefits from higher provision of productive public services and is negatively affected by taxation, while the shadow economy reacts in the opposite way. An informal sector developing as a consequence of the failure of political institutions to promote an efficient market economy, and entrepreneurs going underground due to inefficient public goods provision, may reduce if institutions can be strengthened and fiscal policy moves closer to the median voter's preferences.	E.g. Johnson et al. (1998a,b), Friedman, Johnson, Kaufmann, and Zoido-Lobato (2000), Dreher and Schneider (2009), Dreher, Kotsogiannis and McCorriston (2009), Schneider (2010), Teobaldelli (2011), Teobaldelli and Schneider (2012), Amendola and Dell'Anno (2010), Losby et al. (2002), Schneider and Williams (2013), Hassan and Schneider (2016), Williams and Schneider (2016)
(3) Regulations	Regulations, for example labor market regulations or trade barriers, are another important factor that reduces freedom (of choice) for individuals in the official economy. They lead to a substantial increase in labor costs in the official economy and thus provide another incentive to work in the shadow economy: countries that are more heavily regulated tend to have a higher share of the shadow economy in total GDP. Especially the enforcement and not the overall extent of regulation – mostly not enforced – is the key factor for the burden levied on firms and individuals, inducing them to operate in the shadow economy.	E.g. Johnson, Kaufmann, and Shleifer (1997), Johnson, Kaufmann, and Zoido-Lobato (1998b), Friedman, Johnson, Kaufmann, and Zoido-Lobato (2000), Kucera and Roncolato (2008), Schneider (2011), Hassan and Schneider (2016)

Table 2: The main causes determining the shadow economy

Causal variable/No.	Theoretical reasoning	References
(4) Public sector services	An increase in the shadow economy may lead to fewer state revenues, which in turn reduce the quality and quantity of publicly provided goods and services. Ultimately, this may lead to increasing tax rates for firms and individuals, although deterioration in the quality of the public goods (such as public infrastructure) and of the administration continues. The consequence is an even stronger incentive to participate in the shadow economy. Countries with higher tax revenues achieved by lower tax rates, fewer laws and regulations, a better rule of law and lower corruption levels should thus have smaller shadow economies.	E.g. Johnson, Kaufmann, and Zoido-Lobatón (1998a,b), Feld and Schneider (2010)
(5) Tax morale	The efficiency of the public sector also has an indirect effect on the size of the shadow economy because it affects tax morale. Tax compliance is driven by a psychological tax contract that entails rights and obligations from taxpayers and citizens on the one hand, but also from the state and its tax authorities on the other hand. Taxpayers are more inclined to pay their taxes honestly if they get valuable public services in exchange. However, taxpayers are honest even in cases when the benefit principle of taxation does not hold, i.e. for redistributive policies, if such political decisions follow fair procedures. The treatment of taxpayers by the tax authority also plays a role. If taxpayers are treated like partners in a (tax) contract instead of subordinates in a hierarchical relationship, taxpayers will stick to the obligations of the psychological tax contract more easily. Hence, (better) tax morale and (stronger) social norms may reduce the probability of individuals working in the shadow economy.	E.g. Feld and Frey (2007), Kirchler (2007), Torgler and Schneider (2009), Feld and Larsen (2005, 2009), Feld and Schneider (2010)
(6) Deterrence	Despite the strong focus on deterrence in policies fighting the shadow economy and the unambiguous insights of the traditional economic theory of tax non-compliance, surprisingly little is known from empirical studies about the effects of deterrence. This is because data on the legal background and the frequency of audits are not available on an international basis; even for OECD countries such data are difficult to collect. Either the legal background is quite complicated, differentiating fines and punishment according to the severity of the offense and the true income of the non-complier, or tax authorities do not reveal how intensively auditing is taking place. The little empirical survey evidence available demonstrates that fines and punishment do not exert a negative influence on the shadow economy, while the subjectively perceived risk of detection does. However, results are often weak and Granger causality tests show that the size of the shadow economy can affect deterrence, instead of deterrence reducing the shadow economy.	E.g. Andreoni, Erard and Feinstein (1998), Pedersen (2003), Feld and Larsen (2005, 2009), Feld and Schneider (2010)
(7) Development of the official economy	The development of the official economy is another key factor in the shadow economy. The higher (lower) the unemployment quota (GDP growth), the higher the incentive to work in the shadow economy, <i>ceteris paribus</i> .	Schneider and Williams (2013), Feld and Schneider (2010)
(8) Self-employment	The higher the rate of self-employment, the more activities can be performed in the shadow economy, <i>ceteris paribus</i> .	Schneider and Williams (2013), Feld and Schneider (2010)
(9) Unemployment	The higher the rate of unemployment, the higher the probability to work in the shadow economy, <i>ceteris paribus</i> .	Schneider and Williams (2013), Williams and Schneider (2016)
(10) Size of the agricultural sector	The larger the agricultural sector, the more possibilities to work in the shadow economy, <i>ceteris paribus</i> .	Hassan and Schneider (2016)

3 Methods to estimate the size of the shadow economy

Estimating the size of a shadow economy is a difficult and challenging task.⁸ In this paper we give a short but comprehensive overview of the various procedures for estimating the size of a shadow economy. Three different categories of measurement methods are most widely used, and each is briefly discussed.

3.1 Direct approaches

These are microeconomic approaches that employ either well-designed surveys and samples based on voluntary replies, or tax auditing and other compliance methods. Sample surveys designed to estimate the shadow economy are widely used.⁹ The main disadvantages of this method are the flaws inherent in all surveys. For example, the average precision and results depend greatly on the respondent's willingness to cooperate, it is difficult to assess the amount of undeclared work from a direct questionnaire, most interviewees hesitate to confess to fraudulent behavior, and responses are of uncertain reliability, which makes it difficult to calculate a true estimate (in monetary terms) of the extent of undeclared work. The main advantage of this method lies in the detailed information which can be obtained about the structure of the shadow economy, but results from these kinds of surveys are very sensitive to the way the questionnaire is formulated.¹⁰

Estimates of the shadow economy can also be based on the discrepancy between income declared for tax purposes and that measured by selective checks. Fiscal auditing programs have been particularly effective in this regard. Since these programs are designed to measure the amount of undeclared taxable income, they may also be used to calculate the size of the shadow economy.¹¹ However, a number of difficulties beset this approach. First, using tax compliance data is equivalent to using a (possibly biased) sample of the population. In general, the selection of taxpayers for tax audits is not random but based on properties of submitted (tax) returns that indicate a certain likelihood of tax fraud. Consequently, such a sample is not a random one of the whole population, and estimates of the shadow economy based upon a biased sample may not be accurate. Second, estimates based on tax audits reflect only that portion of the shadow economy discovered by income tax authorities, and this is likely to be only a fraction of all hidden income.

Survey results can also be inconsistent internationally. In addition to the studies by Feld and Larsen (2005, 2008, 2009), Haigner et al. (2013), and Enste and Schneider (2006) for Germany, survey methods have been applied in the Northern countries and Great Britain (Isachsen and Strøm (1985), Pedersen (2003), Schneider and Zukauskas (2016)) as well as in the Netherlands (Van Eck and Kazemier (1988), Kazemier (2006)). The questionnaires underlying these studies are broadly comparable in design; however, recent attempts by the European Union to provide survey results for all member states have run into great difficulties of comparability (Renooy et al. (2004), European Commission (2007)). The wording of the questionnaires becomes more and more cumbersome, depending on the culture of different countries with respect to the underground economy.

⁸ Compare Feld and Schneider (2010), Sauka, Schneider and Williams (2016), Kirchgassner (2016), and Feld and Schneider (2016).

⁹ The direct method of voluntary sample surveys has been extensively used for Norway by Isachsen et al. (1982), and Isachsen and Strom (1985). For Denmark this method is used by Mogensen et al. (1995) in which they report "estimates" of the shadow economy of 2.7% of GDP for 1989, 4.2% of GDP for 1991, 3.0% of GDP for 1993 and 3.1% of GDP for 1994. In Pedersen (2003) estimates of the Danish shadow economy span from 1995 with 3.1%, up to 2001 with 3.8%. See also newer studies like Feld and Larsen (2005, 2008, 2009) which estimate similar sizes for the shadow economy of Germany.

¹⁰ The advantages and disadvantages of this method are extensively dealt by Pedersen (2003), Mogensen (1985), Mogensen et al. (1995) and Kazemier (2006) in their excellent and very carefully conducted investigations.

¹¹ For the United States, IRS (1979, 1983), Simon and Witte (1982), Witte (1987), Clotefelter (1983), and Feige (1986). For a more detailed discussion, see Dallago (1990) and Thomas (1992), for Germany see Feld and Larsen (2009), for the Baltic countries, Poland and Sweden see Schneider and Zukauskas (2016).

A further disadvantage of these two direct methods (surveys and tax auditing) is the point estimate character. In general they capture shadow economic activities only partially and may be seen as lower-bound estimates. Going back to the definition of the shadow economy, this method captures mostly the amount of shadow labor activities in households and rarely in or between firms and these methods do not provide value added figures. However, they have one considerable advantage: they provide detailed information about shadow economy activities, the structure and composition of the activities as well as the socio-economic characteristics and motives of those who work in the shadow economy.

To summarize:

Survey methods are likely to underestimate the shadow economy because people are likely to under-declare in surveys what they are trying to hide from authorities. In order to minimize the number of respondents dishonestly replying or totally declining to answer sensitive questions, structured interviews are undertaken (usually face to face), in which respondents slowly become accustomed to the main purpose of the survey. The first part of the questionnaire aims to shape respondents' perceptions of the issues being explored. The second part asks questions about the respondents' activities in the shadow economy. A third part contains the usual socio-demographic questions. Nevertheless, the results of the shadow economy estimates from survey methods are clearly lower-bound estimates compared to other approaches. They also rely on a very narrow definition of "classical" shadow economy activities.

3.2 Indirect approaches

These approaches, which are also called indicator approaches, are mostly macroeconomic and use various economic and other indicators that contain information about the development of the shadow economy over time. Relating them to the definition of the shadow economy, they provide value added figures. In most cases, legally-bought material is often included; hence, they provide upper-bound estimates with the danger of a double counting problem due to the inclusion of the legally-bought material. Therefore a wide (broad) definition of the shadow economy is applied; especially as some criminal activities like human trafficking are also included. Currently there are five indicators that leave some traces of the shadow economy.

3.2.1 The discrepancy between national expenditure and income statistics

This approach is based on discrepancies between income and expenditure statistics. In national accounting the income measure of GNP should be equal to the expenditure measure of GNP. Thus, if an independent estimate of the expenditure side of the national accounts is available, the gap between the expenditure measure and the income measure can be used as an indicator of the extent of the shadow economy.¹² Since national accounts statisticians are anxious to minimize this discrepancy, the initial discrepancy or first estimate, rather than the published discrepancy, should be employed as an estimate of the shadow economy. If all the components on the expenditure side are measured without error, then this approach would indeed yield a good estimate of the size of the shadow economy. Unfortunately, however, this is not the case. Instead, the discrepancy reflects all omissions and errors in the national accounts statistics as well as the shadow economy. These estimates may therefore be crude and of questionable reliability.¹³

¹² See, for example, Franz (1983) for Austria; MacAfee (1980), O'Higgins (1989) and Smith (1985) for Great Britain; Petersen (1982) and Del Boca (1981) for Germany; Park (1979) for the United States. For a critical survey, see Thomas (1992).

¹³ A related approach is pursued by Pissarides and Weber (1989), who use micro data from household budget surveys to estimate the extent of income understatement by self-employed.

3.2.2 The discrepancy between the official and actual labor force

A decline in participation in the labor force in the official economy can be seen as an indication of increased activity in the shadow economy. If total labor force participation is assumed to be constant, then a decreasing official rate of participation can be seen as an indicator of increased shadow economic activities, *ceteris paribus*.¹⁴ One weakness of this method is that differences in the rate of participation may have other causes. Also, people can work in the shadow economy and have a job in the official economy. Therefore such estimates may be viewed as weak indicators of the size and development of the shadow economy.

3.2.3 The transactions approach

This approach has been fully developed by Feige.¹⁵ It is based upon the assumption that there is a constant relation over time between the volume of transactions and official GNP, as summarized by the well-known Fisher quantity equation, or $M \cdot V = p \cdot T$ (with M money, V velocity, p prices, and T total transactions). Assumptions also have to be made about the velocity of money and about the relationships between the total value of transactions $p \cdot T$ and total (official + unofficial) nominal GNP. Relating total nominal GNP to total transactions, the GNP of the shadow economy can be calculated by subtracting official GNP from total nominal GNP.

However, to derive figures for the shadow economy, one must also assume a base year in which there is no shadow economy and therefore the ratio of $p \cdot T$ to total nominal (official = total) GNP was “normal” and would have been constant over time if there had been no shadow economy. To obtain reliable shadow economy estimates, precise figures on the total volume of transactions should be available. This might be especially difficult for cash transactions, because they depend, among other factors, on the durability of bank notes in terms of the quality of the paper on which they are printed.¹⁶ Also, the assumption is made that all variations in the ratio between the total value of transactions and the officially measured GNP are due to the shadow economy. This means that a considerable amount of data is required in order to eliminate financial transactions from “pure” cross payments, which are legal and have nothing to do with the shadow economy. In general, although this approach is theoretically attractive, the empirical requirements necessary to obtain reliable estimates are so difficult to fulfill that its application can lead to doubtful results. Again, here a very broad definition of the shadow economy is used, especially as all transactions (including criminal ones) are counted.

3.2.4 The currency demand approach

The currency demand approach was first used by Cagan (1958), who considered the correlation between currency demand and tax pressure (as one cause of the shadow economy) for the United States over the period 1919 to 1955. Twenty years later, Gutmann (1977) used the same approach but without any statistical procedures. Cagan’s approach was further developed by Tanzi (1980, 1983), who estimated a currency demand function for the United States for the period 1929 to 1980 in order to calculate the size of the shadow economy. His approach assumes that shadow (or hidden) transactions are undertaken in the form of cash payments so as to leave no observable traces for the authorities. An increase in the size of the shadow economy will therefore increase the demand for currency. To isolate the resulting excess

¹⁴ Such studies have been made for Italy, see for example Contini (1981) and Del Boca (1981); for the United States, see O’Neill (1983), for later studies, see Williams (2009, 2013), Williams and Lansky (2013), and Williams and Rodgers (2013), for a critical survey, see again Thomas (1992).

¹⁵ For an extended description of this approach, see Feige (1996); for a further application to the Netherlands, Boeschoten and Fase (1984), and to Germany, Langfeldt (1984).

¹⁶ For a detailed criticism of the transaction approach see Boeschoten and Fase (1984), Frey and Pommerehne (1984), Kirchgassner (1984), Tanzi (1982a,b, 1986), Dallago (1990), Thomas (1986, 1992, 1999) and Giles (1999a).

demand for currency, an equation for currency demand is estimated over time. All possible conventional factors, such as the development of income, payment habits, interest rates, credit and other debt cards as a substitute for cash and so on, are controlled for. Additionally, variables such as direct and indirect tax burdens, government regulation, state institutions and tax morale, which are assumed to be major factors causing people to work in the shadow economy, are included in the estimation equation. The basic regression equation for currency demand, proposed by Tanzi (1983), is the following:

$$\ln(C/M_2)_t = \beta_0 + \beta_1 \ln(1 + TW)_t + \beta_2 \ln(WS/Y)_t + \beta_3 \ln R_t + \beta_4 \ln(Y/N)_t + u_t,$$

with $\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 < 0$, $\beta_4 > 0$, where \ln denotes natural logarithms, C/M_2 is the ratio of cash holdings to current and deposit accounts, TW is a weighted average tax rate (as a proxy for changes in the size of the shadow economy), WS/Y is a proportion of wages and salaries in national income (to capture changing payment and money holding patterns), R is the interest paid on savings deposits (to capture the opportunity cost of holding cash) and Y/N is per capita income.¹⁷ Any “excess” increase in currency, or the amount unexplained by conventional or normal factors, is then attributed to the rising tax burden and other reasons leading people to work in the shadow economy. Figures for the size and development of the shadow economy can be calculated in a first step by comparing the difference between the development of currency when the direct and indirect tax burden and government regulation are held at lowest values, and the development of currency with the current (higher) burden of taxation and government regulation. Assuming in a second step the same income velocity for currency used in the shadow economy as for legal $M1$ in the official economy, the size of the shadow can be computed and compared to the official GDP.

This is one of the most commonly used approaches. It has been applied to many countries¹⁸ all over the world but has nevertheless been criticized on various grounds.¹⁹ The most commonly raised objections to this method are:

1. Not all transactions in the shadow economy are paid in cash. Isachsen and Strøm (1985) used the survey method to find out that in Norway, in 1980, roughly 80 percent of all transactions in the hidden sector were paid in cash. The size of the total shadow economy (including barter) may thus be even larger than previously estimated.
2. Most studies consider only one factor, the tax burden, as the cause of the shadow economy. Other factors (such as the impact of regulation, taxpayers’ attitudes toward the state, tax morality and so on) are not considered, because for most countries reliable data are not available. If, as seems likely, these other factors also have an impact on the extent of the hidden economy, it might again be higher than reported in most studies.²⁰
3. As discussed by Garcia (1978), Park (1979), and Feige (1996), increases in currency demand deposits are largely due to a slowdown in demand deposits rather than to an increase in currency caused by activities in the shadow economy, at least in the case of the United States.
4. Blades (1982) and Feige (1986, 1996) criticize Tanzi’s studies on the grounds that the US dollar is used as an international currency so Tanzi should have considered (and controlled for) the presence of US

¹⁷ The estimation of such a currency demand equation has been criticized by Thomas (1999) but part of this criticism has been considered by the work of Giles (1999a,b) and Bhattacharyya (1999), who both use the latest econometric techniques.

¹⁸ See Karmann (1986, 1990), Schneider (1997, 1998, 2011), Johnson et al. (1998a), Williams and Windebank (1995), and Schneider and Williams (2013), Hassan and Schneider (2016b) and Williams and Schneider (2016).

¹⁹ See Thomas (1992, 1999), Feige (1986), Pozo (1996), Pedersen (2003), Ahumada et al. (2004), and Schneider and Williams (2013).

²⁰ One (weak) justification for the only use of the tax variable is that this variable has by far the strongest impact on the size of the shadow economy in the studies known to the authors. The only exception is the study by Frey and Weck-Hannemann (1984), where the variable “tax immorality” has a quantitatively larger and statistically stronger influence than the direct tax share in the model approach. In the study by Pommerehne and Schneider (1985), for the US, besides various tax measures, data for regulation, tax immorality, and minimum wage rates are available; the tax variable has a dominating influence and contributes roughly 60–70% to the size of the shadow economy. See also Zilberfarb (1986).

dollars, which are used as an international currency and held in cash abroad.²¹ Frey and Pommerehne (1984) and Thomas (1986, 1992, 1999) claim that Tanzi's parameter estimates are not very stable.²²

5. Most studies assume the same velocity of money in official and shadow economies. As argued by Hill and Kabir (1996) for Canada and by Klovland (1984) for the Scandinavian countries, there is considerable uncertainty about the velocity of money in the official economy, and the velocity of money in the hidden sector is even more difficult to estimate. Without knowledge about the velocity of currency in the shadow economy, one has to accept the assumption of that money has equal velocity in each sector.
6. Ahumada, Alvaredo, Canavese, and Canavese (2004) show that the currency approach together with the assumption of equal income velocity of money in reported and hidden transactions is only correct if the income elasticity is 1.
7. Finally, the assumption of no shadow economy in a base year is open to criticism. Relaxing this assumption would again imply an upward adjustment of the size of the shadow economy.

Again here a broad definition of the shadow economy is used as all cash transactions with some relation to the shadow economy are captured by this method.

3.2.5 The physical input (electricity consumption) method

3.2.5.1 The Kaufmann - Kaliberda Method²³)

To measure overall (official and unofficial) economic activity in an economy, Kaufmann and Kaliberda (1996) assume that electric power consumption is regarded as the single best physical indicator of overall (or official plus unofficial) economic activity. Overall economic activity and electricity consumption have been empirically observed throughout the world to move in lockstep with an electricity-to-GDP elasticity usually close to one. This means that the growth of total electricity consumption is an indicator for growth of overall (official and unofficial) GDP. By having this proxy measurement for the overall economy and then subtracting from this overall measure the estimates of official GDP, Kaufmann and Kaliberda (1996) derive an estimate of unofficial GDP. This method is very simple and appealing. However, it can also be criticized on various grounds:

1. Not all shadow economy activities require a considerable amount of electricity (e.g. personal services), and other energy sources can be used (gas, oil, coal, etc.). Only a part of the shadow economy will be indicated.
2. Over time, there has been considerable technical progress so that both the production and use of electricity are more efficient than in the past, and this will apply in both official and unofficial uses.
3. There may be considerable differences or changes in the elasticity of electricity/GDP across countries and over time.²⁴

²¹ Another study by Tanzi (1982, esp. pp. 110–113) explicitly deals with this criticism. A very careful investigation of the amount of US dollars used abroad and US currency used in the shadow economy and for “classical” crime activities has been undertaken by Rogoff (1998), who concludes that large denomination bills are major driving force for the growth of the shadow economy and classical crime activities, due largely to reduced transaction costs.

²² However in studies for European countries Kirchgässner (1983, 1984) and Schneider (1986) conclude that the estimation results for Germany, Denmark, Norway and Sweden are quite robust when using the currency demand method. Hill and Kabir (1996) find for Canada that the rise of the shadow economy varies with respect to the tax variable used; they conclude “when the theoretically best tax rates are selected and a range of plausible velocity values is used, this method estimates underground economic growth between 1964 and 1995 at between 3% and 11% of GDP.” (p. 1553).

²³ This method was used earlier by Lizzeri (1979), Del Boca and Forte (1982), and then was used much later by Portes (1996), Kaufmann and Kaliberda (1996), Johnson et al. (1997). For a critique see Lackó (1998).

²⁴ Johnson et al. (1997) make an attempt to adjust for changes in the elasticity of electricity/GDP.

3.2.5.2 The Lackó method

Lackó (1998, 1999, 2000a,b) assumes that a certain part of the shadow economy is associated with the household consumption of electricity. This part comprises so-called household production, do-it-yourself activities, and other non-registered production and services. Lackó further assumes that in countries where the portion of the shadow economy associated with household electricity consumption is high, the rest of the hidden economy (or the part Lackó cannot measure) will also be high. Lackó (1996, pp. 19 ff.) assumes that in each country a part of the household consumption of electricity is used in the shadow economy. Lackó's approach (1998, p. 133) can be described by the following two equations:

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

and

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

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 ,

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

H_i is the per capita output of the hidden economy,

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

S_i is the ratio of public social welfare expenditures to GDP, and

D_i is the sum of the number of dependents over 14 years of age and inactive earners, both per 100 active earners.

In a cross country study, she estimates the first equation substituting for H_i with the second equation. For the calculation of the actual size (value added) of the shadow economy, Lackó further needs to know how much GDP is produced by one unit of electricity in the shadow economy of each country. Since these data are not known, she takes the result of one of the known shadow economy estimates calculated for a market economy using another approach for the early 1990s, and applies this to the other countries. Lackó used the shadow economy of the United States as such a base (the shadow economy value of 10.5% of GDP was taken from Morris (1993)) and calculated the size of the shadow economy for other countries. Lackó's method is also open to criticism:

1. Not all shadow economy activities require a considerable amount of electricity and other energy sources can be used.
2. Shadow economy activities do not take place only in the household sector.
3. It is doubtful whether the ratio of social welfare expenditures can be used as the explanatory factor for the shadow economy, especially in transition and developing countries.
4. It is questionable which is the most reliable base value of the shadow economy in order to calculate the size of the shadow economy for all other countries, especially for transition and developing countries.

Also, these two approaches rely on a broad definition of the shadow economy, because they measure all (illegal) activities which require electric power.

3.2.6 The model approach²⁵

3.2.6.1 General remarks

All methods described so far consider just one indicator to capture all effects of the shadow economy. However, shadow economy effects show up simultaneously in production, labor, and money markets. An even more important critique is that the causes determining the size of the shadow economy are taken into account only in some of the monetary approach studies that usually consider one cause, the burden of taxation. The model approach explicitly considers multiple causes of the existence and growth of the shadow economy,²⁶ as well as the multiple effects of the shadow economy over time. The empirical method used is quite different from those used so far. It is based on the statistical theory of unobserved variables, which considers multiple causes and multiple indicators of the phenomenon to be measured.

As the size of the shadow economy is an unknown (hidden) figure, a latent estimator approach using the MIMIC (i.e. multiple indicators, multiple causes estimation) procedure is applied. This method is based on the statistical theory of unobserved variables. The statistical idea behind such a model is to compare a sample covariance matrix, that is, a covariance matrix of observable variables, with the parametric structure imposed on this matrix by a hypothesized model.²⁷ Using covariance information among the observable variables, the unobservable variable is in the first step linked to observable variables in a factor analytical model, also called a measurement model. Second, relationships between the unobservable variable and observable variables are specified through a structural model. Therefore, a MIMIC model is the simultaneous specification of a factor and a structural model. In this sense, the MIMIC model tests the consistency of a “structural” theory through data and is thus a confirmatory rather than an exploratory technique. An economic theory is thus tested examining the consistency of actual data with the hypothesized relationships between the unobservable (latent) variable or factor and the observable (measurable) variables.²⁸ In general, a confirmatory factor analysis has two goals: (i) to estimate parameters such as coefficients and variances; and (ii) to assess the fit of the model. For the analysis of shadow economy activities these two goals mean (i) to estimate the relationships between a set of observable variables, divided into causes and indicators, and the shadow economy activity (unobservable variable); and (ii) to test whether the researcher’s theory or the derived hypotheses as a whole fit the data. MIMIC models are, compared to regression models, a rarely used method by economists, which might be due to under-evaluation of their capabilities with respect to their potential contribution to economic research.

²⁵ See also Aigner et al. (1988, p. 303), applying this approach for the United States over time; for Germany this approach has been applied by Karmann (1986, 1990). The pioneers of this approach are Weck (1983), Frey and Weck-Hannemann (1984), who applied this approach to cross-sectional data from the 24 OECD countries for various years. Before turning to this approach they developed the concept of “soft modeling” (Frey et al. (1982), Frey and Weck (1983a,b)), an approach which has been used to provide a ranking of the relative size of the shadow economy in different countries. One paper dealing extensively with the MIMIC approach, its development and its weaknesses is from Dell’Anno (2003) as well as the excellent study by Giles and Tedds (2002).

²⁶ Thomas (1992); Schneider (2003, 2005, 2011); Pozo (1996); Johnson et al. (1998a,b); Giles (1997a,b, 1999a,b,c); Giles and Tedds (2002), Giles et al. (2002), Dell’Anno (2003) and Dell’Anno and Schneider (2004).

²⁷ Estimation of a MIMIC model with a latent variable can be done by means of a computer program for the analysis of covariance structures, such as LISREL (Linear Structural Relations). A useful overview of the LISREL software package in an economics journal is Cziraky (2004).

²⁸ On the contrary, in an exploratory factor analysis a model is not specified in advance, i.e., beyond the specification of the number of latent variables (factors) and observed variables the researcher does not specify any structure of the model. This means that one assumes that all factors are correlated, all observable variables are directly influenced by all factors, and all measurement errors are uncorrelated with each other. In practice, however, the distinction between a confirmatory and an exploratory factor analysis is weaker. Facing poorly fitting models, researchers using the MIMIC model often modify their models in an exploratory way in order to improve the fit. Thus, most applications fall between the two extreme cases of exploratory (non-specified model structure) and confirmatory (ex-ante specified model structure) factor analysis (Long 1983, pp. 11–17).

3.2.6.2 A detailed description of the MIMIC model²⁹

The concept of the MIMIC model is to examine the relationships between a latent variable “size of shadow economy” and observable variables in terms of the relationships among a number of observable variables by using their information of covariance. The observable variables are grouped into causes and indicators of the latent variable (see figure 1). The key advantages of the MIMIC approach are that it allows modeling of shadow economy activities as an unobservable (latent) variable and that it considers its multiple determinants (causes) and multiple effects (indicators). A factor-analytic approach is applied to measure the size of shadow economy activities as an unobserved variable over time. The unknown coefficients are estimated in a set of structural equations, as the “unobserved” variable, meaning that the size of the shadow economy cannot be measured directly. Formally, the MIMIC model consists of two parts: a structural equation model and a measurement model.



Figure 1: The MIMIC model. Source: Buehn and Schneider (2013), p. 177.

In the measurement model, the unobservable variable η_t determines a p vector $y'_t = (y_{1t}, y_{2t}, \dots, y_{pt})'$ of indicators, that is, observable variables that reflect shadow economy activities, subject to a p vector of random error terms $\varepsilon'_t = (\varepsilon_{1t}, \varepsilon_{2t}, \dots, \varepsilon_{pt})'$. The unobservable variable η_t is a scalar and λ is a p column vector of parameters that relates y_t to η_t . The measurement equation is given by:

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

The structural model determines the unobservable variable η_t by a set of exogenous causes $x'_t = (x_{1t}, x_{2t}, \dots, x_{qt})'$ that may be useful in predicting its movement and size, subject to a structural disturbance error term ζ_t . The structural equation is given by:

$$\eta_t = \gamma' x_t + \zeta_t \tag{3}$$

where γ' is a q row vector of structural parameters.³⁰

Substituting (2) into (3) yields a reduced form equation which expresses the relationships between the observed causes and indicators, that is, between x_t and y_t . This is shown in equation (4):

$$y_t = \Pi x_t + z_t \tag{4}$$

where $\Pi = \lambda \gamma'$ is a reduced form coefficient matrix and $z_t = \lambda \zeta_t + \varepsilon_t$ is a reduced form vector of a linear transformation of disturbances that has a reduced form covariance matrix Ω given as:

$$\Omega = \text{Cov}(z_t) = E[(\lambda \zeta_t + \varepsilon_t)(\lambda \zeta_t + \varepsilon_t)'] = \lambda \psi \lambda' + \Theta_\varepsilon \tag{5}$$

In equation (5), $\psi = \text{Var}(\zeta_t)$ and $\Theta_\varepsilon = E(\varepsilon_t \varepsilon_t')$ is the measurement error’s covariance matrix.

In general, estimation of a MIMIC model uses covariance information of sample data to derive estimates of population parameters. Instead of minimizing the distance between observed and predicted individual values, as in standard econometrics, the MIMIC model minimizes the distance between an observed (sample) covariance matrix and the covariance matrix predicted by the model the researcher imposes on

²⁹ This shortened part 3.2.6 closely follows Buehn and Schneider (2013), pp. 175–181, who use this approach extensively.

³⁰ Without loss of generality, all variables are taken as standardized deviations from their means.

the data. The idea behind such an approach is that the covariance matrix of the observed variables is a function of a set of model parameters:

$$\Sigma = \Sigma(\theta) \tag{6}$$

where Σ is the population covariance matrix of the observed variables, θ is a vector that contains the parameters of the model and $\Sigma(\theta)$ is the covariance matrix as a function of θ , implying that each element of the covariance matrix is a function of one or more model parameters. If the hypothesized model is correct and the parameters are known, the population covariance matrix would be exactly reproduced, that is, Σ will equal $\Sigma(\theta)$. In practice, however, one does not know either the population variances and covariances or the parameters, but instead uses the sample covariance matrix and sample estimates of the unknown parameters for estimation (Bollen, 1989, p. 256).

It is commonly accepted by most scholars who estimate the size of shadow economic activities using the MIMIC model or more general Structural Equation Models (SEMs) with more than one unobservable variable, that such an empirical exercise is a “minefield,” regardless of which method is used. In evaluating the currently available shadow economy estimates of different scholars, one should keep in mind that there is no best or commonly accepted method.

In comparison to other statistical methods, SEMs/MIMIC models offer several advantages for the estimation of shadow economic activities. According to Giles and Tedds (2002), the MIMIC approach is a wider approach than most other competing methods, since it allows one to take multiple indicator and causal variables into consideration at the same time. Moreover, this approach is quite flexible, allowing one to vary the choice of causal and indicator variables according to the particular features of the shadow economic activity studied, the period in question, and the availability of data. SEMs/MIMIC models lead to formal estimation and testing procedures, such as those based on the method of maximum likelihood. These procedures are well known and are generally “optimal” if the sample is sufficiently large (Giles and Tedds, 2002). Schneider and Enste (2000) emphasize that these models lead to some progress in estimation techniques for the size and development of the shadow economy, because this methodology allows wide flexibility in its application. Therefore, they consider it potentially superior to other estimation methods. Cassar (2001) argues that, when compared to other methods, SEMs/MIMIC models do not need restrictive assumptions to operate. Similarly, Thomas (1992, p. 168) argues that the only real constraint of this approach lies not in its conceptual structure, but in the choice of variables. These positive aspects of the SEM approach in general and the MIMIC model in particular do not only apply in its application to the shadow economy, but to all informal economic activities. This means that the MIMIC procedure relies on a broad definition of the shadow economy.

3.2.6.3 Criticism of the MIMIC model

Of course this method has its limitations, too, which are identified in the literature. The three most important points of criticism focus on the model’s implementation, the sample used, and the reliability of the estimates:

1. The most frequent objection is around the meaning of the latent variable (e.g. Helberger and Knepel, 1988; Dell’Anno, 2003). The confirmatory rather than exploratory nature of this approach means that one is more likely to determine whether a certain model is valid than to “find” a suitable model. Therefore, it is possible that the specified model includes potential definitions or informal economic activities other than those studied. For example, it is difficult for a researcher to ensure that traditional crime activities such as drug dealing are completely excluded from analysis of the shadow economy. This criticism, which is probably the most common in the literature, remains difficult to overcome as it goes back to the theoretical assumptions behind the choice of variables and empirical limitations on data availability.
2. Helberger and Knepel (1988) argue that SEM/MIMIC model estimations lead to unstable coefficients with respect to changes in the sample size and alternative model specifications. Dell’Anno (2003) shows, however, that instability disappears asymptotically as the sample size increases. Another issue

is the application of SEMs to time series data because only simple analytical tools such as *q*- and stem-and-leaf plots are available to analyze the properties of the residuals (Dell'Anno, 2003).³¹

3. Criticism is also made with respect to the benchmarking procedure used to derive “real world” figures of shadow economic activities (Breusch, 2005a, 2005b). As the latent variable and its unit of measurement are not observed, SEMs only provide a set of estimated coefficients from which one can calculate an index that shows the dynamics of the unobservable variable. Application of the so-called calibration or benchmarking procedure, regardless which one is used, requires experimentation, and a comparison of the calibrated values in a wide academic debate. Unfortunately, at this stage of research it is not clear which benchmarking method is the best or the most reliable.³²

The economic literature using SEMs is well aware of these limitations. It acknowledges that it is not an easy task to apply this methodology to an economic dataset, but also argues that this does not mean one should abandon the SEM approach. On the contrary, following an interdisciplinary approach to economics, SEMs are valuable tools for economic analysis, particularly when studying the shadow economy. Moreover, the objections mentioned should be considered incentives for further research in this field rather than as a reason to abandon the method. Again going back to the definition of the shadow economy, the MIMIC estimation provides upper-bound macro value added figures, including mostly legally-bought material.

3.3 Results of the size of the German shadow economy using the various estimation methods

Finally, in order for the interested reader to see how big the variance between the different estimations of the size of the shadow economy is, the results for the case of Germany are shown. A significant amount of empirical work has been undertaken on the shadow economy in Germany and this makes it an interesting case study. The results are shown in table 3. The oldest estimate uses the survey method of the Institut für Demoskopie (IfD) in Allensbach (Germany) and shows that the shadow economy was 3.6% of official GDP in 1974. In a much later study Feld and Larsen (2005, 2009) undertook an extensive research project using the survey method to estimate shadow economy activities in the years 2001 to 2006. Using the officially paid wage rate, they concluded that shadow economy activities reached 4.1% in 2001, 3.1% in 2004, 3.6% in 2005 and 2.5% in 2006. Using the much lower shadow economy wage rate, these estimates shrink, however, to 1.3% in 2001 and 1.0% in 2004.

As discussed, we know that the survey method underestimates the size of the shadow economy. Using the discrepancy method and applying national income statistics, Lippert and Walker (1997) estimate the size of the German shadow economy from 1970 to 1980 as between 11.0% and 13.4% of official GDP. Using the discrepancy method applying official and actual employment, Langfeldt (1983) gets much higher estimates for 1970 to 1980, ranging from 23.0% to 34.0%. Applying the physical input method (electricity approach), Feld and Larsen (2005) get results of 14.5% for the year 1985 and 14.6% for 1990. The monetary transaction method developed by Feige calculates the shadow economy to be about 30% between 1980 and 1985. These are the highest estimates for the case of Germany. Switching to the currency demand approach, first used by Kirchgässner (1983, 1984), his study provides values of 3.1% in 1970 and 10.3% in 1980. Kirchgässner's values are quite similar to those obtained by Schneider and Enste (2000, 2002), who also use the currency demand approach to estimate the size of the shadow economy, obtaining figures of 4.5% in 1970 and 14.7% in 2000. Using the MIMIC estimation procedure, which was first applied by Frey and Weck (1983), the results

³¹ Particularly critical are the assumptions $E(\zeta_{ik}^2) = \text{Var}(\zeta_i)$ for all k (homoscedasticity assumption) and $\text{Cov}(\zeta_{ik}, \zeta_{il}) = 0$ for all $k \neq l$ (no autocorrelation in the error terms). Unfortunately, corrections for autocorrelated and heteroscedastic error terms have not yet received sufficient attention in models with unobservable variables (Bollen 1989, p. 58). An interesting exception is Folmer and Karmann (1992).

³² See Dell'Anno and Schneider (2009) for a detailed discussion on different benchmarking procedures. Compare also the latest discussion and critique of the MIMIC procedure by Breusch (2016), Feige (2016a,b), Schneider (2016) and Hashimzade and Heady (2016).

are quite similar to those from the currency demand approach. Frey and Weck (1983) calculate a shadow economy in Germany in 1970 of 5.8% which increases to 8.2% in 1980. Pickardt and Sarda (2006), whose sample used for the MIMIC estimations started a bit later, get a value of 9.4% in 1980, which increases to 16.3% in the year 2000. These are quite similar values to Schneider (2005, 2007). Finally, using the soft modeling variant of the MIMIC approach, Weck-Hannemann (1983) finds a value of 8.3% of GDP in 1975.

Summarizing the results of table 3, one realizes that different estimation procedures produce vastly different results. It is safe to say that the figures produced by the transactions and discrepancy approaches are unrealistically large. An estimated size of the German shadow economy of almost one-third of the official GDP in the mid-eighties is most likely to be an overestimate. The figures obtained using the currency demand and the hidden (latent, MIMIC) approaches are, on the other hand, relatively close together³³ and much lower than those produced by the discrepancy or transactions approach. The estimates from the MIMIC and currency demand approach can be regarded as reasonable estimates of the size of the German shadow economy and the survey approach is likely to produce too low estimates for reasons already discussed.

Table 3: The Size of the Shadow Economy in Germany According to Different Methods (in percentage of official GDP)

Method/Source	Shadow economy (in percentage of official GDP) in:							
	1970	1975	1980	1985	1990	1995	2000	2005
Survey approach	-	3.6 ¹⁾	-	-	-	-	-	-
(IfD Allensbach, 1975)	-	-	-	-	-	-	4.1 ²⁾	3.1 ²⁾
(Feld and Larsen, 2005)	-	-	-	-	-	-	1.3 ³⁾	1.0 ³⁾
Discrepancy between expenditure and income (Lippert and Walker, 1997)	11.0	10.2	13.4	-	-	-	-	-
Discrepancy between official and actual employment (Langfeldt, 1983)	23.0	38.5	34.0	-	-	-	-	-
Physical input method (Feld and Larsen, 2005)	-	-	-	14.5	14.6	-	-	-
Transactions approach (Feige/Langfeldt)	17.2	22.3	29.3	31.4	-	-	-	-
Currency demand approach								
Kirchgässner, 1983	3.1	6.0	10.3	-	-	-	-	-
Langfeldt, 1983, 1984	12.1	11.8	12.6	-	-	-	-	-
Schneider and Enste (2000)	4.5	7.8	9.2	11.3	11.8	12.5	14.7	-
Pickard and Sarda (2006)	-	-	9.41	9.86	10.90	14.70	15.61	-
Latent (MIMIC) approach	5.8	6.1	8.2	-	-	-	-	-
Frey and Weck (1983)	-	-	9.4	10.1	11.4	15.1	16.3	-
Pickardt and Sarda (2006)	-	-	9.4	10.1	11.4	15.1	16.3	-
Schneider (2005, 2007)	4.2	5.8	10.8	11.2	12.2	13.9	16.0	15.4
Soft modeling (Weck-Hannemann, 1983)	-	8.3	-	-	-	-	-	-

4 Some latest developments

in this chapter, their new developments with respect to the research of the shadow economy and new results are shown. Part 4.1 presents a new way of measuring the shadow economy using the survey method in combination with estimates of the shadow economy of the firm. Part 4.2 presents some first results of the digital shadow economy and in Part 4.3 some of the latest results of 143 countries of the size and development of the shadow economy are shown.

³³ This is not surprising as quite often the calibration start-values have been obtained using the currency demand approach in order to transform the relative estimates of the MIMIC approach.

4.1 A new method of measuring the shadow economy: the use of surveys of company managers

Talis J. Putnins and Arnis Sauka use surveys of company managers to measure the size of the shadow economy. They combine miss reported business income and miss reported wages as percentage of GDP. Their method produces detailed information on the structure of the shadow economy, especially in the firm sector. It is based on the premise that company managers are the most likely to know how much business income and wages go unreported due to their unique position in dealing both of these types of income; compare Putnins and Sauka (2015), pp. 471-490. They use a range of survey design features to “maximize” the truthfulness of responses. Their method combines estimates of miss reported business incomes, unregistered or hidden employees, and unreported wages in order to calculate a total estimate of the size of the shadow economy as a percentage of GDP. To their opinion, their approach differs from most other studies of shadow economies which largely focus either on macroeconomic indicators or on surveys about households. They developed first results for Estonia, Latvia and Lithuania. The results are shown in Table 4. The results are compared with the ones of Schneider (2016) and the results of Putnins and Sauka (2015) are in the case of Latvia quite the same to the ones of Schneider. Table 4 shows the results for the years 2009 to 2015 and the average size of the shadow economy over 2009 to 2015 for Latvia is 27.8% according to the method of Putnins and Sauka, and 25.8% according to Schneider (2016). For the other two countries, Estonia and Lithuania, the results are quite different. In Estonia, Putnins and Sauka receive 17.4% and Schneider 28.1% and for Lithuania, Putnins and Sauka estimate the average shadow economy over 2009 to 2015 at 16.4%, compared to 28.2% by Schneider. This new method seems to be promising, but more empirical investigations have to be undertaken to see how reliable this method is.

Table 4: A comparison of the size of the shadow economy (in % of GDP) in the Baltic countries 2009–2015 by Putnins and Sauka with Schneider

Year	Estonia		Latvia		Lithuania	
	Putnins and Sauka	Schneider	Putnins and Sauka	Schneider	Putnins and Sauka	Schneider
2009	20.2%	29.6%	36.6%	27.1%	17.7%	29.6%
2010	19.4%	29.3%	38.1%	27.3%	18.8%	29.7%
2011	18.9%	28.6%	30.2%	26.5%	17.1%	29.0%
2012	19.2%	28.2%	21.1%	26.1%	18.2%	28.5%
2013	15.7%	27.6%	23.8%	25.5%	15.3%	28.0%
2014	13.2%	27.1%	23.5%	24.7%	12.5%	27.1%
2015	14.9%	26.2%	21.3%	23.6%	15.0%	25.8%
Average 2009–2015	17.4%	28.1%	27.8%	25.8%	16.4%	28.2%

Source: Putnins and Sauka (2016), Table 1, p. 12 and Schneider, own calculations, Linz, September 2016.

4.2 Digital shadow economy: Some first preliminary results

It is quite well known that there is also a digital shadow economy, however, research on this phenomenon is quite rare. In a first paper by Gaspareniene, Remeikiene and Schneider (forthcoming 2017) the result is that the phenomenon of digital shadow economy has just been started as an own subject, the authors tried to define it either on a national and international level. They show that the literature proposes a wide variety

of interpretations of digital shadow economy which, in general, refer to unregistered or illegal profit driven activities in e-space, basically related to trade or services provision. Nevertheless, illegal profit-driven activities, such as cybercrimes, digital piracy or e-fraud are in principal criminal offenses and they should be separated from the definition of a digital shadow economy and left for research consideration in the criminal sphere. Qualitative empirical research of the authors has enabled to formulate a definition of the digital shadow economy: Digital shadow economy refers to illegal activities such as digital survey provision and sales of goods and services online. When operating exclusively in digital space, the entities violate the existing legal norms and regulations with a pursuit of illegal mutual interest and material benefits.

The increasing and easy possibilities motivate consumers to get commodities and services via electronic space. At the same time upsurge of e-trade determines rising scopes of shadow economy with respect of favorable conditions for traders and service providers to operate in e-space evading taxes. Gaspareniene, Remeikinene and Schneider (2015) argue that the theoretical analysis of the scientific literature reveals that the digital shadow economy consumption is typically driven by consumers' satisfaction, generated by acquisition of a desired product or service at a lower cost, a wide variety of e-stock, quicker and convenient delivery, social acceptability of illegal activities online, minimal investment risk and low fear of punishment. With the help of a questionnaire the authors undertook a first empirical research and they found out, that the most significant factors of digital shadow economy include lower prices of products and services in digital shadow markets, unfavorable economic situation in the country, technological advancements, IT advantages, time saving and lack of opportunities to obtain a desired product in the local market. Consumers operating in digital shadow economy, neither verify the status of a trader, nor do they request purchase confirmation documents which highly contribute to the motivation of an illegal trader to maintain e-activities unregistered and therefore escape revenue taxation. This paper and the papers of Yip et al. (2012) as well of Yu et al. (2015) show that the digital shadow economy is just starting to get researched. Certainly, more research and more studies are needed here. One should not hide the difficulties to get reliable data, because the origin of the data is quite often unknown, as is the identity of the seller and of the purchaser, etc. However, this should not be an excuse to refrain from further research.

4.3 Latest estimation of the size of the shadow economies of 143 countries over the period 1996 to 2014

In a paper by Medina and Schneider (2017) the authors estimate the size and development of the shadow economies of 143 countries over the period 1996 to 2014. They use the MIMIC method and they apply for the first time the light intensity approach instead of GDP, avoiding the problems arising from GDP being quite often used as a cause and indicator variable. Table 5 provides the summary statistics of the shadow economies of the 143 countries between 1996 and 2014. The average size of the shadow economies of these 143 countries over the period 1996 to 2014 is 32.5% of the official GDP, from 34.82% in 1996 and decreasing to 30.66% in 2014.

In Figure 4 the informal economies per region (average, percent of GDP) over the period 1991-99, 2000-09 and 2010-14 are shown. The lowest shadow economies have been observed in the OECD countries, followed by European countries, East-Asian countries, then Middle East and North African countries and the highest ones in Sub-Saharan African and Latin American Caribbean countries. These results show that the shadow economy has decreased from the 1990s to 2015 by 3-4 percentage points.

Table 5: Summary Statistics of the Shadow Economies of 143 Countries from 1996 to 2014 (interpolated values for 1997, 1999 and 2001)

Country	Average	Stand. Dev.	Median	Minimum	Maximum
Albania	30.76	3.64	31.46	26.24	35.79
Algeria	31.01	4.04	28.79	26.76	38.83
Angola	49.86	2.47	49.42	46.13	56.94

continued **Table 5:** Summary Statistics of the Shadow Economies of 143 Countries from 1996 to 2014 (interpolated values for 1997, 1999 and 2001)

Country	Average	Stand. Dev.	Median	Minimum	Maximum
Argentina	24.48	1.04	23.97	23.34	26.68
Armenia	44.49	2.01	44.76	40.80	47.43
Australia	13.05	1.14	12.87	10.97	14.99
Austria	9.16	0.84	9.23	7.87	10.35
Azerbaijan	52.96	4.33	50.98	47.15	60.60
Bahrain	16.64	0.85	16.73	14.76	18.40
Bangladesh	34.60	1.59	34.81	32.02	37.71
Belarus	48.07	4.03	48.11	38.78	55.18
Belgium	21.15	2.42	21.11	17.70	25.32
Belize	49.80	4.50	48.79	43.80	59.35
Benin	53.75	5.52	52.83	44.58	66.31
Bhutan	28.94	1.51	29.33	25.85	31.31
Bolivia	63.04	3.45	63.24	55.50	69.34
Bosnia and Herzegovina	32.55	2.05	32.51	28.54	36.38
Botswana	32.09	2.60	32.86	26.49	35.91
Brazil	39.86	1.97	39.80	36.20	42.69
Brunei Darussalam	29.11	2.12	29.15	25.31	32.49
Bulgaria	31.56	3.93	30.66	26.54	36.90
Burkina Faso	38.16	3.60	38.68	31.58	42.82
Burundi	34.70	4.92	33.03	28.74	43.08
Cabo Verde	34.32	2.67	35.27	30.07	37.91
Cambodia	51.59	2.32	52.00	47.00	55.17
Cameroon	30.11	3.08	29.37	24.71	35.04
Canada	15.83	0.86	15.68	14.63	18.27
Central African Republic	44.53	3.30	43.60	40.22	53.27
Chad	41.70	3.47	41.14	33.89	46.20
Chile	17.69	1.59	17.04	15.35	19.92
China	12.76	0.75	12.90	11.32	14.04
Colombia	34.16	3.24	33.96	28.56	39.10
Comoros	34.97	3.70	35.41	28.66	39.60
Costa Rica	28.51	2.83	27.23	25.31	35.13
Côte d'Ivoire	39.78	3.31	40.98	34.64	43.97
Croatia	30.73	2.35	30.04	26.82	34.93
Cyprus	29.85	1.23	29.28	28.44	32.67
Czech Republic	17.03	1.78	17.29	13.66	19.10
Democratic Republic of Congo	42.52	4.54	44.12	32.61	48.00
Denmark	16.57	1.78	16.29	13.86	19.82
Dominican Republic	35.57	3.01	35.88	31.18	41.47
Ecuador	39.22	2.38	39.49	34.40	44.04
Egypt	33.30	2.72	34.41	27.07	37.00
El Salvador	45.49	3.13	44.56	40.13	52.24

continued **Table 5:** Summary Statistics of the Shadow Economies of 143 Countries from 1996 to 2014 (interpolated values for 1997, 1999 and 2001)

Country	Average	Stand. Dev.	Median	Minimum	Maximum
Equatorial Guinea	36.98	4.67	39.80	29.39	44.03
Estonia	29.66	2.73	29.89	25.44	34.37
Finland	17.67	1.56	17.06	15.34	20.54
France	14.20	1.33	13.98	12.44	16.57
Gabon	51.44	2.70	51.69	46.85	55.12
Georgia	67.71	3.18	67.72	59.95	73.02
Germany	14.70	1.74	14.64	11.71	17.79
Ghana	42.00	3.28	41.67	37.03	48.47
Greece	28.33	2.18	27.77	24.36	32.97
Guatemala	62.56	4.09	63.44	51.50	70.60
Guinea	38.54	2.75	39.00	29.97	43.17
Guinea-Bissau	39.33	3.36	39.60	34.01	46.66
Guyana	34.31	1.74	33.92	32.34	39.21
Honduras	50.15	3.63	49.27	44.88	57.44
Hong Kong	15.92	1.59	15.43	13.82	19.01
Hungary	25.40	1.69	25.23	23.72	30.03
Iceland	14.86	1.28	14.44	13.17	17.05
India	22.27	1.31	22.48	20.32	24.74
Indonesia	21.09	2.04	21.40	16.19	23.97
Iran	18.20	1.62	18.41	15.30	21.12
Ireland	15.61	1.22	15.35	13.64	18.81
Israel	21.15	1.24	21.53	18.43	22.97
Italy	26.35	1.81	26.36	23.51	29.76
Japan	10.79	1.09	10.81	8.50	12.33
Jordan	18.21	1.31	18.38	15.96	20.49
Kazakhstan	42.78	3.24	41.94	38.92	50.31
Kenya	33.49	2.51	33.11	29.45	38.38
Kuwait	20.36	1.27	20.10	19.07	24.18
Kyrgyz Republic	37.74	3.40	38.04	33.56	44.33
Laos	30.33	2.39	30.18	25.93	34.98
Latvia	25.64	3.13	24.68	21.01	30.50
Lebanon	31.45	1.63	31.21	29.07	34.20
Lesotho	33.46	3.46	32.51	27.38	40.13
Liberia	39.74	3.16	38.30	34.94	43.77
Lithuania	28.09	3.62	28.14	22.42	33.70
Luxembourg	9.47	0.80	9.11	8.59	11.45
Macedonia	36.04	4.00	37.12	28.42	41.88
Madagascar	40.32	2.91	39.01	37.07	46.54
Malawi	38.39	3.39	39.14	31.35	43.90
Malaysia	31.08	0.83	31.10	29.06	32.24
Mali	41.59	3.79	40.49	36.16	48.90

continued **Table 5:** Summary Statistics of the Shadow Economies of 143 Countries from 1996 to 2014 (interpolated values for 1997, 1999 and 2001)

Country	Average	Stand. Dev.	Median	Minimum	Maximum
Mauritania	32.45	2.94	31.64	27.85	36.67
Mauritius	21.84	0.75	21.99	20.06	23.10
Mexico	28.65	1.79	27.85	26.15	32.47
Moldova	39.48	2.23	39.54	36.49	45.10
Mongolia	18.43	1.05	18.36	15.93	21.16
Morocco	33.85	3.45	34.79	27.94	38.70
Mozambique	38.90	3.80	37.62	34.43	47.06
Namibia	28.00	2.31	27.55	24.12	34.06
Nepal	37.70	1.62	38.11	34.15	40.33
New Zealand	13.35	0.68	13.62	11.99	14.36
Nicaragua	42.46	2.22	42.72	37.99	45.22
Niger	37.82	4.06	38.30	30.42	44.02
Nigeria	62.76	3.16	63.58	57.90	68.75
Norway	21.02	1.56	21.24	18.26	23.60
Oman	17.92	1.42	18.22	14.66	19.47
Pakistan	33.05	2.57	32.08	29.32	37.74
Panama	59.61	4.13	60.97	49.12	65.16
Paraguay	34.42	3.46	33.24	29.88	40.94
Peru	54.74	3.22	54.69	47.15	59.90
Philippines	44.32	0.95	44.24	42.89	47.26
Poland	25.56	2.70	26.87	20.32	29.75
Portugal	23.88	1.31	23.60	21.19	26.74
Qatar	17.03	1.77	17.25	13.87	19.14
Republic of Congo	44.06	3.61	43.36	36.85	48.52
Romania	32.21	2.65	31.95	27.86	36.53
Russia	42.60	3.01	42.30	38.49	47.98
Saudi Arabia	16.80	1.84	17.39	13.73	19.52
Senegal	42.91	2.71	43.44	36.34	47.63
Sierra Leone	49.19	5.38	49.77	38.74	57.22
Singapore	11.84	1.30	11.10	9.85	14.06
Slovakia	16.10	2.04	15.06	13.78	19.01
Slovenia	25.05	2.06	25.28	21.79	27.90
South Africa	26.07	2.44	25.84	22.52	30.32
South Korea	25.93	2.75	26.21	21.40	30.87
Spain	24.67	1.41	24.38	22.70	27.77
Sri Lanka	48.76	3.34	48.55	44.54	55.85
Suriname	35.85	3.82	35.27	30.27	45.99
Swaziland	44.65	4.03	45.10	37.19	49.65
Sweden	18.68	1.27	19.02	16.34	20.49
Switzerland	9.48	0.47	9.52	8.60	10.25
Tajikistan	43.81	1.89	43.50	41.34	49.59

continued **Table 5:** Summary Statistics of the Shadow Economies of 143 Countries from 1996 to 2014 (interpolated values for 1997, 1999 and 2001)

Country	Average	Stand. Dev.	Median	Minimum	Maximum
Tanzania	54.44	3.66	53.74	48.43	62.41
Thailand	52.58	3.30	52.94	44.54	57.55
The Bahamas	27.67	1.63	27.41	25.78	33.49
The Gambia	43.32	3.02	44.52	36.23	46.35
The Netherlands	12.45	1.34	12.51	10.32	15.20
Togo	32.90	2.59	33.78	26.35	35.53
Trinidad and Tobago	34.35	1.98	34.44	30.38	38.12
Tunisia	33.20	4.52	32.20	24.63	39.29
Turkey	31.28	2.03	31.32	27.72	34.65
Uganda	40.44	2.44	40.58	35.88	45.35
Ukraine	47.74	4.36	45.69	41.56	56.67
United Kingdom	12.76	0.62	12.88	11.01	14.08
United States	8.19	0.74	8.30	7.14	9.38
Uruguay	46.58	3.02	45.34	42.56	51.10
Venezuela	33.63	2.13	33.60	30.07	38.29
Vietnam	14.62	1.21	14.38	12.65	16.44
Zimbabwe	51.42	3.67	50.36	45.50	59.40
	32.50	1.12	32.50	7.14	73.02

Source: Medina and Schneider (2017).

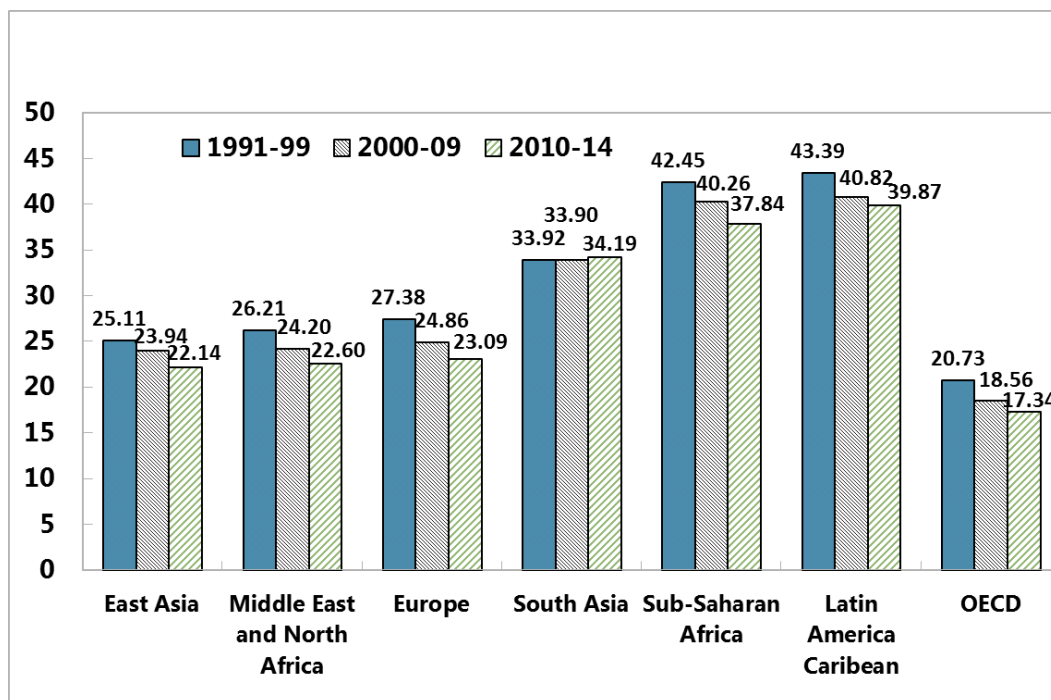


Figure 4: Informal Economy by Region (average, percent of GDP). Source: Medina and Schneider (2017).

5 Summary and concluding remarks: problems and open questions

In this paper some of the most recent developments in research about the measurement of the shadow economy are described and critiqued. The discussion of the recent literature shows that the measurement methods cover a huge area and, hence, produce quite different results (compare table 3) with huge variances. First, if we summarize our findings about the methods to estimate the size and development of the shadow economy, we come to the following critical remarks.

The survey method has the disadvantages that often only households are considered, while firms are, at least partly, left out, that non-responses and/or incorrect responses are given, and that results for the financial volume of “black” hours worked and not of the value added are obtained (compare here Feld and Larsen (2005, 2008, 2009), and Kazemier (2006)).

The discrepancy method has the drawback that quite often a combination of “rough” estimations and unclear assumptions about them are used, the calculation method is often not clear, and the documentation and procedures are often not made public (compare here Thomas (1992)).

The monetary and/or electricity methods result in some very high estimates and only macro-estimates are available. Moreover, a breakdown by sector or industry is not possible, and there are challenges in converting millions of kWh into a value-added figure when using the electricity method (compare Thomas (1992), and Schneider and Williams (2013)).

The MIMIC (latent) method has a number of criticized points, such as (1) only relative coefficients (no absolute values) are obtained, (2) the estimations are quite often highly sensitive with respect to changes in data and specifications, (3) there are difficulties in differentiating between the selection of causes and indicators, and (4) the calibration procedure and starting values used have a great influence on the results (compare Breusch (2005a,b), and Schneider and Williams (2013), Feige (2016a,b) and Schneider (2016)).

Second, what type of conclusions can we draw and what have we learnt during 35 years of shadow economy research?

1. There is no ideal or leading method to estimate the size and development of the shadow economy. All methods have serious methodological problems and weaknesses.
2. If possible, researchers should use several methods to come closer to the “true” value of the size and development of the shadow economy.
3. Much more research is needed with respect to estimation methodology and empirical results for different countries and periods.
4. The focus should now be on micro-shadow economy research, and on undertaking experiments in order to reach two goals:
 - (i) a better micro-foundation, and
 - (ii) better knowledge of why people work in the shadow economy, what motivates them and what they earn.

Third and finally, which research questions remain?

1. A common and internationally accepted definition of the shadow economy is still missing. Such a definition or convention is needed to make comparisons between the shadow economies of different countries more reliable.
2. The link between theory and empirical estimation of the shadow economy is still unsatisfactory. In the best case theory provides us with derived signs of the causal factors, but the “core” causal factors are still unknown, as are the “core” indicators in which shadow economy activities are reflected.
3. A satisfactory validation method should be developed for the empirical results to make it easier to judge their plausibility.

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