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AN ANALYSIS OF THE INFLUENCE OF SHADOW ECONOMY ON ECONOMIC DEVELOPMENT

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Abstract

The shadow economy is an umbrella concept that covers different aspects of the informal economic sectors. Conventional wisdom states that an increased size of the shadow economy hampers economic growth. However, we adopt a more nuanced conceptual framework, considering the mixed effects exercised by the shadow economy on economic development and full employment of labour resources. Thus, we estimate the size of the shadow economy employing a Multiple Indicators and Multiple Causes model. To cope with the uncertainty that emerges from the large set of potential determinants of economic development, we employ the resulting proxy of the shadow economy in a Bayesian Model Averaging/Weighted-Average Least Squares. Alternative approaches to data are considered for a robustness check. We find that for a dataset of 124 post-industrial and developing economies covering the period between 1991 and 2017, the shadow economy can both positively and negatively affect economic development. Our results show that the 'net' effect exercised by the shadow economy on the official sectors is an open question. The main implication is that any policy aiming to reduce the size of the shadow economy should be accompanied by an improvement of the economy's formal sectors to absorb unemployment.

Keywords: shadow economy, economic development, tax burden, Bayesian Model Averaging (BMA) Weighted-Average Least Squares (WALS)

1. INTRODUCTION

A growing literature examines the bi-univocal linkages between the shadow economy and economic development in the context of (post)modernization processes that occur for both developed and developing countries, as these linkages are modulated by various factors - such as financial development, economic freedom,

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technological development, economic and financial globalization, the status of entrepreneurial activities, the quality of public institutions and policies, or cultural and behavioural factors (Saunoris, 2018, 2024; Canh & Thanh, 2020; Younas et al., 2022; Rahman et al., 2023; Vătavu et al., 2023; Dang & Nguyen, 2024). Nevertheless, the evidence provided by this literature suggests that the underlying mechanisms that govern such linkages lead to complex and sometimes ambiguous results. While usually an increased size of the shadow economy lowers the tax revenues, reduces the supply of public goods and services, lowers labour and capital productivity, and increases corruption, it can also contribute to improved living standards, consumption and savings, and opportunities for entrepreneurship. Consequently, a consensus about the effects of the shadow economy on economic development has yet to emerge. Such a consensus might be highly relevant to a better understanding of the mechanisms of economic development in contemporary economies. For instance, a critical issue is that the informal economy is usually labour-intensive but not capital-intensive (see for this argument, Elgin & Oztunali, 2014; Basbay et al., 2016; Chen et al., 2021). Hence, a potentially non-linear relationship between the size of the shadow economy and the diffusion of technological progress, energy consumption, efficiency, or environmental degradation might occur. Broadly, some recent empirical evidence (Nguyen, 2022) suggests that there is a long-run association between economic complexity (as this is reflected by the knowledge materialised in the production system - Hartmann et al., 2017) and the size of the shadow economy (although the possible benefits to the shadow economy that occurs from an increase in economic complexity may be more modest in comparison with those from formal sectors).

In this context, the present study raises the following research question: What is the 'net' impact of an increased size of the shadow economy on economic development, and what are some transmission channels carrying out such an impact?

Companies and individuals seeking to avoid the payment of taxes and social contributions, to meet minimum wages, maximum working hours or the legal quality standards for their products and services, to escape bureaucratic requirements or simply to make an ‘extra buck’, households engaged in ‘do-it-yourself’ or ‘help your neighbours’ activities, smugglers, drugs dealers, members of organized crime, all have their share in the ‘parallel’ or shadow economy. This type of economic activity is part of everyday life and it affects most of world’s post-industrial or developing societies. Its existence determined by the heavy tax burden, insufficient provision of good quality public goods, political structures seeking to extend their regulatory powers over the business sector and to control the conditions concerning the entry and exit from markets, corruption and excessive bureaucracy, or the failures of the official economy and lack of entrepreneurial opportunities in formal sectors. The size of the shadow economy has constantly increased since the end of the XX century. As Giles & Tedds (2002) notes: “there is a consensus that in almost every country that has been studied the underground economy has been growing relative to GDP or GNP over the past two or three decades.”

Nevertheless, despite its tremendous importance, there is still little consensus about the nature and extent of the influence exercised by the shadow economy on economic development.

The conventional wisdom is that: “The shadow economy absorbs critical resources from the formal economy and to a certain extent impedes the implementation of policies that are necessary for the common good” (Poufinas, 2021).

However, more recent literature provides theoretical arguments and empirical evidence according to which the impact exercised by shadow economy on economic and social processes is not exclusively a negative one. For instance, Saunoris (2018) uses data on over 100 countries from 1970 to 2008, revealing that the marginal externality effect of growth in the official sector on the official sector is positive. Further, input productivities are higher in the unofficial sector relative to the official sector. Bayar et al. (2020) analyzes 11 post-transition EU members over the 1995-2015 period, determining that both the shadow economy and human development are significant determinants of foreign direct investment inflows. For a dataset of 162 countries during 1999-2007, Nikopour and Habibullahz (2011) discovers that a cubic, S-shape, functional form justifies the relationship between shadow economy and economic growth. Medina and Schneider (2019) finds that for Pakistan, between 1976 and 2015, the shadow economy has positively and negatively contributed to GDP per capita in long and short runs. Huynh and Nguyen (2020) reports that shadow economy reduces income inequality in the case of 19 Asian countries studied from 1990 to 2015.

Based on this literature, we propose a two-fold contribution. First, we advance a theoretical framework which considers both positive and negative effects exercised by the shadow economy on economic development and ‘full employment’ of labour resources. We argue that, by accounting for the ‘net’ result, there can be, at a particular stage of economic development, a specific ‘optimal’ size of the shadow economy.

Second, we test for the possible non-linear impact exercised by the shadow economy on economic development, as the GDP per capita statistics provided by World Bank data (2021) captures it. For a dataset of 124 developed and emerging economies covering a period between 1991 and 2017, and by using the data provided by Medina and Schneider (2019) to assess the size of the shadow economy, we find empirical support for the existence of both positive and negative effects of shadow economy on the official sectors.

The study provides several results that are distinct from the other findings in the literature. First, by building a formal model and an underlying theoretical framework, we argue that the shadow economy can both positively and negatively affect economic development. Second, we show that such an outcome remains robust even when different methodological approaches for empirically assessing the shadow economy's impact are considered. Thirdly, we find significant non-linear effects seldom considered by other studies. Fourthly, we suggest that the labour market represents an important transmission channel often overlooked by the existing literature. Fifthly, we deal with model uncertainty using a Bayesian Model Averaging (BMA) / Weighted-Average Least Squares (WALS) framework.

2. CONCEPTUAL FRAMEWORK

Economic development is a multifaceted concept that encompasses various dimensions. These dimensions refer to: the productivity of the human, natural, and financial resources; the economic freedom, the specific features of the business environment and the spread of entrepreneurial initiatives; the diffusion of innovations, new technology and a knowledge-based economy; physical infrastructure support through which the resources are allocated into society; public sector functioning, and the quality of public policies and institutions; the development of human capital through the investments in education and health; the social mobility and the economic, social and cultural openness; social justice and equitable distribution of incomes and wealth; the environmental impact of economic activities and environment preservation for future generations. Hence, several proxies of economic development can be considered. These proxies can be related to business development, GDP growth, allocation of wealth in the economy, poverty reduction, reduction of individual and regional inequalities, the development and efficiency of the financial sector, physical or psychological health of the population, firm growth, foreign trade volume, or environmental performance (see Levine & Tantardini, 2024, for a current extended literature review).

Therefore, although this study relies on the more conventional real GDP per capita proxy for economic development, we acknowledge that a broader measure of development may be considered.

Furthermore, we consider the following argument from Johnson et al. (1997): "Economies find themselves in either of two very different equilibria. In the first, tax distortions and regulations are low, government revenues are high, the provision of public goods in the official sector is sufficient, and therefore the unofficial sector is small. In the second equilibrium, in the official sector taxes and regulations are prohibitive, public finances are precarious, public goods provision is inadequate, and as a consequence, much of the economic activity is concentrated in the unofficial sector".

Thus, we focus our explanatory framework on the idea that the existence of shadow economy compensates for both the failures of official economy and the distortionary effects of fiscal policy. If the official sectors are highly efficient and public authorities are able to provide a constant flow of good quality public goods, then the size of shadow economy tends to be small. Opposite, if the formal markets are significantly inefficient and taxation is distorting their mechanisms, while the provision of public goods is inadequate as structure and volume, the informal economy finds opportunities to extend itself.

A 'rationale' public authority will recognize the existence of these two possible states of the economy and will correspondingly adjust the public policies according to the current prevalent state and possible total effects of the shadow economy. By 'total effects', we understand the direct effects that work through labour supply and demand plus indirect effects that involve government spending responses to available tax revenues (Davis & Henrekson, 2004).

Therefore, in order to provide a possible explanation for the impact exercised by the shadow economy on economic activity, we start with a simple utility function of the public authority. Such function depends only on two variables: the fiscal revenues, τ^*y, (where y is the volume of economic activity in formal sectors and τ is the tax rate), and respectively, the ‘de facto’ rate of unemployment (the fraction of the labour force that is not occupied either in formal or informal sectors of the economy), u. Thus:

$$U^S: \alpha_1 * \tau y + \alpha_2 * u, \alpha_1 > 0; \alpha_2 < 0 \quad (1)$$

For an economy where the informal sector is present, the rate u will be lower than the official rate of unemployment and it will depend on the size of both formal (y) and informal (s) sectors:

$$u = \beta_1 * y + \beta_2 * s, \beta_1, \beta_2 < 0 \quad (2)$$

An important issue here is that the labor force from underground sectors is characterized by a high degree of heterogeneity. More exactly, a fraction of this is recorded as unemployed because it is part of the official labour force. Another fraction is composed by retired people, illegal immigrants, minors and other individuals, who are not officially recorded as labour force. Finally, there are individuals, which have simultaneously an official and unofficial job (Tanzi, 1999; Dell’Anno & Schneider, 2003). Hence, the official unemployment rate might be only weakly correlated with the shadow economy. Nevertheless, we take into account a global ‘de facto’ unemployment rate which covers all individuals actively seeking a job in both official and unofficial sectors.

Furthermore, we presume a non-mediated (but non-linear as well) impact exercised by the shadow economy on the officially recorded volume of economic activity. On one hand, this type of economic activity diverts natural, human and financial resources from legally organized activities. On another, it may deliver beneficial outcomes at the societal level and substitute on different market and society segments, the formal economic entities that are inefficient or absent. In other words, the informal sectors may provide various types of ‘safety networks’ and the formal and informal economies can complement each other (Medina & Schneider, 2019). Consequently:

$$y = \omega_1 * s + \omega_2 * s^2, \omega_1 > 0; \omega_2 < 0 \quad (3)$$

By substituting (2) and (3) in (1), we obtain the following form of the public authority’ utility function:

$$U^S: \left(\alpha_1 \tau \omega_1 + \alpha_2(\beta_1 \omega_1 + \beta_2)\right)s + (\alpha_1 \tau \omega_2 + \alpha_2 \beta_1 \omega_2)s^2 \quad (4)$$

The ‘optimal’ level of the shadow economy, $s*$, i.e. that level which maximizes the public authority utility, is obtained by imposing $\frac{\partial U^S}{\partial s} = 0$:

$$s^* = -\frac{\left(\alpha_1 \tau \omega_1 + \alpha_2(\beta_1 \omega_1 + \beta_2)\right)}{2(\alpha_1 \tau \omega_2 + \alpha_2 \beta_1 \omega_2)} \quad (5)$$

Despite its simplicity, relation (5) illustrates our core argument. According to this argument, the exact nature and amplitude of the effects associated to shadow economy will depend on the relative importance for a given society (which aims to achieve and maintain the ‘full employment of resources) of the recognized economic activity and ‘de facto’ unemployment. It will also be determined by the response function-specific parameters that modulate the impact exercised by the shadow economy on the official economic activity, the fiscal policy (as captured by tax rate), and the absorption of the labour force by the formal and informal sectors.

This model also suggests that public authorities can influence the size of the shadow economy by correspondingly adjusting fiscal policy (and, in particular, the tax burden). Of course, when fiscal policy is drawn and implemented, the unofficial economic activities are not explicitly considered. Nevertheless, any adjustment in this policy is susceptible to influence not only the absolute size of the informal sector, but also its relative importance in the economy and society. Meanwhile, a larger size of the shadow economy can increase the tax burden in the official economy and distort its resource allocation mechanisms. Hence, the net effect exercised by the shifts in fiscal policy cannot be anticipated on an ex-ante basis. To make things even more complex, the impact of taxation heavily depends on taxpayers' behavior. As Hill (2002) explains: "Changes in people's opportunities to evade taxes is another cause, one that may be reflected in changes in sectoral employment (such as the growth of sectors in which evasion is easier) or in type of employment (such as shifts from paid employment to self-employment) or in market structure (such as the supplanting of small by "big box" stores). Changes may also occur in people's attitudes about the morality of cheating on their taxes".

Other aspects can be incorporated into this explanatory framework. For instance, one can account for the role of capital formation in both official and informal sectors. A higher rate of capital accumulation in the case of shadow economy can lead to a substitution effect: intellectual, material, and financial resources are diverted from the official economy, with the cost of registering lower accumulation rates.

Moreover, the vital role played by the overall quality of institutions should be mentioned here. Particularly relevant are those involved in fighting tax evasion and corruption. In a broader sense, all institutions enforcing the rule of law, property rights' protection, corresponding execution of contracts and sound pro-growth policies' implementation are relevant to some extent.

However, some shadow activities (such as money laundering, drug trafficking or tax evasion) have an international dimension. For that reason, a society's degree of international openness may explain the underground economy.

Finally, cultural variables are important as well: how permissive is a society in regard to such activities may depend on citizens' shared views on authority, obedience to rules and life.

All these variables affect both formal and informal economy. If we further account for the fiscal policy response to changes in social and macroeconomic environment, then its response function can be depicted as:

$$\tau = \tau_0 + \varphi_1 * k + \varphi_2 * I \\ +\varphi_3 * o, \varphi_1, \varphi_2, \varphi_3 > 0 \tag{6}$$

Here, k stands for global capital accumulation rate, I is an indicator capturing the quality of public institutions and policies, and o is the degree of openness. τ_0 is the minimal 'autonomous' tax burden, which is not dependent on socioeconomic conditions, but is connected to public authorities' capacity to exert their basic functions.

Such response function indicates that, in the context of higher capital accumulation growth, better public institutions, and higher degree of openness, public authorities may impose greater tax rates and collect more tax revenues. With this, the 'optimal' degree of the shadow economy becomes now:

$$s^* = -\frac{\left(\alpha_1(\tau_0 + \varphi_1 * k + \varphi_2 * I + \varphi_3 * o)\omega_1 + \alpha_2(\beta_1\omega_1 + \beta_2)\right)}{2(\alpha_1(\tau_0 + \varphi_1 * k + \varphi_2 * I + \varphi_3 * o)\omega_2 + \alpha_2\beta_1\omega_2)} \quad (7)$$

Several cases of interest may occur here (Table 1):

By accounting for these cases, we conclude that shadow economy can exercise both positive and negative effects on the official economy. Therefore, its 'optimal' size largely depends on the 'net' outcome of such effects, fiscal policy, institutional and socio-economic conditions.

Our theoretical framework links several arguments. The starting point is the idea that a society is choosing between the supply of public goods and services, which are financed through fiscal revenues and, respectively, the level of unemployment. The

Table 1. Specific cases of the model

Parameter behavior	'Optimal' size of shadow economy	Case description
$\tau \to 0$	$s^* \to -\left(\frac{\omega_1}{2\omega_2} + \frac{\beta_2}{2\beta_1\omega_2}\right)$	Expansionary fiscal policy with low tax burden; 'optimal' size depends on both the interactions between formal and informal sectors of the economy and on the relative capacity of the official economy to absorb the labor force.
$\tau \to 0; \|\beta_1\| \gg \|\beta_2\|$	$s^* \to -\left(\frac{\omega_1}{2\omega_2}\right)$	Expansionary fiscal policy with low tax burden; the official economy largely absorbs the labor force. The 'optimal' size depends exclusively on the interactions between formal and informal sectors of the economy.
$I, o \to 0$	$s^* \to -\frac{\left(\alpha_1(\tau_0 + \varphi_1 * k)\omega_1 + \alpha_2(\beta_1\omega_1 + \beta_2)\right)}{2(\alpha_1(\tau_0 + \varphi_1 * k)\omega_2 + \alpha_2\beta_1\omega_2)}$	Poor quality of public institutions and policies and low degree of international openness.
$\beta_2, \omega_1 \to 0$	$s^* \to 0$	'shadow economy absorbs only a tiny fraction of the labor force, and this exercises no positive non-mediated impact on the official economy. Most of the resources are concentrated in the official economy.
$\beta_1, \omega_2 \to 0$	$s^* \to +\infty$	shadow economy absorbs a high fraction of the labor force, and this exercises a substantial positive non-mediated impact on the official economy.
$\beta_1, \beta_2 \to \beta$	$s^* \to -\frac{\left(\frac{\alpha_1(\tau_0 + \varphi_1 * k + \varphi_2 * I + \varphi_3 * o)\omega_1}{\beta} + \alpha_2(\omega_1 + 1)\right)}{2\left(\frac{\alpha_1(\tau_0 + \varphi_1 * k + \varphi_2 * I + \varphi_3 * o)\omega_2}{\beta} + \alpha_2\omega_2\right)}$	The labor resources are shared by official and 'shadow' sectors and there is a 'knife-edge equilibrium' amongst them.

existence of the shadow economy leads to a level of unemployment that is de facto lower than the official figures. Such a (non-linear) effect happened because the entities operating in informal sectors of the economy may substitute those from formal industries which are inefficient or absent. The nature and amplitude of such a substitution effect can be modulated by several variables including the role of capital formation in official and informal sectors, the quality of the institutional infrastructure, a society's degree of international openness, as well as cultural and behavioural factors.

If the expansionary/restrictive nature of the fiscal policy and the capacity of the shadow economy to absorb unemployment are considered, several cases can be distinguished in our framework. The differences between these cases implicitly reflect the levels of economic development and the differences in the design and implementation of public policies.

Consequently, we further seek empirical evidence for the impact exercised by the shadow economy on official economic development.

3. METHODOLOGY AND INTERNATIONAL DATA

In order to provide some empirical evidence for the impact exercised by the shadow economy on economic development, at least two methodological steps should be considered: 1) select an appropriate method for assessing the size of shadow economy and, respectively, 2) involve a framework dealing with the uncertainty related to the 'true' model of economic development.

To deal with the uncertainty that emerges from the large set of potential determinants of economic development, we start with a Bayesian Model Averaging (BMA) / Weighted-Average Least Squares (WALS) framework. This can cope with different types of model-related uncertainty and, thus, better incorporate the role played by the shadow economy alongside other determinants identified by various endogenous growth theories.

Nonetheless, we also consider an alternative examination of the data involving a Partial Frontier Efficiency (PFE) analysis for robustness.

Finally, we examine the evidence for a potential non-linear impact of the shadow economy's size on economic development and formally test for such an impact using a reduced explanatory model.

Furthermore, since the effects of the shadow economy are modulated by factors associated with the level of economic development, we include both developed and emerging economies in our dataset. The aim is to obtain a dataset as large as possible under the sole restriction of data availability. It should be mentioned that the considered estimation methodology can deal with the resulting heterogeneity of the empirical data. Nevertheless, we re-estimate the general model for different sub-samples and derive some conclusions about the robustness of our results.

3.1. Defining and measuring the shadow economy

The shadow economy is not only a reality, but also a major economic and social phenomenon. However, there is little consensus in defining it as 'shadow', 'underground', 'informal', 'unofficial', 'cash', 'grey', 'dark' or 'parallel economy'. Indeed, there is a plethora of definitions in the literature that covers different facets of informal economic activity. However, in this paper, we do not consider a precise definition of the shadow economy. Instead, we take the largest possible inclusion sphere of this concept: the market- and non-market-based production and distribution of legal and illegal goods and services that escape the official reporting to tax authorities or which are intentionally excluded from the official estimate of economic activity (see Smith, 1994 for a similar approach). These goods and services may be the object of both monetary and non-monetary transactions. The existence of shadow economy is the outcome of a large set of determinants related to the status of the official economy, public policies, the institutional and legal systems, citizens' attitudes, values and perceptions, social norms and cultural paradigm prevailing in the society or social and economic mobility and openness. shadow economy can interact and compete with the official economy upon which it exercises both positive and negative effects.

Nevertheless, such diversity of approaches has practical consequences for the empirical estimation of shadow economy's size. Literature provides different methods to assess this size and estimate the relative and absolute dimension of shadow economy compared with the official one.

As Almenar et al. (2020) resumes: "Effectively, six key methods have been used to estimate the size of the underground economy… In the first three approaches, measurements are based on the amount of currency in circulation in the economy… A fourth approach, the national accounts/judgemental method, involves no formal modelling of the underground economy. Instead, it rests on breaking down either the expenditure or income side of national accounts into its components and then applying subjective judgements as to the maximum likely levels of unrecorded incomes or expenditures. The fifth approach is the latent variable or MIMIC model. This approach uses a structural econometric model… This expenditure-based method uses estimates of the relationship between food consumption and income (i.e. an Engel curve) to measure the size of the underground economy".

Each of these methods presents specific advantages and disadvantages. For instance, the model approach is a useful tool to estimate the size and development of the 'shadow economy simultaneously',but requires another method to calibrate the model. The currency demand approach can lead to highly implausible results. An alternative is the survey method, but gathering and interpreting questionnaire data might be difficult (see, OECD/ILO/IMF/CIS Statistical Committee, 2002; Kirchgassner, 2017).

We consider the Multiple Indicators and Multiple Causes (MIMIC) models from among the various approaches to the' shadow economy' estimation. Such models are a particular case of Structural Equation Modelling (SEM). In these models, the shadow economy is depicted as a latent variable related to a set of observed indicators, and additionally to a set of causal variables. Here, the technical suggestion is to compare a sample covariance matrix with the parametric structure imposed by a theoretical structural model. One of the first applications of this model in estimating the shadow economy was done by Frey and Weck-Hanneman (1984). In this study, the MIMIC approach was used to estimate the relative size and development time of the hidden economy of OECD countries. Its further development implying a dynamic version (DYMIMIC) was proposed among others by Aigner et al. (1988) and Giles (2000). After these initial studies, the MIMIC model was extensively used to estimate the size of various countries' shadow economy (Dell'Anno, 2007; Bucek, 2017; Gaspareniene et al., 2018; Remeikienė et al., 2018; Dybka et al., 2019).

The MIMIC approach is not free of criticism (Breusch, 2005; Schneider & Buehn, 2016). Thus, caution should be exercised when the MIMIC model is applied and its complex requirements must be well-thought-out.

Notwithstanding its limitations, the MIMIC approach provides a rich and flexible framework which can incorporate various indicators and effects exercised by the shadow economy. Thus, we follow the approach proposed by Medina and Schneider (2019). By using a modified version of the MIMIC model, it provides one of the most comprehensive databases on the size of the shadow economy in existence, as it covers 157 countries from 1991 to 2017. The proposed approach considers a broad view of the shadow economy: "all economic activities which are hidden from official authorities for monetary, regulatory, and institutional reasons. Monetary reasons include avoiding paying taxes and all social security contributions, regulatory reasons include avoiding governmental bureaucracy or the burden of regulatory framework, while institutional reasons include corruption law, the quality of political institutions and weak rule of law" (Medina & Schneider, 2019:4).

In the detailed methodology, the estimation of shadow economy size depends on the following drivers: (i) a measure of the tax burden on the economy, (ii) institutional quality, (iii) openness, as proxied by trade openness, and (iv) unemployment. The implied MIMIC model also uses measurable indicators, such as: (a) currency, as a fraction of broad money, (b) labour force participation, and (iii) a measure of the size of the economy. A particularly interesting feature of this approach is that it includes a robustness assessment for the proposed estimations that avoid the use of GDP per capita as both cause and indicator variables. Instead, it relies on the night-lights approach by Henderson et al. (2012) to capture the economic activity independently.

3.2. Dealing with model uncertainty: The Bayesian Model Averaging (BMA) / Weighted-Average Least Squares (WALS) framework

Explaining growth is far from trivial. Due to the large number of potential determinants, there is a large degree of uncertainty linked to the 'true' growth explanatory framework (Durlauf et al., 2008). Brock et al. (2003) identifies three main types of 'uncertainty':

1. Theory-related uncertainty is when there is no well-developed theoretical grounds and a broad consensus about the driving forces of the economic processes;
2. Specification-related uncertainty occurs when it is not clear how a specific theoretical framework should be translated into the formal specification of a model; and, respectively,
3. Heterogeneity-related uncertainty relates to model assumptions regarding empirical observations.

Moreover, we expect for different growth models to be influenced by all these types of uncertainty. We argue that this is the case for a model including shadow economy among its explanatory variables (alongside more standard endogenous and exogenous variables). The Bayesian Model Averaging (BMA) framework is a tool dealing with these different types of model-related uncertainty and it is designed to address the problem of a large number of potential explanatory variables when there is no mature theoretical foundation to support their selection. So, which variables should be added to the model? Furthermore, which is their relative importance? The inference based on a single model might not be sufficient in such a case, or, worst, it might be even infeasible with a limited number of observations. BMA addresses these issues in a canonical regression problem (with being a vector of *n* observations):

$$y = \alpha_\gamma + X_\gamma \beta_\gamma + \varepsilon, \varepsilon \sim N(0, \sigma^2) \tag{8}$$

BMA is working by estimating models for all possible combinations of the explanatory variables *{X}* and by constructing a weighted average over all of them (if the matrix X includes K explanatories, this implies a 2^K models to be explored). The model weights for this averaging approach originate in posterior model probabilities that arise from Bayes' theorem (where $p(y|X)$ denotes the integrated likelihood supposed to be constant over all models and $p(M|y, X)$ is the posterior model probability – PMP):

$$p(M_\gamma|y, X) = \frac{p(y|M_\gamma, X)p(M_\gamma)}{p(y|X)} = \frac{p(y|M_\gamma, X)p(M_\gamma)}{\sum_{s=1}^{2^K} p(y|M_s, X)p(M_s)} \tag{9}$$

In other words, PMP is proportional to 1 the marginal likelihood of the model $p(y|M_\gamma, X)$ times a prior model probability $p(M_\gamma)$. Here the model prior $p(M_\gamma)$ plays a key role: it reflects the ex-ante beliefs about the structure of the model, and it should be call forth. If there is a complete lack of prior knowledge in model construction, then perhaps a good choice will be to set a uniform prior probability for each model. Nevertheless, several prior options can be involved in order to provide sensitivity analysis.

Further, it can be noticed that until now, the impact of all explanatory variables is supposed to be unclear. Still, there are cases in which only some variables are affected by model uncertainty, while for others, there are some conceptual (or other types) reasons justifying their inclusion into the model. In this case, the regression problem can be re-specified as:

$$y = \alpha_\gamma + X_{1\gamma}\beta_{1\gamma} + X_{2\gamma}\beta_{2\gamma} + \varepsilon, \varepsilon \sim N(0, \sigma^2) \tag{10}$$

Here X_1, X_2 are $nXk_j, j=1,2$ matrices of observations on two subsets of deterministic regressors with β_1, β_2 being k_jX1 vectors of unknown regression parameters ($k_1 \geq 1, k_2 \geq 0, K = k_1 + k_2 \leq n-1$). In Danilov and Magnus (2004) terminology, the elements of X_1 are labelled as 'focus regressors' (explanatory variables that should be included into the model), while X_2 includes the 'auxiliary regressors' (additional explanatory variables with a lower degree of certainty, in terms of model inclusion). Nevertheless, the focus is placed on β_1 estimates. Hence, the role of X_2 type variables is to improve these estimates, whereas β_2 is a vector of nuisance parameters. We will explore here two directions. The first is the case of 'full uncertainty' (when all variables, including the size of shadow economy are treated as 'auxiliary'). The second sees informal sector's size as being the 'focus repressor'(X_1=s) and all the other variables as 'auxiliary'.

As de Luca and Magnus (2011) notes "The choice of excluding different subsets of auxiliary regressors is therefore motivated by a trade-off between bias and precision in the estimators of the focus regression parameters".

Since uncertainty is related only to $X2$ variables, the number of possible models to be considered becomes equal to 2^{k_2}. Thus, if M_i is the i-th model in the model space and it is obtained by including only a subset k_{2_i} of auxiliary regressors $\left(0 \le k_{2_i} \le k_2\right)$ then the representation of the model is:

$$y = \alpha_\gamma + X_{1_\gamma}\beta_{1_\gamma} + X_{2_i}\beta_{2_i} + \varepsilon_i, \varepsilon_i \sim N(0, \sigma^2), i = 1,2,\dots 2^{k_2} \tag{11}$$

Here X_{2_i} is a nXk_{2_i} matrix of observations on the included subset of k_{2_i} auxiliary β_{2_i} regressors, is the corresponding sub-vector of auxiliary parameters, while ε_i stands for the new vector of disturbances after excluding $k_2 - k_{2_i}$ auxiliary regressors.

We consider the BMA estimator developed in Magnus et al. (2010) (for an implementation see de Luca & Magnus, 2011). Such estimator accounts for the distinction between 'focus' and 'auxiliary' regressors. It deals with two significant issues in the BMA implementation: a) the computational burden and b) the fact that often no prior information is available and informative priors need to be specified. A more general proper prior that admits an improper prior as a particular case is used.

Nevertheless, the BMA estimator suffers from two significant problems. First, there is a substantial computational burden proportional to the dimension of the model space.

Second, the choice of the prior distribution on β_2 may be difficult, when no prior information is available. Furthermore, the chosen priors imply that the risk of the BMA estimator to be unbounded. Therefore, we also explore the Weighted-Average Least Squares (WALS) estimator. WALS is an alternative model-averaging technique introduced initially by Magnus and Durbin (1999) and Danilov and Magnus (2004).

WALS relies on preliminary orthogonal transformations of the auxiliary regressors and their parameters. More exactly, WALS starts with an orthogonal k_2Xk_2 matrix P and a diagonal k_2Xk_2 matrix Λ such that $P^\top X_2{}^\top M_1 X_2 P = \Lambda$. These matrices are then used to define $Z_2 = X_2 P \Lambda^{-\frac{1}{2}}$ and $\gamma_2 = \Lambda^{\frac{1}{2}} P^\top \beta_2$ such that $Z_2{}^\top M_1 Z_2 = I_{k_2}$ and $Z_2\gamma_2 = X_2\beta_2$. The original vector of auxiliar parameters β_2 can be recovered from $\beta_2 = P\Lambda^{-\frac{1}{2}}\gamma_2$ (see for more details on WALS, Magnus & Durbin, 1999; Danilov & Magnus, 2004; de Luca & Magnus, 2011).

In the framework of BMA, WALS, we employ a development model that includes the size of shadow economy as an explanatory variable. As control variables, besides the size, we include the stock of physical capital in an economy, government final consumption expenditures, inflation, natural resources rents, international migration, labour force participation, business disclosure, trade, the spread of Internet, carbon dioxide (CO2) emissions, the status of democracy and regional dummies (see Knack & Keefer, 1995; Barro, 1996, 2001, 2003; Hanushek & Kimko, 2000; Madon, 2000; Davis & Haltiwanger, 2001; Baum & Lake, 2003; de Haan, 2007; Knutsen, 2012; Busse & Koeniger, 2015; Schmidt et al., 2018; Li, 2019; Mardani et al., 2019, for some theoretical arguments and empirical models). The status of democracy is captured on different dimensions by the International Institute for Democracy and Electoral Assistance' Global State of Democracy indices (Skaaning, 2020).

3.3. International data

We first employ the estimates of the shadow economy size proposed by Medina and Schneider (2019). Data are collected from Appendix 'A' (Table A.1.) of this study for a dataset of 124 both developed and emerging economies covering a period between 1991 and 2017. For the same reference period, we further collect data from World Bank (2021) for the (log) GDP per capita, PPP (constant 2017 international $) as the dependent variable and gross fixed capital formation (as % of GDP), general government final consumption expenditure (% of GDP), inflation (measured based on GDP deflator), total natural resources rents (% of GDP), urban population (as % of the total population), international migrant stock (as % of the population), labour force participation rate for ages 15-24, total (%) (Modelled ILO estimate), business extent of disclosure index, crop production index (2014-2016 =100), external balance on goods and services (as % of GDP), the percentage of the population using the Internet and CO_2 emissions (kg per PPP $ of GDP), as control variables.

In addition, we collect data from the International Institute for Democracy and Electoral Assistance' Global State of Democracy database (available at: https://www.idea.int/gsod-indices/dataset-resources) (Skaaning, 2020) for five indices that synthetically capture various institutional features of the included economies ('Freedom of expression', 'Freedom of movement and residence', 'Freedom of academic and cultural expression', 'Freedom of academic and cultural expression', and 'Civil society participation').

In order to capture the implied long-run effects, all the variables are expressed as averages of all available data between 1991 and 2017. Hence, we adopt in our study a cross-section perspective by dropping out the short-run shocks.

The main statistics for the dependent GDP per capita variable and the size of shadow economy are reported in Table 2. It appears

Table 2. Main statistics for GDP per capita and size of shadow economy

Statistic	(Log) GDP per capita, PPP (constant 2017 international $)	Size of the shadow economy (%GDP)- Medina and Schneider (2019)
Mean	3.989	30.586
Median	3.989	31.480
Maximum	4.926	62.893
Minimum	2.915	6.348
Standard deviation	0.509	12.902
Skewness	-0.208	0.155
Kurtosis	2.064	2.395
Jarque-Bera	5.419	2.387
Probability	0.067	0.303
Observations	124	124

that the data are non-normally distributed, and they display a specific heterogeneity that should be accounted for by the estimation methodology.

3.4. Another look at the data: Partial frontier efficiency analysis

We also choose an alternative method of examining the data, namely the partial frontier efficiency analysis. The idea is to see if each country from the dataset (which is viewed as a ‘decision-making unit’- DMU) ‘employs’ the shadow economy in order to generate economic output. Thus, one can study the corresponding ‘efficiency’ of such diversity’s use, by involving a nonparametric approach – such as ‘data envelopment analysis’ (DEA) or ‘free disposal hull’ (FDH). Still, those approaches have been criticized for lacking a well-defined data-generating process and, even more important, for being vulnerable to outliers and different types of measurement errors. Such criticism has led to alternative ‘partial frontier’ approaches, particularly order-m efficiency analysis (Cazals et al., 2002) and order-α (Aragon et al., 2005), which are more robust to the presence of extreme values. These methods allow for ‘superefficient’ observations to be located beyond the estimated production-possibility frontier. We use only the order-α method based on expected minimum input functions (or expected maximal output functions). α can be viewed as a ‘fine tuning’, which determines the number of superefficient DMUs. The estimator is related to the FDH estimator, but it will not envelop all the data. We adhere to the Tauchmann (2012) implementation of this method. Two estimation versions are possible: 1) ‘input-oriented efficiency’, the factor by which shadow economy use at the level of each DMU can be proportionally reduced, without affecting the output of economic activity; and, respectively, 2) ‘output-oriented efficiency’, the factor by which this output can be proportionally increased, while leaving shadow economy unchanged.

However, in the context of the present analysis, the input-oriented approach does not make much sense. Consequently, we involve only the output-oriented estimation of efficiency. The purpose is to highlight those countries displaying maximal/minimal levels of ‘efficiency’ in the employment of their shadow economy and to check the geographical spread. When the partial frontier efficiency analysis is performed, a heterogeneous picture emerges.

As Figure 1 shows, in terms of output-oriented efficiency, the first ‘superefficient’ positions are occupied by developing countries like Mozambique, Burundi, Ethiopia, Niger, Central African Republic, Rwanda, or Sierra Leone. In these countries, the shadow economy can compensate for the weak development of markets, high income disparities, structural rigidities, and reduced opportunities to employ the resources and take entrepreneurial initiatives.

4. RESULTS AND DISCUSSION

4.1. Main results

Table 3 reports the results of the BMA analysis with full uncertainty specification and, respectively, with shadow economy as ‘focus’ variable. A neutral Subbotin (0.5) prior is involved. Such prior combines transparency in treating ignorance with a trivial computational burden (Einmahl et al., 2011).

The most important finding here is that in the cross-section BMA framework, the shadow economy appears to affect official economic development positively. However, the estimated amplitude of such effect is different when the size of the informal sector is treated based on a complete uncertainty assumption and, respectively, when it is always included in regressions. Supplementary, the corresponding PIP is in the first case below 0.6 and so a clear conclusion cannot be definitively drawn based on this analysis.

For the rest of the explanatory variables, high PIPs, exceeding 0.8, are obtained for capital formation, the share of the urban population, crop production, and external trade.

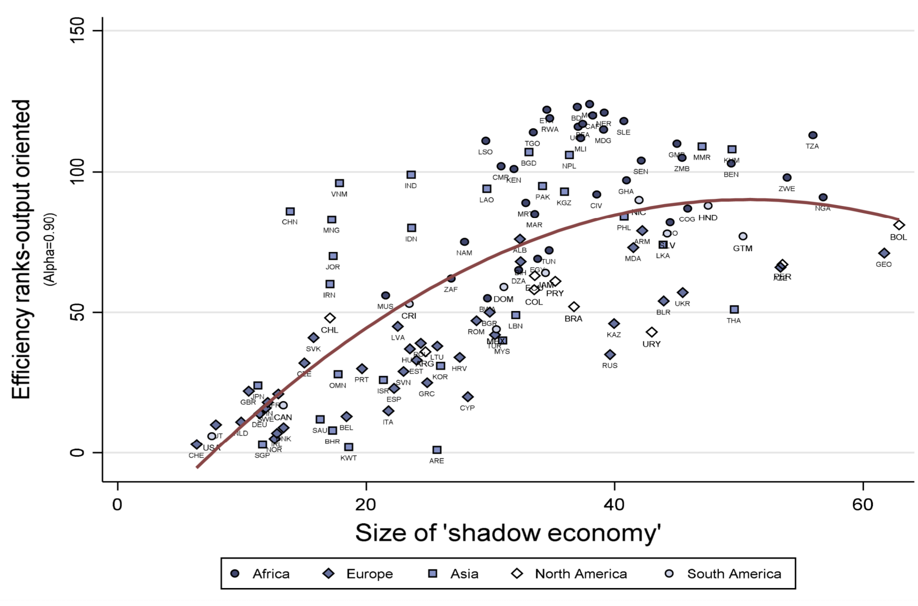
Meanwhile, other variables (such as inflation, total natural resources rent, international migrant stock, or individuals using the Internet) appear to have only a low capacity to explain differences in development for the countries in our dataset.

Finally, the descriptors of the Global State of Democracy display some explanatory power with a positive posterior estimated coefficient, while the corresponding values for regional dummies reveal the presence of some continent effects in development.

We further present in Table 4 the outcomes of the WALS methodology.

The WALS approach provides more compelling empirical evidence for the positive impact exercised by the shadow economy on development. In addition, this impact is robust to various prior specifications, and the corresponding sizes are largely comparable. Nevertheless, the estimated size of this impact is more than double the one provided by BMA.

It is interesting to note that, while the



Notes: This figure displays the scatter plot for the size of shadow economy against a set of 124 countries ranks as this results in terms of output-oriented efficiency, from a nondegenerated partial frontier efficiency analysis (*order-α* method), as implemented by Tauchmann (2012). For *α*, we choose the 90th percentile as the benchmark. The procedure invokes bootstrapping using 400 replications. The 'production function' uses as inputs the size of shadow economy.

Figure 1. Partial frontier efficiency analysis - size of shadow economy and efficiency ranks (output-oriented)

Table 3. Economic development and shadow economy: BMA estimates; full sample

Variables	**Full uncertainty (1)**	**Size of shadow economy as 'focus' variable (2)**
Size of the shadow economy(%GDP)-Medina and Schneider(2019)	0.005 (0.005) [0.574]	0.009 (0.003)
Gross fixed capital formation (% of GDP)	0.036 (0.006) [1.000]	0.033 (0.006) [1.000]
General government final consumption expenditure (% of GDP)	0.005 (0.008) [0.296]	0.013 (0.010) [0.725]
Inflation, GDP deflator (annual %)	-0.000 (0.000) [0.081]	-0.000 (0.000) [0.116]
Total natural resources rents (% of GDP)	0.001 (0.003) [0.164]	0.000 (0.002) [0.092]
Urban population (% of total population)	0.016 (0.003) [1.000]	0.014 (0.002) [1.000]
International migrant stock (% of population)	0.002 (0.004) [0.255]	0.003 (0.004) [0.374]
Labor force participation rate for ages 15-24, total (%) (modeled ILO estimate)	0.006 (0.004) [0.761]	0.004 (0.003) [0.641]
Business extent of disclosure index (0=less disclosure to 10=more disclosure)	0.009 (0.016) [0.296]	0.013 (0.017) [0.445]
Crop production index (2014-2016 = 100)	0.012 (0.002) [1.000]	0.010 (0.002) [1.000]
Trade (% of GDP)	0.003 (0.005) [0.386]	0.008 (0.004) [0.831]
Individuals using the Internet (% of population)	0.000 (0.002) [0.086]	0.001 (0.002) [0.121]
CO2 emissions (kg per PPP $ of GDP)	0.022 (0.082) [0.104]	0.023 (0.080) [0.119]
Global State of Democracy-Checks on government	0.198 (0.419) [0.234]	0.190 (0.390) [0.247]
Global State of Democracy-Freedom of expression	0.285 (0.480) [0.317]	0.341 (0.495) [0.382]
Global State of Democracy-Freedom of movement and residence	0.217 (0.333) [0.360]	0.362 (0.338) [0.617]
Global State of Democracy-Freedom of academic and cultural expression	0.237 (0.417) [0.298]	0.180 (0.358) [0.261]
Global State of Democracy-Civil society participation	0.100 (0.287) [0.158]	0.104 (0.270) [0.186]
Dummy for Africa	-0.009 (0.043) [0.091]	-0.024 (0.065) [0.176]
Dummy for Asia	0.064 (0.110) [0.313]	0.141 (0.128) [0.623]
Dummy for South America	-0.008 (0.050) [0.068]	-0.013 (0.057) [0.093]
Number of cross-section observations	124	124
k1	0	1
k2	21	20
Model space	2097152	1048576

Standard errors are in () and posterior inclusion probabilities (PIPs) are in [].

Notes: A Subbotin prior is used. As a rough guideline, Masanjala and Papageorgiou (2008) suggests that a posterior inclusion probability of 0.5 corresponds approximately to a t-ratio of one in absolute value.

Table 4. Economic development and shadow economy: WALS estimates; full sample and various priors

Variables	Model 1 **(1)**	Model 2 **(2)**	Model 3 **(3)**
Size of the shadow economy (%GDP)-Medina and Schneider(2019)	0.013	0.014	0.013
	(0.002)	(0.003)	(0.002)
Gross fixed capital formation (% of GDP)	0.027	0.026	0.027
	(0.005)	(0.005)	(0.005)
General government final consumption expenditure (% of GDP)	0.018	0.017	0.018
	(0.005)	(0.005)	(0.005)
Inflation, GDP deflator (annual %)	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Total natural resources rents (% of GDP)	0.003	0.002	0.003
	(0.004)	(0.003)	(0.004)
Urban population (% of total population)	0.010	0.010	0.010
	(0.002)	(0.002)	(0.002)
International migrant stock (% of population)	0.005	0.005	0.005
	(0.003)	(0.003)	(0.003)
Labor force participation rate for ages 15-24, total (%) (modeled ILO	0.005	0.005	0.005
estimate)	(0.002)	(0.002)	(0.002)
Business extent of disclosure index (0 = less disclosure to 10 = more	0.030	0.030	0.030
disclosure)	(0.010)	(0.010)	(0.010)
Crop production index (2014-2016 = 100)	0.008	0.008	0.008
	(0.001)	(0.001)	(0.001)
Trade (% of GDP)	0.008	0.008	0.008
	(0.002)	(0.002)	(0.002)
Individuals using the Internet (% of population)	0.003	0.003	0.003
	(0.004)	(0.004)	(0.004)
CO2 emissions (kg per PPP $ of GDP)	0.159	0.165	0.161
	(0.123)	(0.123)	(0.123)
Global State of Democracy-Checks on government	0.274	0.284	0.277
	(0.330)	(0.342)	(0.333)
Global State of Democracy-Freedom of expression	0.151	0.136	0.148
	(0.570)	(0.591)	(0.575)
Global State of Democracy-Freedom of movement and residence	0.377	0.386	0.379
	(0.183)	(0.180)	(0.182)
Global State of Democracy-Freedom of academic and cultural expression	0.407	0.413	0.408
	(0.432)	(0.448)	(0.436)
Global State of Democracy-Civil society participation	0.156	0.157	0.156
	(0.314)	(0.326)	(0.317)
Dummy for Africa	-0.149	-0.146	-0.150
	(0.086)	(0.086)	(0.086)
Dummy for Asia	0.121	0.120	0.121
	(0.084)	(0.084)	(0.084)
Dummy for South America	-0.111	-0.108	-0.110
	(0.103)	(0.103)	(0.103)
Number of cross-section observations	124	124	124
k1	1	1	1
k2	20	20	20
q	0.888	1.000	0.800
c	0.693	0.693	0.938
σ	0.265	0.265	0.265
K	44.907	44.907	44.907

Standard errors are in () parentheses. Notes: A Weibull prior is used in Column 1; Column 2 involves a neutral Laplace prior; while Column 3 a Subbotin prior.

mentioned explanatory variables remain significant, others, like the general government final consumption expenditure, young labour force participation, business disclosure index and all descriptors of Global State of Democracy (with the notable exception of academic and cultural expression's freedom and civil society participation), become substantially significant. In the meantime, no important changes occur for the regional dummies.

Therefore, it appears that the WALS specific preliminary orthogonal transformations of the auxiliary regressors and their parameters allow better use of prior distributions and treat better the concept of ignorance about the role played by the auxiliary regressors.

4.2. Dealing with convergence in growth

Economic growth is not an autonomous process because it only partially depends on country-specific endogenous factors. Moreover, in a globalized world, the economies are integrated with a complex web of factor flows and knowledge advancements. This fact can clarify both convergences/divergences in their growth rates and their internal structural features.

In the standard neoclassical approach, convergence can be explain based on Solow-Swan model of economic growth, and it implies that a decrease in the investment returns can cause a decline in a country's growth rate as it approaches its steady-state level of capital per unit of labor. Thus, less developed economies should exhibit higher rates of capital accumulation and should grow faster. Such a situation may lead to a 'catch-up' in growth (Sala-i-Martin, 1996).

In more critical details, Galor (1996) draws a distinction between three competing hypotheses: a) The absolute convergence hypothesis - according to which countries converge on long-run, in terms of economic growth, regardless of their initial conditions; b) The conditional convergence hypothesis - the convergence process (still independent to the initial conditions) occurs only for countries similar in their structural characteristics; and, respectively, c) The club convergence hypothesis (polarization, persistent poverty, and clustering) - when convergence depends on both structural features and similarity in the initial conditions.

While the absolute convergence hypothesis is poorly supported by evidence, with a lack of progress in closing the income gap between countries (Johnson & Papageorgiou, 2020), more empirical support is received by the other two forms of convergence.

For instance, Quah (1997) delivers evidence of empirical regularities - emerging twin peaks, incipient polarization and stratification - that occur in patterns of economic growth across countries. Tan (2010) attributes a significant role to similarities in institutional quality and ethnic fractionalization for grouping countries with similar long-run behaviour in terms of growth. McQuinn and Whelan (2006) finds, for a dataset of ninety-six countries over the period 1950-2000, that the conditional convergence speed is about seven per cent per year.

Meanwhile, there is evidence that, besides resources, technology, human capital, or institutions' quality, there is a substantial heterogeneity in terms of economic growth across geographical regions (Baddeley et al., 1998; Gardiner et al., 2004). Differences in productivity and growth across regions can be explained in a standard neoclassical growth model by the differences in the rate of (exogenous) technical progress and the regional differences in the growth of the capital-labour ratio. In contrast, in an endogenous growth model, such differences can depend on the geographical diffusion of technology and knowledge and on the regional mobility of labour. The 'New Economic Geography' regional forces related to economic integration (trade, factor flows) cause the emergence of spatial agglomeration, clustering processes and specialization of economic activity and to the formation of "a large variety of economic agglomeration (or concentration) in geographical space" (Fujita & Krugman, 2004).

Accounting for such arguments, in favour of some potential lift-up effects deriving from geographical proximity or structural similarities, we check if their inclusion in the explanatory framework leads to a different impact of shadow economy. With this purpose, we seek to take advantage of the geographical spread for the countries in our dataset and of the fact that the included OECD countries may provide a good case study for the conditional convergence, while the European Union's member states may allow testing the club convergence hypothesis. In addition, we check if shared past historical experiences (such as communist or colonial regimes) are relevant in explaining the role played by underground economic sectors. Therefore, we re-estimate the model for different sub-samples by involving the WALS framework. Table 5 reports the results.

According to these results, the shadow economy impact cannot be emphasized either by considering the conditional convergence hypothesis or the club convergence hypothesis. Nonetheless, when the group-specific differences among countries sharing a common communist or colonial past are considered, the respective impact seams to decline in amplitude. For post-colonial countries, the impact is reduced with almost 50 % in comparison with the countries benefiting from OECD or EU membership.

In addition, the coefficients associated with other variables (in particular with the use of the Internet or the institutional and political descriptors) substantially vary across different sub-samples both in terms of size and sign. Moreover, the relative importance in explaining economic development for young labour force participation rate declines across these subsamples, being almost half for ex-colonies and post-communist economies in comparison with the OECD and EU economies. Finally, we observe that various forms of economic convergence tend to overwrite the regional effects (at least to a certain extent). The regional dummies lose their significance and suffer sign changes from one sub-sample to another by considering such forms of convergence.

4.3. Dealing with the non-linear impact of the shadow economy

As relation (3) suggests, the impact exercised by the underground economy on official sectors might be, in fact, non-linear. Various sources of this non-linear impact can occur during the interactions between formal and informal economy. For that reason, we further test if this effect is present in our dataset.

First, we check for regression between the official level of development and the size of the shadow economy, if the variances of the

Table 5. Economic development and shadow economy: WALS estimates; various sub-samples

Variable	OECD membership (1)	EU membership (2)	Post-communist economies (3)	Decolonization in XX century (4)
Size of the shadow economy (% GDP) -	0.023	0.025	0.019	0.013
Medina and Schneider(2019)	(0.007)	(0.008)	(0.008)	(0.006)
Gross fixed capital formation (% of GDP)	0.025	0.048	0.040	0.017
	(0.011)	(0.012)	(0.019)	(0.008)
General government final consumption	0.012	0.041	0.041	0.011
expenditure (% of GDP)	(0.009)	(0.016)	(0.018)	(0.010)
Inflation, GDP deflator (annual %)	-0.005	-0.001	-0.001	0.000
	(0.016)	(0.003)	(0.000)	(0.001)
Total natural resources rents (% of GDP)	-0.019	-0.101	0.011	0.001
	(0.020)	(0.080)	(0.008)	(0.007)
Urban population (% of total population)	0.004	0.004	0.000	0.010
	(0.003)	(0.003)	(0.008)	(0.004)
International migrant stock (% of population)	0.007	0.008	0.010	0.001
	(0.005)	(0.007)	(0.006)	(0.008)
Labor force participation rate for ages 15-24,	0.009	0.014	0.006	0.005
total (%) (modeled ILO estimate)	(0.003)	(0.005)	(0.009)	(0.003)
Business extent of disclosure index (0=less	0.018	0.017	0.037	0.018
disclosure to 10=more disclosure)	(0.013)	(0.014)	(0.021)	(0.028)
Crop production index (2014-2016 = 100)	0.006	0.004	0.007	0.007
	(0.003)	(0.003)	(0.004)	(0.003)
Trade (% of GDP)	0.004	0.007	0.015	0.010
	(0.007)	(0.007)	(0.009)	(0.005)
Individuals using the Internet (% of	0.003	-0.015	-0.010	0.013
population)	(0.006)	(0.009)	(0.011)	(0.009)
CO2 emissions (kg per PPP $ of GDP)	0.047	-0.161	-0.363	0.307
	(0.199)	(0.204)	(0.228)	(0.371)
Global State of Democracy-Checks on	-0.231	0.087	-1.068	0.501
government	(0.603)	(0.681)	(1.027)	(0.717)
Global State of Democracy-Freedom of	0.173	0.214	-0.229	-0.149
expression	(0.856)	(1.004)	(1.169)	(1.178)
Global State of Democracy-Freedom of	0.871	0.722	-0.004	0.438
movement and residence	(0.390)	(0.432)	(0.433)	(0.324)
Global State of Democracy-Freedom of	0.733	-0.426	2.539	0.940
academic and cultural expression	(0.674)	(0.634)	(1.560)	(0.842)
Global State of Democracy-Civil society	0.322	0.960	0.860	-0.175
participation	(0.475)	(0.519)	(0.809)	(0.742)
Dummy for Africa	0.305		-0.740	0.179
	(0.270)		(0.547)	(0.194)
Dummy for Asia	0.021		-0.295	0.513
	(0.135)		(0.216)	(0.214)
Dummy for South America	0.112			
	(0.187)			
Number of cross-section observations	35	25	26	53
k1	1	1	1	1
k2	2	17	19	19
q	1	1	1	1
c	0.693	0.693	0.693	0.693
σ	0.139	0.099	0.144	0.320
k	74.235	80.086	79.289	22.374

Standard errors are in () parentheses.

Notes: A neutral Laplace prior is used. $k = \sqrt{\frac{\lambda_{\max}\left(X_2^{T} M_1 X_2\right)}{\lambda_{\min}\left(X_2^{T} M_1 X_2\right)}} \geq 1$, with $\lambda_{\max}, \lambda_{\min}$ being the maximum and minimum eigenvalues of $X_2^{T} M_1 X_2$, is a measure of' inaccuracy': larger is *k*, the more ill-conditioned is the matrix $X_2^{T} M_1 X_2$ (the inverse and eigenvalue routines used in the orthogonal transformations of the auxiliary regressors and their parameters can be prone to numerical errors) (see de Luca and Magnus, 2011). The values of this parameter show that there are no special convergence issues for the considered models.

error terms are not constant across observations, by employing a multiplicative heteroskedastic linear regression model. Table 6 reports the estimates from such a model.

The Wald test at the bottom of the output is a test for the parameters of the variance function. The statistic of 7.653 is significant, indicating that heteroskedasticity is present. In addition, the significant z statistic for the natural logarithm of the size of the shadow economy also indicates the presence of heteroskedasticity. The multiplicative factor of the variance associated with the size of shadow economy suggests that the variance of the effects implied for societies with small-size underground sectors is lower than that of high-size shadow economy ones.

These results lead us to the idea that there are grounds for testing potential non-linear effects of shadow economy on development. In order to simplify the analysis, we consider a reduced explanatory model retaining as development's determinant only the gross fixed capital formation, general government final consumption expenditure, urban population, and labour force participation rate for ages 15-24, business disclosure index, crop production index, trade and freedom of movement and residence. Figure 2 estimates a least squares quadratic fit of the size of shadow economy on log income per capita and it plots an augmented component-plus-residual plot.

As this figure suggests, non-linear effects may occur for 'extreme' low/high sizes of shadow economy. Table 7 formally tests for the presence of such effects in the framework of WALS methodology. Several findings can be emphasized here.

First, for the full sample, both levels and squared levels are statistically significant. A 'reverse U-shaped' impact can be evidenced: the effect of shadow economy is positive up below a specific threshold. Above that, the adverse effects prevail. Nevertheless, the amplitude of negative effects is significantly lower.

Table 6. A multiplicative heteroskedastic linear regression model for GDP per capita and size of the shadow economy

Size of the shadow economy (%GDP) - Medina and Schneider(2019)	-0.031***
	(0.003)
Constant	4.930***
	(0.071)
$ln\left(\sigma^2\right)$	
Natural logarithm of size of the shadow economy (%GDP) - Medina and Schneider(2019)	1.257**
	(0.457)
Constant	-6.229***
	(1.587)
Number of cross-section observations	124
Wald test of $ln\left(\sigma^2\right)=0$	7.653
Probability of Wald test	0.006

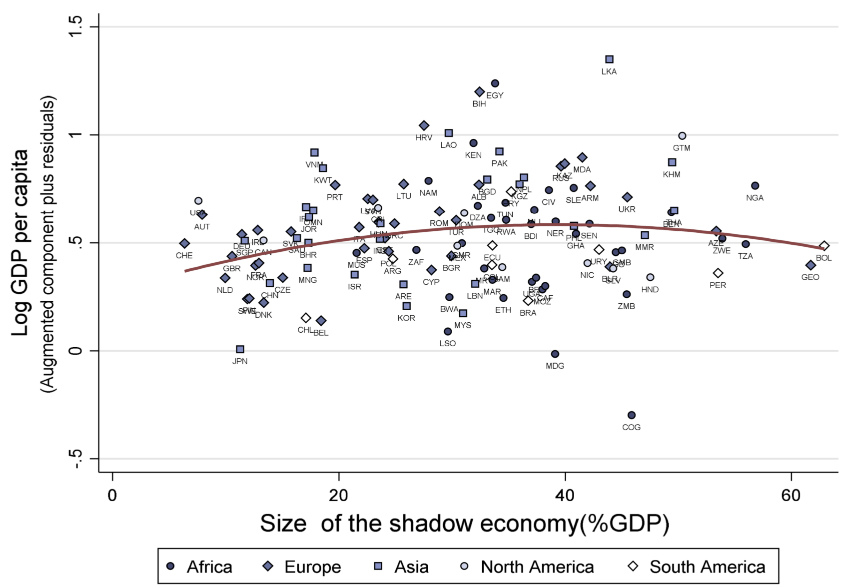
Robust standard errors in parentheses
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$
Notes: The model for each observation i is written as: $y_i = \beta_1 * s_i + \varepsilon_i$ (where y_i stands for (Log) GDP per capita for economy "i" and S_i is the size of the shadow economy) and the variance function is written as: $\sigma_i^2 = \sigma^2 * s^{\gamma}_i$ (where γ is an unknown parameter of the variance function). To ensure that we will get positive values for the variance σ_i^2 for all possible values of the unknown parameter γ, this function is re-written that σ_i^2 is an exponential function of a linear combination of $ln(s)$ and a constant term: $\sigma_i^2 = e^{\{\alpha_0 + \alpha_1 ln(s_i)\}}, \alpha_0 = ln\left(\sigma^2\right); \alpha_1 = \gamma$. The Wald test for heteroskedasticity is reported as the bottom of the table. This test suggests the presence of heteroskedasticity.

Second, when different sub-samples are considered, there appear to be considerable differences among these. There is a significant decline in the statistical significance of the shadow economy for OECD countries, as an explanatory variable, both in terms of levels and squared levels. The same outcome occurs for EU member states. In addition, for the OECD sub-sample, non-linear effects cannot be identified at all. Meanwhile, for developing post-communist and post-colonial countries, the non-linear impact of the informal sector is present (with a similar prevalence of positive effects as for the total sample). In addition, the estimated amplitude of this effect is in both sub-samples approximately twice the full sample.

Third, for the other explanatory variables, although their type of estimated impact is preserved, the results are somehow less robust compared with the full model (and, especially for variables like urban population, business disclosure or trade).

Fourth, the Global State of Democracy - freedom of movement and residence variable is highly significant in this reduced model. Higher social and labour market mobility clearly influences in a positive manner the development processes regardless of the sub-sample considered.

Finally, the reduced model performs better in terms of convergence with lower associated ‘measures of inaccuracy’. For the full sample, estimated parameters are usually close to those provided by OLS regression.



Notes: This figure estimates a least squares quadratic fit of the size of shadow economy on log income per capita. It is also an augmented component-plus-residual plot with the vertical axis representing the fitted values (as predicted by the size of shadow economy and its square) of log income per capita plus the residuals from the full regression model, while horizontal axis represents the size of shadow economy. The estimation is done conditional on the gross fixed capital formation, general government final consumption expenditure, urban population, labor force participation rate for ages 15-24, business disclosure index, crop production index, trade and freedom of movement and residence. The effect of size of shadow economy displays some potential non-linearities.

Figure 2. Size of shadow economy and development: possible non-linear effects

Table 7. Non-linear effects of the shadow economy on economic development

	OLS estimates	WALS estimates				
	Full sample	Full sample	OECD membership	EU membership	Post-communist economies	Decolonization in XX century
WALS	(1)	(2)	(3)	(4)	(5)	(6)
Size of the shadow economy (%GDP)-Medina and Schneider (2019)	0.033*** (0.007)	0.034 (0.007)	0.009 (0.022)	0.064 (0.038)	0.059 (0.014)	0.069 (0.014)
Size of the shadow economy (% GDP) squared	-0.000*** (0.000)	-0.000 (0.000)	0.000 (0.001)	-0.001 (0.001)	-0.001 (0.000)	-0.001 (0.000)
Gross fixed capital formation (% of GDP)	0.028*** (0.004)	0.027 (0.004)	0.029 (0.007)	0.027 (0.011)	0.017 (0.009)	0.022 (0.006)
General government final consumption expenditure (% of GDP)	0.013* (0.005)	0.017 (0.005)	0.022 (0.007)	0.028 (0.013)	0.016 (0.011)	0.005 (0.007)
Urban population (% of total population)	0.016*** (0.001)	0.014 (0.002)	0.007 (0.002)	0.004 (0.003)	0.012 (0.003)	0.013 (0.003)
Labor force participation rate for ages 15-24, total (%) (modeled ILO estimate)	0.005** (0.002)	0.006 (0.002)	0.011 (0.002)	0.011 (0.003)	0.012 (0.005)	0.002 (0.003)
Business extent of disclosure index (0=less disclosure to 10=more disclosure)	0.022* (0.011)	0.031 (0.011)	0.016 (0.010)	0.019 (0.013)	0.002 (0.014)	0.057 (0.022)
Crop production index (2014-2016 = 100)	0.010*** (0.001)	0.010 (0.001)	0.010 (0.002)	0.008 (0.002)	0.011 (0.002)	0.009 (0.002)
Trade (% of GDP)	0.011*** (0.003)	0.010 (0.003)	0.003 (0.006)	0.004 (0.009)	0.004 (0.003)	0.013 (0.004)
Global State of Democracy-Freedom of movement and residence	0.692*** (0.130)	0.731 (0.130)	1.250 (0.223)	0.922 (0.275)	0.510 (0.162)	0.386 (0.195)
Number of cross-section observations	124	124	35	25	26	53
k1		2	2	2	2	2
k2		8	8	8	8	8
q		0.888	0.888	0.888	0.888	0.888
c		0.693	0.693	0.693	0.693	0.693
σ		0.266	0.140	0.144	0.163	0.299
k		4.376	4.757	4.371	6.356	2.952

Standard errors in (); * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: A neutral Subbotin prior is used.

4.4. Labor market as transmission channel

Our results provide some empirical evidence supporting the idea that shadow economy has both positive and negative effects on economic development. Nevertheless, this does not fully clarify how such effects are incorporated in the evolutionary path followed by official economy. Which are the involved transmission channels?

Our formal model suggests that a key variable is represented by the level of employment. We argue that this is particularly the case of the ‘vulnerable employment’ (contributing family workers and own-account workers). These individuals are less likely to have formal work arrangements, decent working conditions and an effective representation by trade unions. Consequently, it is plausible to presume that this category is more susceptible to look for working opportunities in informal sectors. Moreover, there are compelling evidence to support this assumption (OECD/ILO, 2019). Hence, we consider a mediation model like the one depicted by Figure 3.

In this model, there is a direct effect, which arises from the interactions between formal economy and underground activities. Additionally, an indirect effect is exercised, via the vulnerable employment. Thus, the total impact of the shadow economy on development is obtained by combining these two types of effects.

Table 8 provides a quantitative assessment of direct and indirect effects.

The estimates are obtained in the framework of a Structural Equation Modelling (SEM) with only observed continuous variables and linear regressions. Based on these estimates, several conclusions can be drawn here.

First, the vulnerable employment is largely driven by the size of the shadow economy. The corresponding impact is positive and statistically significant at 1% for the entire sample as well as for the different sub-samples. Second, the vulnerable employment itself is detrimental to economic development (with a negative and significant at 5% for the full sample, but not so significant in the case of individual sub-samples). Accordingly, the indirect impact exercised on development by the size of the shadow economy via vulnerable employment is a negative. Nevertheless, the absolute amplitude of vulnerable employment is estimated to be much smaller than the positive direct impact of shadow economy. Third, when total effects (direct plus indirect ones) are computed, the positive influence of the size of shadow economy is maintains for the full dataset and its different component sub-samples. Overall, these estimates show that a larger shadow economy contributes to an increase in the labour market tensions and to weaken the position of informal employees.

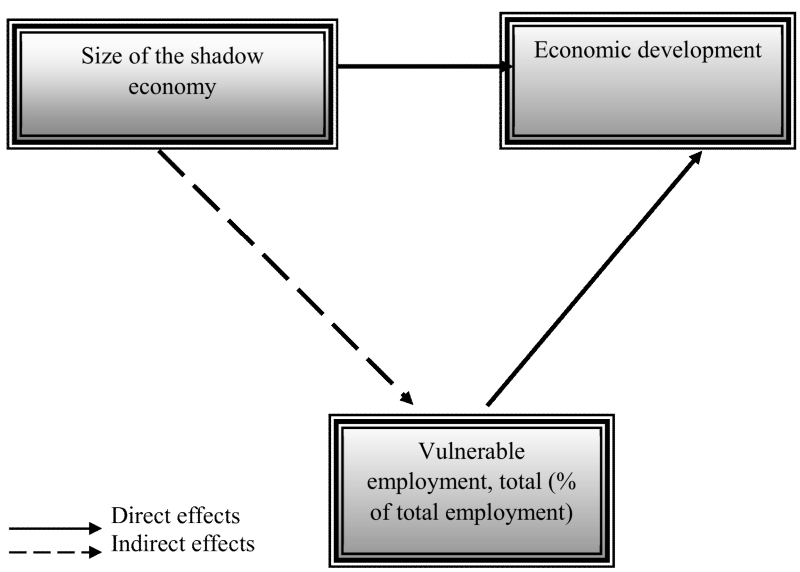


Figure 3. A mediation model for shadow economy and economic development transmission channels (via vulnerable employment)

Table 8. Labor market as a transmission channel for the effects exercised by the shadow economy on economic development

Type of effects	**Full sample**	**OECD membership**	**EU membership**	**Post-communist economies**	**Decolonization in XX century**
I. Direct effects	(1)	(2)	(3)	(4)	(5)
Structural equation for: Vulnerable employment, total (% of total employment) (modeled ILO estimate)					
Size of the shadow economy (%GDP)- Medina and Schneider (2019)	1.332^{***} (0.061)	0.816^{***} (0.057)	0.687^{***} (0.058)	0.866^{***} (0.126)	1.723^{***} (0.083)
Structural equation for: (Log)GDP per capita, PPP (constant 2017 international \$)					
Vulnerable employment, total (% of total employment) (modeled ILO estimate)	-0.019^{*} (0.007)	-0.030 (0.047)	0.020 (0.051)	0.012 (0.014)	-0.011 (0.007)
Size of the shadow economy (%GDP) - Medina and Schneider (2019)	0.132^{***} (0.011)	0.234^{***} (0.042)	0.191^{***} (0.038)	0.101^{***} (0.015)	0.113^{***} (0.013)
II. Indirect effects					
Size of the shadow economy (%GDP) on (Log)GDP per capita,	-0.025** (0.010)	-0.024 (0.039)	0.014 (0.035)	0.011 (0.012)	-0.011 (0.013)
III. Total effects (direct + indirect effects)					
Structural equation for: Vulnerable employment, total (% of total employment) (modeled ILO estimate)					
Size of the shadow economy (%GDP)- Medina and Schneider (2019)	1.332^{***} (0.061)	0.816^{***} (0.057)	0.687^{***} (0.058)	0.866^{***} (0.126)	1.723^{***} (0.083)
Structural equation for: (Log)GDP per capita, PPP (constant 2017 international \$)					
Vulnerable employment, total (% of total employment) (modeled ILO estimate)	-0.019^{**} (0.007)	-0.030 (0.047)	0.020 (0.051)	0.012 (0.014)	-0.011 (0.007)
Size of the shadow economy (%GDP)- Medina and Schneider (2019)	0.107^{***} (0.005)	0.210*** (0.016)	0.205*** (0.015)	0.111*** (0.009)	0.093*** (0.005)
Cross-section observations	124	35	25	26	53
Log likelihood	-1307.3871	-305.816	-208.929	-267.124	-517.767

Standard errors are in () parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: The mediation model depicted by Figure 1 is estimated in the framework of a *Structural Equation Modeling* (SEM) with only observed continuous variables and linear regressions. A maximum likelihood estimation method is used with Observed Information Matrix (OIM) as optimization technique. All the eigenvalues lie inside the unit circle and SEM satisfies stability condition.

5. DISCUSSION

Our results show that empirical evidence supports the positive and negative impact of the shadow economy on economic development. However, how likely are these results? Several aspects can be outlined here.

First, it appears that the influence of

shadow economy largely depends on the overall development stage of the economy. In addition, such influence reflects the path dependence, which is specific for development processes. For countries sharing a communist or colonial past, the shadow economy is less able to affect development positively and its detrimental effects are more significant than the positive ones.

We find that such dependence on the effects exercised by the shadow economy on the development stage and historical conditions is also proven by other findings in the literature (Goel et al., 2019).

As we argue in this study, such outcome might be explained, among others, by official economy's relative capacity to absorb and use efficiently the labour force and other types of resources. When this capacity is high, then the shadow economy exercises mainly a detrimental impact on development. Opposite, when the official economy is inefficient, it does not provide enough opportunities for 'full employment' and there is no effective conversion of available public revenues into market-supporting public goods, then the shadow economy may act as a substitute for the official economy. In such a case, it attracts non-utilized resources, improves competition and efficiency in official sectors, and stimulates the entrepreneurial initiative.

Second, our results show a certain non-linearity and a 'reverse U-shaped' relationship between the shadow economy and economic development. Nevertheless, the empirical threshold changes from one sub-sample to another: the development stage matters in explaining the absolute impact of the shadow economy and the balance of positive and negative effects exercised by it on development.

Third, we place our analysis in the framework of an endogenous growth model. In such a model, the explanatory power of shadow economy is modulated by the relative importance of other development determinants. The most relevant determinants are the standard variables (capital formation, available labour force or government consumption expenditures). Moreover, the results emphasize other determinants of development (e.g. transparency of business activity, the technology of information, the environmental impact or the status of democratic institutions). However, our analysis does not explicitly account for the possible interactions between the shadow economy and other variables. For instance, it can be argued that more vital public institutions and a sound democratic frame can inhibit the shadow economy development. Potential influences may arise from the spread of information technology (which alleviates the asymmetry of information between the agents from formal and informal sectors) or from the environmental issues related to the activities in the underground economy. Therefore, a future research direction should address the interactions amongst the implied explanatory variables.

Fourth, we consider the vulnerable employment as a transmission channel for the impact exercised by the shadow economy. The existence of such a channel is conceptually consistent and it is supported by empirical evidence. Nevertheless, it may not be the only possible transmission channel; others are equally good candidates. For instance, individuals engaged in informal activities may have a different attitude toward risk than those from official sectors. They may innovate, create, and diffuse knowledge and information at the global society level, which is beneficial to development processes. Furthermore, the shadow economy may provide informal ‘safety networks’ for official-sector companies and, thus, attenuate their operational risks.

Another possible transmission channel is linked to the values, norms and ‘unwritten rules of the game’ shared by society members. Particularly relevant are those directly linked to a more permissive attitude toward informal or illegal activity, i.e. the degree to which community members think they should ‘take care of themselves' beyond the political authorities and political power. For instance, Lindbeck et al. (1999) argues that the intensity of the norm, as felt by the individual, diminishes with the population share of welfare recipients. Such a situation may lead to multiple equilibriums and extended dynamics of social and economic activities.

In short, a more detailed analysis is required to completely elucidate the channels through which the effects of shadow economy are translated into development.

Fifth, as we have already mentioned, the MIMIC approach to the estimation of shadow economy size is not free from criticism. So, the analysis should complement the estimates provided by other methods in order to offer a better picture of results’ robustness.

Sixth, our explanatory framework hinges heavily on the role played by tax burden. Still, precise details related to the content of fiscal policy should be provided. A key issue is the existence or absence of the so-call ‘automatic stabilisers’ (those elements of fiscal policy that might reduce tax burden and increase public spending without discretionary government actions). In particular, automatic stabilizers provide income replacement as soon as unemployment starts to rise (Dolls et al., 2012). These stabilizers provide income insurance, and, thus, they can reduce the need for households’ engagement in the underground economy.

Seventh, we do not address the issue of shadow economy structure. Intuitively, it can be argued that its different sectors exercise a different impact on economic development. Underground and informal production of goods and services may have very different consequences than illegal goods' production. Consequently, another possible future research direction could account for the structural features of the shadow economy and focus on the effects associated with its various components.

6. CONCLUSIONS

We find that shadow economy can exercise positive and negative effects on economic development, measured in official GDP per capita. We also show that such effects largely depend on the current development stage and the historical evolution of an economy. Vulnerable employment may act as a transmission channel, while the tax burden is a driver of both the size of shadow economy and economic development. The size of shadow economy can be placed in the framework of an endogenous growth explanatory model as both a driver and an inhibitor.

In terms of public policies, perhaps the essential message of such findings is that in order to reduce the detrimental consequences of ‘shadow’ activities, the public authorities should not only reduce the marginal tax rate and apply more transparent and straightforward fiscal rules but also improve market-supporting institutions and the rule of law.

This study has several limitations. Further research directions should include an assessment of results' robustness in respect to various estimation techniques for the size of the shadow economy and a deeper analysis of the variables via which its impact is translated into development. Nevertheless, it provides theoretical arguments and empirical evidence that the 'net' effect exercised by the shadow economy on the official sectors is an open question.

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АНАЛИЗА УТИЦАЈА СИВЕ ЕКОНОМИЈЕ НА ЕКОНОМСКИ РАЗВОЈ

Bogdan Dima, Ştefana Maria Dima, Ciprian Preda

Извод

Сива економија је кровни концепт који покрива различите аспекте неформалних економских сектора. Општеприхваћено је да повећана величина сиве економије омета економски раст. Међутим, ми усвајамо нијансиранији концептуални оквир, узимајући у обзир мешовите ефекте које сива економија има на економски развој и пуну запосленост радних ресурса. Стога процењујемо величину сиве економије користећи модел вишеструких индикатора и вишеструких узрока. Да бисмо се носили са неизвесношћу која произилази из великог скупа потенцијалних детерминанти економског развоја, користимо резултујућу замену сиве економије у Бајесовом моделу усредњавања/пондерисаног просека најмањих квадрата. Алтернативни приступи подацима се разматрају за проверу робусности. Утврдили смо да за скуп података од 124 постиндустријске и економије у развоју које покривају период између 1991. и 2017. године, сива економија може и позитивно и негативно утицати на економски развој. Наши резултати показују да је „нето“ ефекат који сива економија има на званичне секторе отворено питање. Главна импликација је да свака политика која има за циљ смањење обима сиве економије треба да буде праћена побољшањем формалних сектора економије како би се апсорбовала незапосленост.

Кључне речи: сива економија, економски развој, пореско оптерећење, Бајесов модел усредњавања (*BMA*), метод пондерисаног просека најмањих квадрата (*WALS*).

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