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Flexibility and Reliability when Measuring the Informal Economy

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Abstract

Informal economy can have ambiguous consequences on economic growth and the morality of a given society, among others, differing significantly in size over time and across different territories. Against this background, quantifying shadow economy is a necessary but complicated task that relies on mensuration procedures such as survey data models, questionnaires, and econometric approaches. The present article aims to review the basic assumptions and main features of the current informal sector assessment methodology, exploring the potential inaccuracy issues inherent to flexible methods and the inflexibility concerns present in more reliable processes. While the "General Equilibrium" approaches embody the most plausible and promising attempts to reconcile flexibility and reliability properties, this document will try to elucidate whether a reasonable balance is accomplishable under the methodologies available nowadays.

Keywords: informal economy, measurement, estimation, methodology, review.

Flexibilidad y fiabilidad en la medición de la economía sumergida

Resumen

La economía sumergida puede tener consecuencias ambiguas sobre el crecimiento económico y la moralidad de una sociedad determinada, entre otras, y diferir considerablemente en tamaño a lo largo del tiempo y en los distintos territorios. En este contexto, cuantificar la economía sumergida es una tarea necesaria pero complicada que se basa en procedimientos de medición como modelos de datos de encuestas, cuestionarios y enfoques econométricos. El presente artículo pretende revisar los supuestos básicos y las principales características de la actual metodología de evaluación del sector informal, explorando los posibles problemas de inexactitud inherentes a los métodos flexibles y las preocupaciones de inflexibilidad presentes en los procesos más fiables. Si bien los enfoques de «equilibrio general» encarnan los intentos más plausibles y prometedores de conciliar las propiedades de flexibilidad y fiabilidad, este documento tratará de dilucidar si es posible alcanzar un equilibrio razonable con las metodologías disponibles en la actualidad.

Palabras clave: economía informal, medición, estimación, metodología, revisión.

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I. INTRODUCTION

The concept of the informal economy[1] has witnessed a surge in popularity over the past few decades due to the unclear indicators and causes related to its presence (Schneider and Buehn, 2018). There is no academic consensus as to its precise definition: the International Labor Organization (ILO, 1974) described it as a sector where workers lack any form of protection, encompassing small or medium-sized enterprises constrained by technology that relies on minimal physical capital. Aligning with this conceptualization, the Organization for Economic Co-operation and Development (OECD, 2002) characterizes it as economic activities resulting in lower tax payments, reduced contributions to the state, or violations of labor standards. However, newer advancements acknowledge the diverse nature of informal activities (Medina and Schneider, 2018) as portrayed by Eurostat (2024), which posits that informal income is deemed "invisible", indicating that its proportion remains unknown in official statistics.

Informal activities are usually classified regarding their nature. Legal activities include income whose concealment is justified by the State as a mean to alleviate social pressure (e.g. domestic activities, street vending...). On the other hand, Criminal activities are explicitly illegal by nature, as they constitute a threat to society (for instance, drug-trafficking). In addition, tax evasion is related with the so-called "tax gap", which constitutes a threat to economic growth—one of the most significant shadow economy consequences within many countries (GESTHA, 2014; Irandoust, in press). For that reason, the present article will make a difference between activities driven by tax evasion and criminal activities, that will be hereinafter referred to as "Non-taxable" activities (Prado, 2004).

As foreseen before, there are a number of elements that shape the quantification of shadow economy[2] across time and space. Lewis (1954) laid the first primary hypothesis as to the causes of informal economy, according to which, non-developed countries would present a more prominent informal economy compared to developed countries, given migration processes that cause the labor market to interact with the informal labor. On the other hand, while trade liberalization and quality of institutions are widely acknowledged causes positively affecting the development of an economy (Hart, 2008; Maloney, 2004, Schneider and Buehn, 2018), tax burden or excessive regulatory costs may fuel tax evasion (Non-taxable activities) or domestic activities (Legal activities) when the informal sector entry costs are comparatively lower. In consequence, if a country increases the quality of its institutions, appropriately reducing corruption, agents working on informal activities could encounter prohibitive costs (Schneider and Williams, 2013), leading to a non-favorable situation according to the benefit/cost (efficiency) rule the agent applies to determine the profitability of a given venture (Alm and Torgler, 2003; Barzel, 1997; Daude et al., 2013).

A quick glance at figures 1, 2 and 3 illustrate the size variability of shadow economy over time, with the particular mention of non-developed countries, whose average size has decreased by a 4% from 1993 to 2018. These economies exhibit a significantly higher average ratio of informal activities with regard to developed (OECD) countries.

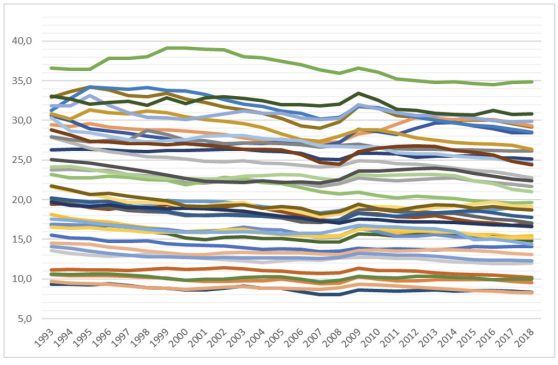

Figure 1. Informal to formal economy ratio in OECD countries. MIMIC method (%, 1993-2018)
Note: Data from Elgin et al. (2021).

[1] Other similar terms include shadow, underground, unobserved, black, invisible, hidden, parallel, illegal, irregular or urban economy.

[2] We have selected 38 OECD and non-developed countries. Selection was motivated by the availability of estimates for comparing Multiple Indicators, Multiple Causes (MIMIC) and Dynamic General Equilibrium (DGE) methodologies. Data comes from Elgin et al. (2021).

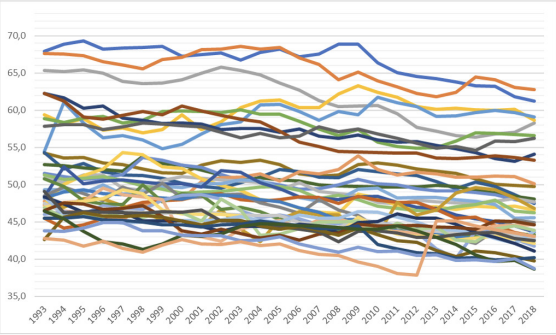

Figure 2. Informal to formal economy ratio in non-developed countries. MIMIC method (%, 1993-2018).
Note: Data from Elgin et al. (2021).

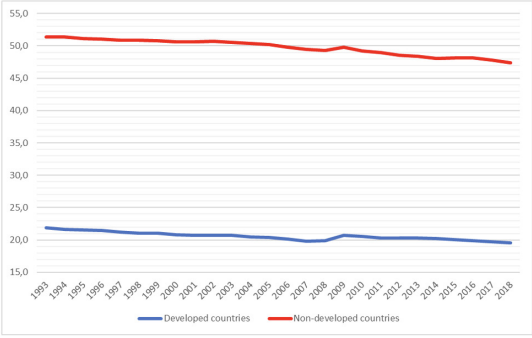

Figure 3. Average ratio of informal to formal economy in OECD and non-developed countries. MIMIC method (%, 1993-1998).
Note: Data from Elgin et al. (2021).

However, the differences depicted in these figures cannot be solely explained by the elements broached thus far. As a matter of fact, a different methodology in the drafting of figures 4 and 5 (DGE method) leads to a contrasting result: the behavior of shadow economy on both groups of countries shows a different chronological development, as pictured in figure 6. The election of the popular MIMIC method, used in figures 1, 2 and 3, results in a higher percentage of informal economy with respect to a DGE procedure. While this occurrence may not seem decisive, the difference deriving from the election of one methodology or the other may constitute up to a 10% gap in the case of non-developed countries. Secondly, a behavioral change is depicted around 2009 when using MIMIC estimation. Therefore, it is logical to state that the estimation of shadow economy and its interpretations will be directly affected by the methodology that is employed to quantify it.

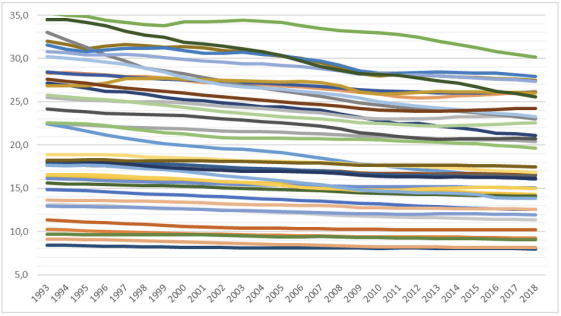

Figure 4. Informal to formal economy ratio in OECD countries. DGE method (%, 1993-2018).
Note: Data from Elgin et al. (2021).

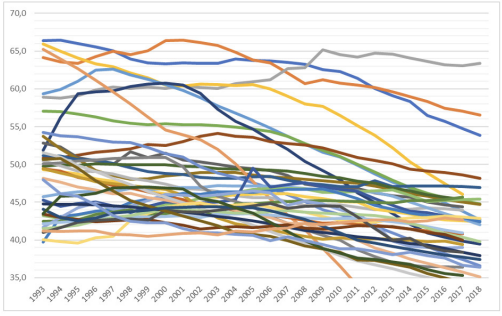

Figure 5. Informal to formal economy ratio in non-developed countries. DGE method (%, 1993-2018).
Note: Data from Elgin et al. (2021).

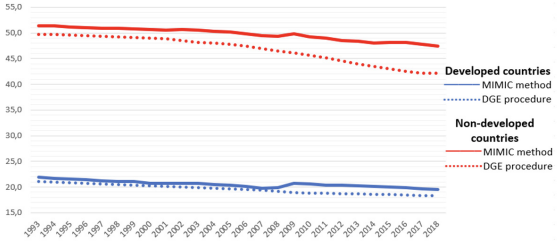

Figure 6. Average ratio of informal to formal economy in OECD and non-developed countries. Comparison of MIMIC and DGE approaches (%, 1993-2018).
Note: Data from Elgin et al. (2021).

There are other reasons that underline the importance of being aware of the size of the informal economy. Given the fact it is an unobservable measure, it is hard to predict and foresee its consequences on (formal) economy or society. Official economy can be affected by the dynamics/spillovers/externalities arising from informal activities. Examples of this include the informal economy's capacity to accommodate the surplus labor demand left unattended by the formal sector, thereby boosting economic growth.

In contrast, it very often comes together with other negative consequences, such as the exclusion of its workers from social security benefits (e.g. maternity/paternity benefits), a higher risk of occupational accidents and lower life expectancy, stemming from the lack of control and fulfilment of legal and industrial standards, the promotion of socially undesirable patterns, such as gender inequality, among others. Nevertheless, some authors have pointed out that eliminating this sector does not necessarily imply a direct benefit for official economy (Elgin, 2021). Studies that delve into the economic implications of the informal sector typically rely on data derived from estimates of its size. Therefore, the measurement of the size of informal activities becomes crucial when realizing that the absence of accurate estimates may introduce bias into subsequent research. In light of the exposed above, it seems rational to state that categorizing informal economy solely as Legal, Non-taxable, or Criminal activities is not sufficient, as it would not encompass the diverse nature of shadow economy.

Some challenges inherent to the quantification of informal economy have been exposed by Schneider and Buehn (2018), Medina and Schneider (2018), Mauleón and Sardà (2018), and Elgin (2021). As a common note, it is remarkable that all of these authors have identified issues with both the theoretical and empirical frameworks when defining informal economy. The present article presents a renewed examination of traditional methodologies for estimating informal economy, taking into consideration the latest developments in this area. In addition to prior studies, this document will pose two questions that are of transcendence to the quest of finding a suitable measurement for shadow economy. It must be noted that the term "suitable" will be used to denote a quantification derived from a model that reconciles both flexibility[3] and reliability properties. The initial inquiry will try to elucidate what actions should be avoided to attain a suitable measurement of informal economy. The authors will attempt to answer this question by thoroughly examining the prevalent methodologies in the literature as to gain a comprehensive understanding of their primary issues. The second question poses: what potential solutions exist for the challenges hindering a suitable measurement of the informal economy?

The prevailing methodologies for measuring the informal economy are commonly categorized as either direct or indirect methods—a classification widely accepted following the work of Schneider and Enste (2000). This paper is organized as follows. Next section will focus on direct methods to quantify shadow economy. Section 3 delves into indirect methods. Section 4 presents the latest approaches and trends for measuring informal activities within academic literature. The concluding section will address the two key questions above-mentioned while proposing suggestions and hints on future research.

2. Direct methods

The adjective "direct" used in this expression refers to the use of primary data sources in the quantification of shadow economy. The data comes from surveys, questionnaires or interviews targeting potential informal agents. The estimates rely on micro-founded models to which some econometric procedure is applied, reason whereby they are occasionally referred to as "microeconomic approaches".

Given the extremely high cost of data collection, usually entailing some kind of field work, most of the studies of this kind are undertaken by international organizations. For instance, The World Bank Enterprise Surveys conducts face-to-face interviews with entrepreneurs from 130,000 companies in 146 countries, extracting the proportion of formal companies that compete against informal ones, assessing the years of unregistered operation, or the proportion of companies that identify informal business practices as a limitation, among other indicators. In another vein, the Executive Opinion Surveys, valuable for business cycle analyses, have been carried out since 1979, covering 13,000 companies in 145 economies. They tackle the

[3] It seems the term "flexibility" or "flexible" property was first stated by Schneider and Buehn (2018). Another interpretation of this concept is that of a measure that comprehends a wide variety of informal activities, so "completeness" property could be also a synonym for "flexibility". We will refer to this property as in the above-mentioned work so to extend the analysis to other methodologies.

issue of informal economy by directly asking the respondents to rank their country depending on how much of its economic activity they estimate as undeclared or unregistered, with 1= Most activities are not reported; 7 = Most activities are declared or registered (Elgin, 2021).

Despite the pragmatic and logistical effort inherent to these direct quantification methods, the truth is that they usually provide estimates that lack statistical significance, given the fact that their main analytical unit comes from surveys and similar sources (García et al., 2015). In an effort to palliate these problems, there is a tendency to increase the sample size, increasing the costs. It is also important to note that informal activities can be legal or illegal in nature, as given the possibility of respondents providing inaccurate information, the methodology may predominantly yield estimates related to Legal activities.

Against these drawbacks, direct methods are useful to determine which elements of shadow economy have the most influence, or which of them provide more rigorous information and relevant features on irregular incomes. Hence, they are especially valuable for elucidating and categorizing the sources of income, as well as understanding how those differ from official ones.

A summary of the strengths and weaknesses of direct quantification models may be useful to the reader for comparative purposes:

Advantages

- Direct methods can be effective to measure Legal activities. With an appropriate design of data collection, informal agents engaged in informal activities will not feel uncomfortable or compelled to lie in their responses.
- The qualitative nature of this process allows deep research on the origin of informal income.

Disadvantages

- To enhance the reliability of the results, researchers typically aim for very large samples, which can render the survey development cost prohibitive at times.
- The elaboration of a surveys is a meticulous, exhaustive process, particularly given the need to minimize inaccurate responses.
- A survey typically focuses on a specific period, contrasting with the recurring and systematic nature of a phenomenon such as informal economy.
- This methodology might not be the most suitable to obtain an estimate encompassing a wide variety of informal income, as it could predominantly capture Legal activities.

3. Indirect methods

An indirect calculation method allows to obtain an estimate from secondary data sources. In general, the use of these quantification procedures implies the use of a set of given assumptions:

1. At least part of the informal economy will already be accounted for in official statistics, due to statistical crossing operations or informal income spent in formal consumption of goods and services (Prado, 2004).
2. One or more indicators must be chosen to reflect the presence of hidden activities.
3. The estimated volume of informal income should not be added to formal income, given the first assumption.

The selection of indicators will constitute the most important limitation of this quantification model. Indeed, the normal or usual value of an indicator is established through a theoretical model. The indicator(s) can be estimated using econometric techniques. Consequently, the existence of informal activities is determined when the indicator(s) chosen tend to deviate from a certain theoretical value.

The indicator(s) is (are) usually linked with a macroeconomic aggregate. When the aggregate is non-monetary, variations from its normal value are termed “discrepancies”. If a monetary aggregate is employed, the estimation procedure is referred to as “monetary method”.

3.1. Non-monetary methods

The most popular discrepancy-based models are:

- *Income-expenditure discrepancies*. Initially, most literature focused on discrepancies between expenses and income within households. Examples include Dilnot and Morris (1981), Isachsen et al. (1982), Matthews (1984) or Smith (1986). This type of discrepancies also focused on different economic sectors (Isachsen et al., 1982).
- *Labor market discrepancies*. Within this framework, differences between the active and employed population are examined (Del Boca, 1981; O'Neill, 1983; Serrano-Sanz et al., 1998).
- *Physical input method*. This method, proposed by Kaliberda and Kaufmann (1996), is built on the assumption that electricity consumption is the best physical indicator of both formal and informal sectors, since the elasticity between electricity and GDP is usually close to one. Therefore, potential discrepancies among the growth of this indicator and official GDP could expose informal activities. This is the reason why sometimes it is referred to as the "electricity consumption" method. However, there are a number of drawbacks to this approach: nowadays electricity consumption has progressively become more efficient in both the formal and informal sectors. Furthermore, there may be differences in the elasticity of electricity/GDP across countries or changes over time, and not all informal activities require a considerable amount of electricity (Restrepo-Echevarría, 2014).

While these methods bear on crucial aspects of the business cycle, such as households or specific sectors, they also exhibit a high variability in their results, influenced by the time scale and the specific econometric model being employed. For these reasons, their popularity diminished in favor of monetary methods (Prado, 2004).

3.2. Monetary methods

The use of a monetary aggregate as an indicator of the trail left by hidden activities in official statistics assumes that economic agents conduct and finalize their transactions using non-taxable means of payment. There are several proposals according to the selected monetary aggregate.

3.2.1. C/M ratio

Cagan (1958) used information of the United States economy during the period 1919-1955, estimating an equation that related the ratio of cash between deposits and other macroeconomic variables:

$$Ln\frac{C}{M} = k + 0.22Ln(X_1) - 1.16Ln(X_2) - 0.21Ln(X_3) \quad (1)$$

Where C is cash, M are deposits, K is a constant, X_1 is the weight of per capita income taxes (tax burden), X_2 is the expected per capita income and X_3 is the net rate of return on deposits.

The author concludes that the money demand increases through an increase in tax burden (X_1), a lower per capita income (X_2) and/or a lower net rate of return on deposits (X_3).

The implications of this rationale are important: first, economic agents complete their transactions with non-taxable means of payment to a greater extent if the tax burden increases. This makes the equation susceptible to be used to measure tax evasion. On the other hand, an economy with a lower GDP per capita and/or a lower net return on deposits will have the greatest estimated impact. These implications are related with the investigation of the causes and origins of informal economy. In addition to this, subsequent models incorporated variations of this equation, allowing to state that this theoretical approach had a notable influence on empirical studies.

Nonetheless, this quantification approach also has its own limitations, bearing in mind that not all informal activities have a tax evasion nature, cash is not the only mean of payment available in the market or the potential influence of other variables over the cash/deposits ratio.

3.2.2. C/M empirical applied ratio

Gutmann (1977) proposed a model similar to Cagan's, also assuming the agents' use of cash and establishing the increase of shadow economy arising from the dependent relation between tax burden and demand for money, by which if one increases, the other will behave proportionally. Even so, Gutmann's new approach included other assumptions:

1. A base year is chosen. The volume of informal activities in that year is negligible, so it can be considered null.
2. The velocity of money is assumed to be the same in both sectors.

The model stands out for its ease of use, considering it is only conformed by income, deposits, and cash. Some of the assumptions newly established became standardized in subsequent monetary methods, as well as in other model branches. On a more pragmatical note, it must be noted that the application requires the use of a cash-to-deposits ratio corresponding to a base year—the one in which the presence of the informal economy is assumed to be null. The use of this ratio makes several limitations arise: assuming that informal activities do not exist in an economy during the base year. Therefore, the selection of a base year can distort the estimation even assuming that hidden activities were null. A sensitivity analysis for different base years and time periods would be required to ensure the robustness of the model.

Additionally, the model is based in the quantity theory of money, so the velocity of money becomes a new issue: its calculation derives from observable measures, limited to the assumption that the velocity of money is the same in both the formal and informal sectors.

The present method introduces elements in line with Cagan's suggestions, further including new restrictions that highlight the need to simplify to make the model solvable—though this was the first empirical implementation.

3.2.3. Transactions approach

Feige (1979) also builds on the quantitative theory of money, assuming the velocity of cash (V^C) and deposits (V^D) to be different for the first time.

$$Cv^C + Dv^D = P \times T \quad (2)$$

Where ^{C} is cash, ^{D} is deposits, ^{P} is the price level and ^{T} is the number of transactions. A base year is selected, preferably the one in which the informal economy is considered insignificant. Also, the total production is equal to the formal outcome in the base year. From (2) we obtain

$$K^* = \frac{P_t \times T_t}{Y^*} | t = 0 \quad (3)$$

Replacing $^{Y^*}$ (total production in the base year), K_T is calculated for the rest of the period. The rest of the Y_T series come from re-arranging (3):

$$Y_t = \frac{P_t \times T_t}{K_t} \quad (4)$$

Finally, the volume of informal activities is obtained by $Y_t^I = Y_t - Y_t^F$. Feige also proposed using GNP for the Y_t^F variable. Since no econometric procedure is needed, this method is simpler compared to previous approaches. However, the transactions' abstraction also comes with a loss of information as to which transactions are being included. Indeed, even starting from the quantitative theory in (2) and assuming different velocities of money for both cash and deposits, these variables cannot be found—though they do not influence results. Furthermore, as it happened with previous quantification procedures, the assumption of the absence of informal activities in a base year is still necessary to find an estimate of the informal economy.

3.2.4. C/M_2 ratio

All proposed methods used the ratio of cash and demand deposits. Tanzi (1982) held that this indicator may not be adequate, since the variables included in the estimation of the demand for money mainly explain the variations in that ratio. In other words, the indicator should reflect modifications resulting from the agent's decision to vary payment methods. Agents perceive the opportunity cost of holding cash and deposits. When the interest rate rises, demand for deposits will be stimulated. Therefore, omitting other payment methods cause the informal to formal economy ratio to be distorted. In econometric terms, this would imply

that the regressors are not statistically significant.

The author proposes to use the ratio C/M_2 , that is, cash over the aggregate that contains the monetary base, demand deposits, savings deposits, and deposits redeemable at a period of notice of up to and including three months. This implies recognizing many more factors that can affect the indicator, among which the interest rate on deposits or the estimated real income per capita can be found (Rodríguez, 2007), further enhancing the equation while retaining the tax burden variable.

Eventually, in Tanzi (1983) the ratio was changed to the M_2 aggregate. The assumptions of this methodology can be observed along with its theoretical development.

Again, the core is the quantity theory of money.

$$M_I v_I = PY_I \quad (5)$$

$$M_F v_F = PY_F \quad (6)$$

It is observed that the informal sector (^{I}) and the formal sector (^{F}) share the same price level. In the informal economy, a lower price level can be assumed for the same volume of money. This may lead to a downward bias in the estimates. However, Mauleón and Sardà (2018) show that this bias is moderate.

Dividing (5) by (6) we obtain

Again, the core is the quantity theory of money.

$$\frac{M_I}{M_F} = \frac{Y_I}{Y_F} \quad (7)$$

So that $V_1 = V_F$, meaning that the velocity of money is also assumed to be equal on both sectors. Hence, the informal and formal monetary aggregate would experience variations according to the ratio of hidden to formal GDP. Estimating the proportion of informal activities is simplified to the estimation of the monetary aggregates from each sector.

In the development of this methodology, Tanzi imposed the following restrictions:

- None of the estimated monetary aggregates would be affected by the price level, according to equation (7). This means that the use of indicators in real or nominal terms should not condition the qualitative evolution of the proportion of hidden activities.
- The velocity of money is equal in both sectors. Otherwise, in (7) equality would not be fulfilled. This is somewhat questionable. For instance, Neumann and Wesche (1995) claim that, in the case of Criminal or Non-taxable activities informal, agents tend to increase cash in large quantities given an elastic demand for money. Eventually, this would result in the reduction of the velocity of money, while Feige (1979) argues the opposite.

There are indeed weaknesses in Tanzi's model, but more importantly, there are noticeable improvements with respect to the previous literature. First, flexibility is improved when using a broader monetary aggregate. One of the most important contributions is that it is not assumed that hidden activities are null in a certain period. The repeal of the inexistence of informal activities during a period of time comes from the realisation that the ratio of informal to formal economy is not constant, abandoning the definition of constants such as the number of transactions in Feige's model. This renders an easy method to implement with real data. For instance, its use was extended to delve into the causes of informal economy and the relations of informal aggregates with other observables such as employment (Matthews, 1982; 1983). In fact, when referring to the money demand approach, the usual choice is Tanzi's procedure.

3.3. Multiple Indicators, Multiple Causes method

Aligned with the advancements in information technologies, the modelling of informal economy through econometric techniques gained attractiveness. This was further promoted by the growing adoption of the money demand approach. Zellner (1970), Goldberger (1972), and Jöreskog and Goldberger (1975) notably contributed to this innovation wave through the development of a structural equation model (Structural Equation Modelling, SEM). These models consist in specifying two estimates: the first relates the latent (unobserved) variables to their causes, while the second estimate specifies an indicator or proxy variable as a function of the latent variables raised in the previous estimate. These authors proposed a SEM of a single latent or unobservable variable.

The model, known as Multiple Indicators, Multiple Causes (MIMIC), began to be widely used in various areas of social sciences.

The first estimates of the informal economy by means of a MIMIC approach appears in Frey and Weck-Hannemann (1984). The specification consisted in declaring the ratio of the informal to formal economy as the latent variable, called the "MIMIC index". However, the result of this method does not generate a time series of the latent variable. Instead, a structural model is first specified, which is responsible for relating the causal variables of the informal economy with the proportion of hidden activities. Afterwards, a factorial or quantification model is proposed, whose function is to relate the latent variable to the observable variables (indicators).

In the factorial model, the usual choice of indicators includes a monetary aggregate, GDP per capita growth or labour market indicators, such as the activity rate. As for the structural model, the estimated coefficients are necessary to test the factorial model. The MIMIC method is useful to obtain evidence about some economic theory, since estimates are obtained by multiplying the latent variable index by some informal economy data. This gives the method a certain duality in its nature, using both endogenous variables (latent variable) and exogenous variables (data on the informal economy). Therefore, the model does not provide an estimate of the level, but rather provides measures for changes or variations on the latent variable. Figure 7 summarizes the process followed with the MIMIC methodology.

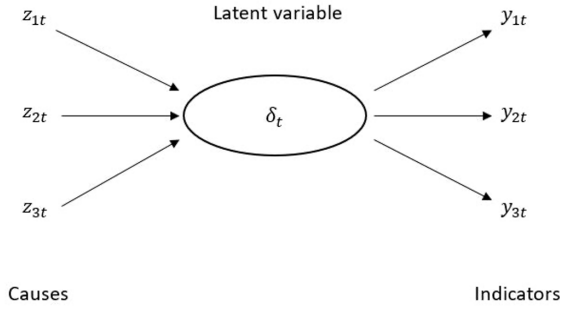

Figure 7. Structure of the MIMIC model.
Note: Own elaboration.

Differing from monetary methods, where a single indicator was taken as a trace of the informal economy, MIMIC can use multiple indicators and causes. This has two great advantages. The first is that in the structural model the multiple causes potentially comprehend the diverse nature of shadow economy (Legal, Non-taxable, and Criminal activities). On the other hand, multiple indicators improve the tracking of these informal activities—a notable advantage, since informal economy often manifests differently across specific economic sectors (Schneider et al., 2010).

Despite these advantages, certain drawbacks must be pointed out:

- The selection of causal variables and indicators is usually subjective. This could make sense when using the model in its confirmatory or exploratory version—for instance, when testing some economic theory.
- The above has been employed as a rationale for dedicating the MIMIC method to offering insights into the causes of the informal economy, rather than assisting in measuring its size.
- Estimates require data on the informal economy (informal GDP or informal to formal economy ratio). Since this data consists of informal economy estimates, the error is added to the actual error in the estimation process—errors generated in the structural and factorial models.
- Estimates are sensitive to shadow economy exogenous data, time scale, causal variables, indicators, and the sample of economic agents (such as different countries).
- The economic interpretation of the estimated coefficients is ambiguous due to lack of normalization in the causal variables, and transformations in the causal variables that continue to refer to the same latent variable. This is also a problem in the exploratory application of the model—it is not known if latent variable will not be affected after the transformation of the equation (Breusch, 2005a, b, c).

These problems raise doubts about its reliability. Hence, some authors suggest its application by reinforcing its confirmatory or exploratory nature. Additionally, it should be

employed in geographically close territories or among homogeneous agents (Mauleón and Sardà, 2018).

4. General Equilibrium models

Recently, the application of economic growth models to the research on informal economy has experimented an increasing interest. The motivation of these models is based in the General Equilibrium theory (microeconomic-based models), that represents the behaviour of a simplified economy over time, either within a deterministic or stochastic setup[4]. Hence, the development of these models comprehends some standardised steps—though some works may not follow this structure:

- *Description and setup*. Models are built on the assumption that there exist a representative household whose utility or "felicity" function is maximized. This is a mathematical function with "good properties", meaning that it is simple enough to be used throughout the mathematical development of the model. The level of utility or "felicity" increases with a rise in the level of consumption and decreases if there is an increase in hours worked. Hours worked are split in both sectors. Formal and informal technologies are expressed as production functions—the informal production being the one with no physical capital input, which means it will be less productive than the formal sector. The other economic agent is the government, usually financing a non-productive stream of public expenditure by means of a time-balanced budget. It collects taxes and charges a fee if tax audits result in finding informal income.
- Solving the optimization problem. Maximizing the household's utility function is done for each of the time unit of research subject to the dynamic restrictions on total hours worked available, the development of physical capital, total output, government budget household... Thus, this problem can be expressed in mathematical terms as a dynamic optimization problem. Popular solving methods mostly rely on discrete-time properties (usually year-by-year values), including the "dynamic programming" or "lagrangian" methods.
- *Calibration*. This phase is one of the most critical on the flexibility and reliability properties of these models. The solution to the optimization problem results in equilibrium conditions that provide the levels or changes on the informal economy's output. However, to obtain these results, some parameters and informal series, such as informal hours worked or the elasticity of substitution between the hours worked, are unknown. Researchers often include data on informal economy estimates with the aim to reduce the complexity of application of the models to real data. A usual approach consists of taking an initial level of informal economy—the period where that initial data will be applied is named the "base year". Using this exogenous data, the model can provide balanced growth rates of some time series of aggregates, informal economy productivity and hours worked being the most relevant. Thus, this phase determines (calibrates) the values of critical parameters and aggregates. Differences in flexibility and reliability will exist regarding the ability of the model to endogenize these parameters and informal aggregates, enhancing reliability if endogenization is present and flexibility if a wide variety of informal activities are included in the estimates. To test for reliability, researchers usually conduct sensibility analysis with respect to some parameters.

The main results that have been drawn with this type of models are applications framed within the economic growth literature: the quantification of the Solow residual, the analysis of conditional convergence between countries, the endogenization

[4] Deterministic frameworks are called Dynamic General Equilibrium (DGE) models while stochastic applications are termed Dynamic Stochastic General Equilibrium (DSGE) models.

and explanation of the growth rate of technology, among others (Barro and Sala-i-Martin, 2004). The ideal scenario would be to apply these models to informal economy similarly to when studying the official economy, ensuring the optimal modelling of the functioning and dynamics of this subset of activities. While the approach may vary, most existing research has leaned towards employing DSGE models.

The first approach is likely to be attributed to Loayza (1996) and Sarte (2000). They considered that the economy was represented by a production function named "AK". Then, Roca et al. (2001) explored by means of a DGE model the difference between aggregates from different economies due to the presence of the informal sector. However, an estimation of informal activities remained pending. In this regard, the work of Ihrig and Moe (2004) was awaited. Afterwards, diverse applications have been developed. Some of these encompass the examination of the effects of informality on intertemporal shocks and various aspects of the labour market, the processes of fiscal adjustment, and the evaluation of related policies. Additionally, some works delved into the transfer of companies between the two sectors with different productivities and the elucidation of high volatility in consumption, among other applications (Busato and Chiarini, 2004; Gómez-Plana and Pascual, 2011; Costa et al., 2020; Prado, 2011; Restrepo-Echevarria, 2014).

While research employing these models has been growing, there are few works addressing an estimation of informal economy, with existing ones being based on the model proposed by Ihrig and Moe (2004). For instance, Elgin and Oztunali (2012) improved the model by incorporating endogenous growth rates of both economies. Another important body of literature has focused on estimating the Criminal activities of this economy, with special emphasis on the phenomenon known as "shadow banking" (Fève et al., 2019; Meeks et al., 2013). Orsi et al. (2014) employ a DSGE model to estimate tax evasion in Italy, calibrating the model through Bayesian estimation. This fusion of the deterministic features of general equilibrium models with econometric procedures for calibration is commonly observed, meaning that DSGE models extend their application beyond the mere quantification of the informal economy (Orsi et al., 2012; Smets and Wouters, 2007).

The difficulty of measuring informal economy at the aggregate level has so far been cleared. Nevertheless, it is easier than measuring the informal economy at the microeconomic level, since it implies the use of questionnaires and surveys, which belongs to direct methods. However, measuring informal economy at the sectoral level is possible using general equilibrium models. An example of this is found on Elgin and Sezgin (2017), where a hybrid approach is proposed based on a DGE setup whose critical parameters are calibrated from survey data. As the model incorporates properties of both indirect and direct methods, it appears that general equilibrium models should not be categorized solely under indirect methodologies. This might be the reason why authors like Elgin (2021) have opted to refer to them as "model-based methods", separating them from non-monetary and monetary approaches.

Some of the most important works present reliability problems: the estimates of Elgin and Oztunali (2012) exhibit a notable bias as they impose arbitrary growth rates on time series. Specifically, they assume the productivity of the informal economy to grow at the average rate of capital and productivity of the formal sector. In Orsi et al. (2014), the growth rates of both formal and informal economy are assumed to be equal.

These criticisms are made by Solis-Garcia and Xie (2018), so they propose an alternative model aiming for a more realistic setup—attempting to endogenize some critical time series or parameters. Using a similar deterministic framework (DGE), they introduce a balanced growth path, from which a compatible estimate could be derived. Based on time-balanced growth, this methodology allows them to calibrate the elasticity of hours worked in the informal economy—a crucial parameter that had previously only been estimated once. Furthermore, they manage to extract the path of productivity of the informal sector. This means that they do not need to impose additional restrictions/simplifications. Hence, the model should be flexible, as it does not explicitly restrict the size of shadow economy to a certain set of

activities. In fact, it would be more reliable than previous approaches, since it overcomes technical limitations and common simplifications.

However, Gómez and Ríos-Blanco (2022) showed this methodology does not fulfil its purpose: the set of equilibrium conditions for the economy to evolve along its balanced-growth path include the condition that the informal and formal economy grow at the same rate. Since the value of the base year of informal to formal economy ratio is taken from Schneider et al. (2010), the estimates will be constant at any time and equal to that initial ratio. The simulations of Solis-Garcia and Xie (2018) show a variable relationship between shadow and formal production. This is due to a typo in an expression. Once corrected, the simulations show a constant relationship, as expected.

In response to Gómez and Ríos-Blanco (2022), the comment of Solis-Garcia and Xie (2022) develops an alternative model where only a subset of equilibrium conditions from their original proposal are imposed, so that informal and official economy growth rates are not necessarily equal. Hence, the informal to formal economy ratio is not constant, while still manages to endogenize the elasticity of hours worked in the informal economy and the time series of informal productivity. All in all, this model addresses the main issues identified in general equilibrium models.

5. Conclusions

Throughout this paper, the most popular methodologies for estimating informal economy have been thoroughly examined, indicating their frequent categorization into direct and indirect methods, as well as their respective strengths and weaknesses following the stream of thought left in academic literature. For illustrative and logistic purposes, figure 8 condenses the qualities and drawbacks enumerated in sections 2 and 3 of this document.

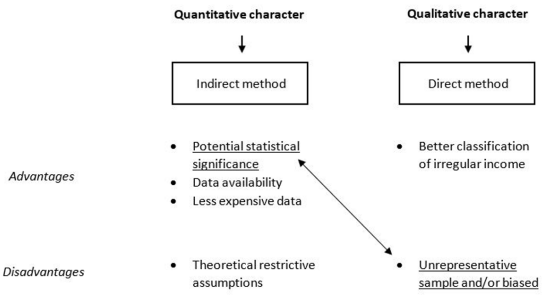

Figure 8. Summary of the characteristics of the main methodologies.
Note: Own elaboration.

Both categories are related, and therefore should not be isolated. Any model pursuing a precise estimation of shadow economy should be largely based on the indirect framework. Nevertheless, direct methodologies could help to identify potential causal variables. Indirect methods present the advantages stemming from the employment of secondary data sources, turning the statistical insignificance inherent to direct methods into an advantage of its own. Even then, the theoretical assumptions which are needed to apply models to real data still pose the main downside of indirect (quantitative) methods.

In this line, along the review of the main indirect methods, some technical problems threatening the reliability of these models have been broached: the MIMIC method usually gives poor econometric fits depending on the sample selected, showcasing an extreme sensitivity to the latter. Most non-monetary methods also present non-robust results.

Monetary methods are simpler. Even so, that simplicity comes together with an "incomplete", "reduced" or "simplistic" view of a phenomenon as diverse as shadow economy. It is worth remembering that most of the regressors used in the equation are related with tax burden, making the money demand method a valuable instrument for the analysis of tax evasion (GESTHA, 2014).

Despite this pragmatic utility, the "equal velocity of money" assumption in both the official and informal sector embodies one of the main limits of these methods.

Similar issues may be observed in non-monetary methods, including the popular physical input method: masterfully incorporating electricity consumption and its relation to a country's GDP as an indicator, this method has acquired significant relevance as a mean to track Criminal activities, such as drug trafficking (Rodríguez, 2007).

1. What actions should be avoided to attain a suitable measurement of informal economy?

The use of these "short view" models may be useful for the estimation of certain types of informal economy. However, it is important to bear in mind the diverse and wide nature of informal activities, light under which the MIMIC method seems to be the closest to attain what the authors referred as "suitable measurement of the informal economy": an "universal" and flexible method that encompasses the diverse nature of informal economy. It may very well be that the use of a wide range of indicators and causes has determined the better adaptability of the MIMIC method to a concept as manifold and everchanging as shadow economy. Be that as it may, this apparent "best fit" does not mean the method is free of criticism, since Schneider and Buehn (2018) and Elgin (2021) are among the authors to illustrate the technical drawbacks of this method, so that it cannot be assured it is reliable.

The attempts of (better) measuring Legal, Criminal and Non-taxable activities are the unquestionable cause of the increasing complexity of the model, resulting in a difficult empirical application and further technical problems. The simplifications presented by alternative models ended up by limiting the scope of informal activities, or reducing the reliability of results (for instance, the use of informal economy data on a base year or equal velocity of money in both sectors).

This reductionist view constitutes a risk of bias for studies that focus on the effects and consequences of the informality, since they rely on informal economic estimates. Measuring informal economy should encompass all the diverse activities that arise its multiple causes and consequences.

Given the trade-off between reliability and flexibility—with reliability being compromised as a method becomes more flexible, and vice versa—it could be argued that informal economy estimation methods fall short in capturing its inherent complexity. This shortcoming may represent the failure to balance the flexibility-reliability binomial, two concepts whose incompatibility arises from the nature of the reviewed methods, which do not align with the entirety of hidden income.

2. What potential solutions exist for the challenges hindering a suitable measurement of the informal economy?

In line with Schneider and Buehn (2018), it would be desirable not to stick to a single type of methodology when it comes to study the informal economy size. The inexistence of a method conciliating the flexibility-reliability binomial makes the research on causes and consequences of shadow economy differ depending on the sample of study, supporting the idea of complementarity of direct and indirect methods. The pre-eminence of general equilibrium models and their deterministic or stochastic behaviour gives the researchers a new opportunity to match both direct and indirect method properties. This is illustrated in the hybrid approach of Elsing and Sezgin (2017). Also, we reviewed examples of these frameworks being applied to study determinants and effects of the informality.

The disappearance of some of the classic indirect methodologies' problems makes the General Equilibrium approach a real candidate to be further studied and developed. Though the approach still presents some drawbacks, authors like Solis-Garcia and Xie (2022) demonstrated that the assumptions can be relaxed in view of making the model even more functional. The endogenization of the productivity of the informal sector further increases the reliability of the approach, even though such statement should be confirmed with a validation method[5]. This validation procedure is somehow present in econometric estimates by means of statistical robustness checks. However,

[5] A "universal" validation method was still a pending task in indirect methods (Medina and Schneider, 2018).

general equilibrium models, given they arise from the economic growth literature, are mostly based on deterministic setups, so they do not use such econometric tests. Nowadays, a common check is to perform a sensibility analysis with respect to crucial parameters. This could suggest that, perhaps, there is no need to find an "universal" validation method for every indirect methodology, given the fact that general equilibrium models diverge from the conventional econometric setups.

These models do not explicitly impose a causal relationship between informal indicators and variables. In other words, it could help to relax the assumption that only a specific type of informal activities is incorporated within the modelled economy. An exploration on new measures based on these methodologies is recommendable, further complemented by the inclusion of new indicators of robustness or validation checks. In any event, whether these types of models are close to meet the flexibility-reliability binomial remains an open question.

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