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Shadow Economies around the World: New Results for 158 Countries over 1991-2015

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Shadow Economies around the World: New Results for 158 Countries over 1991-2015

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Abstract

Using the MIMIC method, this paper is a first attempt to estimate the size of the shadow economy of 158 countries over the period 1991 up to 2015. In addition to performing a variety of robustness tests, this paper explicitly addresses endogeneity concerns to the use of GDP as cause and indicator, by using the light intensity approach as an indicator variable as proxy for the size of the economy. Results suggest that the average size of the shadow economy of these 158 countries over 1991-2015 is 32.5% of official GDP, which was 34.82% in 1991 and decreased to 30.66% in 2015.

JEL-Codes: C390, C510, C820, H110, H260, U170.

Keywords: shadow economies of 158 countries, MIMIC estimations, the light intensity approach, tax burden, regulation, trade openness, corruption.

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Revised version

The views expressed in this paper are those of the authors and do not necessarily represent those of the IMF or IMF policy.

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1 Introduction

Up to now the shadow economy is by nature difficult to measure. Agents engaged in shadow economy activities try to stay undetected. The request for information of the extend of the shadow economy and its development over time is motivated by its political relevance. Moreover, the total economic activity, including official and unofficial production of goods and services is important in the design of economic policies that respond to fluctuations and economic development over time and across space. Furthermore, the size of the shadow economy is a core input to estimate the extend of tax evasion and thus for decisions on its adequate control.

Empirical research into the size and development of the global shadow economy has grown rapidly (Feld and Schneider 2010, Gerxhani 2003, Schneider 2011, 2015, Schneider and Williams 2013, Williams and Schneider 2016, and Hassan and Schneider 2016). The goal of this paper is threefold:

- (1) To present the latest shadow economy estimates for 158 countries all over the world over the period 1991 up to 2015 and to discuss the different developments.
- (2) address endogeneity concerns to the use of GDP by using the light intensity approach instead of the GDP as an indicator variable as proxy for the size of the economy.
- (3) Run a variety of robustness tests to further assess the validity of our results.

To our knowledge this is one of the first attempts to include the light intensity approach at indicator variable.

Generally, the shadow economy is known by different names, such as the hidden economy, grey economy, black economy or lack economy, cash economy or informal economy. All these synonyms refer to some type of shadow economy activities. We use the following definition: The shadow economy includes all economic activities which are hidden from official authorities for various reasons. This varies from being monetary, to regulatory, to 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 quality of political institutions and weak rule of law. Given the purpose of our study, the shadow economy reflects mostly the

legal economic and productive activities, that, if recorded, would contribute to national GDP, therefore the definition of the shadow economy in our study tries to avoid illegal or criminal activities, do-it-yourself, or other household activities.¹

Our paper is organized as follows: In section 2 some theoretical considerations are drawn and discussing the most important cause variables and deriving the theoretically expected sign on the shadow economy. Then the use of indicator variables follows. Section 3 shortly discusses the methods to estimate the shadow economy with the MIMIC approach, and discusses the econometric results of the MIMIC estimations. Section 4 addresses shortcomings, introduces the use of night lights as proxy for the size of the economy and discusses additional robustness tests. Section 5 presents the results of the size of the shadow economy of the 158 countries. Section 6 summarizes and concludes.

2 Theoretical considerations

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

¹ Of course, we are aware that there are overlapping areas, like prostitution, illegal construction firms, compare e.g. Williams and Schneider (2016).

$$SE = SE \left[p \left(\overset{+}{A}, \overset{-}{F} \right); f; B \left(\overset{+}{T}, \overset{+}{W} \right) \right]$$

Hence, shadow economic activities may be defined as those economic activities and income earned that circumvent government regulation, taxation or observation. More narrowly, the shadow economy includes monetary and non-monetary transactions of a legal nature; hence all productive economic activities that would generally be taxable were they reported to the state (tax) authorities. Such activities are deliberately concealed from public authorities to avoid payment of income, value added or other taxes and social security contributions, or to avoid compliance with certain legal labor market standards such as minimum wages, maximum working hours, or safety standards and administrative procedures. The shadow economy thus focuses on productive economic activities that would normally be included in the national accounts, but which remain underground due to tax or regulatory burdens.² Although such legal activities would contribute to a country's value added, they are not captured in national accounts because they are produced in illicit ways. Informal household economic activities such as do-it-yourself activities and neighborly help are typically excluded from the analysis of the shadow economy.³ What are the most important determinants influencing the shadow economy?

2.1 Causes and Signs of Informality

The size of the informal economy depends on various elements. The literature highlights specific causes and indicators of the informal economy. Main causes:

- (i) *Tax burden and the size of government:* It is widely accepted by the literature that one of the most important causes leading to proliferation of informality is the tax burden, measured in this study by an index of fiscal freedom from the

² Although classical crime activities such as drug dealing are independent of increasing taxes and the causal variables included in the empirical models are only imperfectly linked (or causal) to classical crime activities, the footprints used to indicate shadow economic activities such as currency in circulation also apply for classic crime. Hence, macroeconomic shadow economy estimates do not typically distinguish legal from illegal underground activities; but instead represent the whole informal economy spectrum.

³ From a social perspective, maybe even from an economic one, soft forms of illicit employment such as moonlighting (e.g. construction work in private homes) and its contribution to aggregate value added may be assessed positively. For a discussion of these issues, see Thomas (1992) and Buehn, Karmann and Schneider (2009).

Heritage Foundation, which includes the top individual and corporate income tax, as well as the tax burden share of GDP. Additionally, this study also includes the Government consumption as a share of GDP, as one could expect that bigger government and a larger tax burden should encourage more economic activity to shift to the informal sector.

- (ii) *Institutional quality*: The World Bank produces a number of governance indicators, specifically: (a) the rule of law, (b) the control of corruption, and (c) government stability. In countries where the rule of law is respected and there is little corruption, businesses will understand the cost of operating in the formal economy, while lack of respect for the law or high corruption would encourage informal economic activity.
- (iii) *Trade Openness*: Trade as a share of GDP indicate market size and a country's openness to the world. As economies grow, it is likely to be more difficult to move economic activity from the formal to the informal sector. Furthermore, as international trade increases, it would be harder to hide trade from the authorities.

The size of the informal economy, commonly affects these indicators:

- (iv) *Monetary indicators*: People engaged in the informal economy usually conduct their activities in cash. Most shadow economy activities are, hence, reflected in additional use of cash. This indicator is captured in M0/M1, where the usual definition of M0 corresponds to the currency outside the banks and of M1 corresponds to M0 plus deposits.
- (v) *Labor force participation rate*: As more economic activity and workers shift to the informal economy, these workers would no longer show up as part of the labor force in national surveys.

- (vi) *Economic growth*: This study uses growth of GDP per capita. A larger informal economy would be associated with more economic activity moving out of the formal economy and would show as a decrease in economic growth.⁴

3 Estimation methods and MIMIC estimation results

3.1 Measuring the Informal Economy⁵

This subsection describes the main methodologies used to measure the informal economy, highlighting their advantages and drawbacks.⁶ These approaches can be divided into direct or indirect (including the model-based ones):

3.1.1 Direct approaches

The most common direct approaches to measuring the size of the informal economy rely on surveys and samples based on voluntary replies, or tax auditing and other compliance methods. While providing great detail about the structure of the informal economy, the results are sensitive to the way the questionnaire is formulated and respondents' willingness to cooperate. Consequently, surveys are unlikely to capture all informal activities.⁷

3.1.2 Indirect approaches

Indirect approaches, alternatively called "indicator" approaches, are mostly macroeconomic in nature. These are in part based on: the discrepancy between national expenditure and income statistics; the discrepancy between the official and actual labor force; the "electricity consumption" approach of Kauffman and Kaliberda (1996); the "monetary transaction" approach of Feige (1979); and the "currency demand" approach of Cagan (1958) among others; and the "Multiple Indicators, Multiple Causes" (MIMIC). Specifically:

⁴ Additionally, and to address criticism to the use of official GDP, in section 4 this study relies on data on light intensity from outer space as a proxy for the "true" economic growth achieved by countries. This approach has been also successfully used by Medina, Jonelis, and Cangul (2017) in the context of Sub-Saharan African countries.

⁵ As there is available a huge literature about the various methods available to measure a shadow economy, a detailed overview about it as well as the problems using these methods (including the MIMIC method) are not discussed here. See e.g. Schneider and Enste (2002), Feld and Schneider (2010), Schneider, Buehn and Montenegro (2010), Schneider (2010, 2015), Schneider and Williams (2013), Williams and Schneider (2016).

⁶ Based on Schneider and Este (2002), Feld and Schneider (2010), Williams and Schneider (2016).

⁷ See Isanchen and Strom (1985), Witte (1987), Mogensen et al. (1995), and Feige (1996).

- ***Discrepancy between national expenditure and income statistics:*** If those working in the informal economy were able to hide their incomes for tax purposes but not their expenditure, then the difference between national income and national expenditure estimates could be used to approximate the size of the informal economy. This approach assumes that all the components of the expenditure side are measured without error and constructed so that they are statistically independent from income factors.⁸
- ***Discrepancy between official and actual labor force:*** If the total labor force participation is assumed to be constant, a decline in official labor force participation can be interpreted as an increase in the importance of the informal economy. Since fluctuation in the participation rate might have many other explanations, such as the position in the business cycle, difficulty in finding a job and education and retirement decisions, but these estimates represent weak indicators of the size of the informal economy.⁹
- ***Electricity approach:*** Kaufmann and Kaliberda (1996) endorse the idea that electricity consumption is the single best physical indicator of overall (official and unofficial) economic activity. Using findings that indicate the electricity-overall GDP elasticity is close to one, these authors suggest using the difference between growth of electricity consumption and growth of official GDP as a proxy for the growth of the informal economy. This method is simple and appealing, but has many drawbacks, including: (i) not all informal economy activities require a considerable amount of electricity (e.g. personal services) or the use of other energy sources (like coal, gas, etc.), hence only part of the informal economy growth is captured; and (ii) the electricity-overall GDP elasticity might significantly vary across countries and over time.¹⁰

⁸ See for example MacAfee (1980), and Yoo and Hyun (1998).

⁹ See for example Contini (1981), Del Boca (1981), and O'Neil (1983).

¹⁰ See for example Del Boca and Forte (1982), Portes (1996) and Johnson et al. (1997).

- Transaction approach:** Using Fischer's quantity equation, $Money * Velocity = Prices * Transactions$, and assuming that there is a constant relationship between the money flows related to transactions and the total (official and unofficial) value added, i.e. $Prices * Transactions = k (official\ GDP + informal\ economy)$, it is reasonable to derive the following equation $Money * Velocity = k (official\ GDP + informal\ economy)$. The stock of money and official GDP estimates are known, and money velocity can be estimated. Thus, if the size of the informal economy as a ratio of the official economy is known for a benchmark year, then the informal economy can be calculated for the rest of the sample. Although theoretically attractive, this method has several weaknesses, for instance: (i) the assumption of k constant over time seems quite arbitrary; and (ii) other factors like the development of checks and credit cards could also affect the desired amount of cash holdings and thus velocity.¹¹
- Currency demand approach:** Assuming that informal transactions take the form of cash payments, in order not to leave an observable trace for the authorities, an increase in the size of the informal economy will, consequently, increase the demand for currency. To isolate this "excess" demand for currency, Tanzi (1980) suggests using a time series approach in which currency demand is a function of conventional factors, such as the evolution of income, payment practices and interest rates, and factors causing people to work in the informal economy, like the direct and indirect tax burden, government regulation and the complexity of the tax system. However, there are several problems associated with this method and its assumptions: (i) this procedure may underestimate the size of the informal economy, because not all transactions take place using cash as means of exchange; (ii) increases in currency demand deposits may occur because of a slowdown in demand deposits rather than an increase in currency used in informal activities; (iii) it seems arbitrary to assume equal velocity of money in both types of

¹¹ See for example Feige (1979), Boeschoten and Fase (1984) and Langfeldt (1984).

economies; and (iv) the assumption of no informal economy in a base year is arguable.¹²

- ***Multiple Indicators, Multiple Causes (MIMIC) approach:*** This method explicitly considers several causes, as well as the multiple effects, of the informal economy. The methodology makes use of the associations between the observable causes and the effects of an unobserved variable, in this case the informal economy, to estimate the variable itself (Loayza, 1996).¹³ This methodology is described in detail in subchapter 3.2.

3.2 MIMIC approach

The MIMIC model is a special type of structural equation modelling (SEM) that is widely applied in psychometrics and social science research and is based on the statistical theory of unobserved variables developed in the 1970s by Zellner [4] and Joreskog et al. [5]. The MIMIC model is a theory-based approach to confirm the influence of a set of exogenous causal variables on the latent variable (shadow economy), and also the effect of the shadow economy on macroeconomic indicator variables [6]. At first, it is important to establish a theoretical model explaining the relationship between the exogenous variables and the latent variable. Therefore, the MIMIC model is considered to be a confirmatory rather than an explanatory method [7,8]. The hypothesized path of the relationships between the observed variables and the latent shadow economy based on our theoretical considerations is depicted in the following Figure 3.1. The pioneers to apply the MIMIC model to measure the size of the shadow economy in 17 OECD countries were Frey et al. [9]. Following them, various scholars like Tafenau et al. [10], Tedds [11], Schneider et al. [7], Dell'Anno [12], Hassan et al. [13], Buehn et al. [14], Farzanegan [6], and Chaudhuri et al. [15] applied the MIMIC model to measure the size of the shadow economy. Formally, the MIMIC model has two parts: the structural model and the measurement model. The

¹² See for example Cagan (1958), Gutmann (1977), Tanzi (1980, 1983), Schneider (1997) and Johnson et al. (1998).

¹³ See Schneider (2010, 2015) Feld and Schneider (2010), Abdi and Medina (2016), Vuletin (2008), and Williams and Schneider (2016).

structural model shows that the latent variable is linearly determined by a set of exogenous causal variables which can be illustrated as follows:

$$\eta = \gamma' \chi + \zeta \tag{1}$$

Where,

χ is a vector of causal variables, γ is a vector of scalars, η is the latent variable (shadow economy) and ζ is a structural disturbance term.

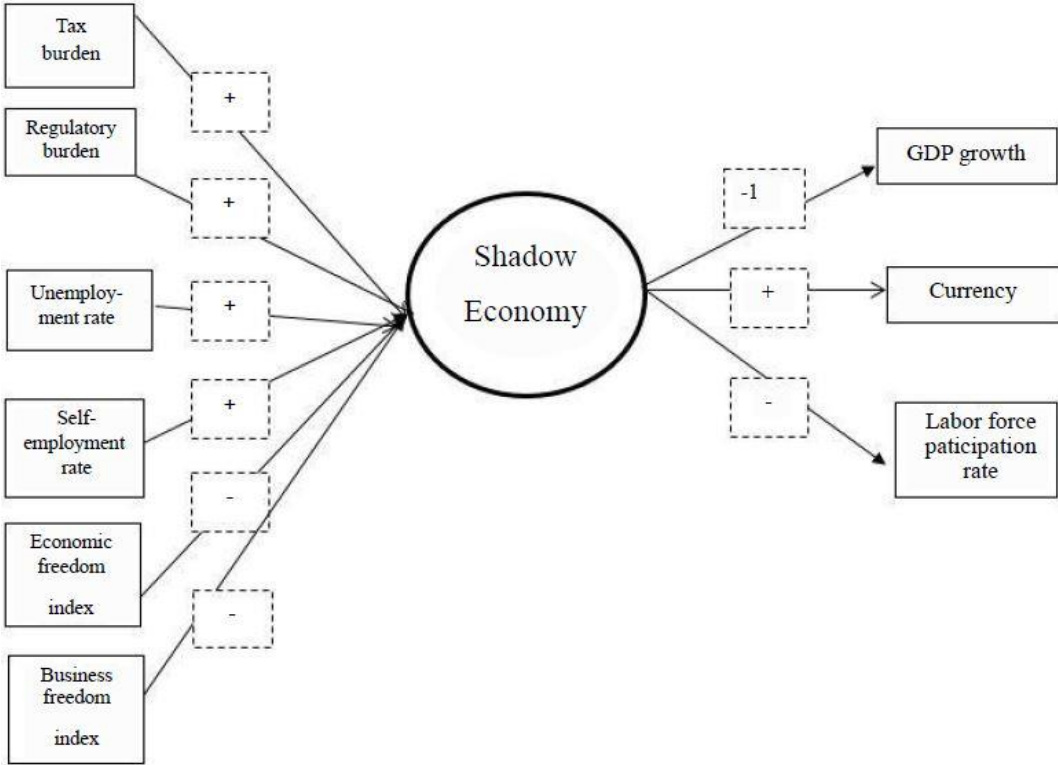
The measurement model which links the shadow economy with the set of selected indicators is specified by:

$$y = \lambda \eta + \varepsilon \tag{2}$$

Where, y is a vector of indicator variables, and λ is a vector of loading factors to represent the magnitude of the expected change for a unit change in the latent variable η . The ε is the measurement error term.

The MIMIC model simultaneously takes into account different causes and indicators that directly influence the development of the size of the shadow economy over time.

Figure 3.1: Hypothesized MIMIC path for estimating the shadow economy



3.3 MIMIC estimation results

In tables 3.1 to 3.3, which include six specifications per table, the MIMIC estimation results over the period 1991-2015 for 158 countries (maximum sample) are presented.¹⁴ Table 3.1 contains the estimation results for all countries. All cause variables (trade openness, unemployment, size of government, fiscal freedom, rule of law, control of corruption, government stability, have the theoretically expected signs, and most of them are highly statistically significant. Also the indicator variables have the theoretical expected signs and are highly statistically significant. The test statistics are satisfactory.

Table 3.1: MIMIC Model Estimation Results: 1991-2015, All Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.086***	-0.085***	-0.137***	-0.086***	-0.086***	-0.113***
GDP per capita	-0.332***	-0.335***	-0.37***	-0.298***	-0.302***	-0.334***
Unemployment Rate	0.051**	0.054***	0.069***	0.053**	0.057***	0.069***
Size of Government	0.102***	0.102***	0.111***			
Fiscal Freedom				-0.131***	-0.134***	-0.147***
Rule of Law	-0.049***			-0.06***		
Control of Corruption		-0.042***			-0.046**	
Government Stability			-0.054***			-0.015
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.521***	-0.532***	-0.31***	-0.452***	-0.468***	-0.249***
Growth of GDP per capita	-0.208**	-0.245***	-0.386***	-0.113	-0.144*	-0.157***
Statistical Tests						
RMSEA	0.073	0.073	0.067	0.078	0.078	0.055
Chi-square	513.407	506.43	649.062	508.189	500.667	535.332
Observations	1897	1892	2350	1758	1757	1998
Countries	151	151	122	144	144	120

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 3.2 contains the estimation results of 105 developing countries (maximum sample). Here the cause variable rule of law is not statistically significant in specification 1, as well as control of corruption in specification 2. These variables are significant and with the expected sign in the other specifications. The indicator variable labor force is again highly statistically significant.

¹⁴ The MIMIC regression includes 151 countries. This estimation generated the coefficients and standard deviations. Following this, during the calibration phase, eight countries were dropped as the time series were not long enough, Specifically, Afghanistan, Macao, Macedonia, Serbia, St. Lucia, St. Vincent and the Grenadines, Sudan, and Tonga. Moreover, for 15 additional countries availability on the drivers' information permitted the estimation of the informal economy, and therefore, were added to the sample. Specifically, Austria, Belgium, Ethiopia, Finland, France, Germany, Greece, Ireland, Italy, Mauritania, Netherlands, Niger, Rwanda, Togo, and United Kingdom. This completes the list of 158 countries with shadow economy estimates (Table 3, specification 1).

Table 3.2: MIMIC Model Estimation Results: 1991-2015, Developing Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.114***	-0.111***	-0.134***	-0.117***	-0.116***	-0.131***
GDP per capita	-0.282***	-0.287***	-0.337***	-0.244***	-0.245***	-0.291***
Unemployment Rate	0.062***	0.059***	0.074***	0.085***	0.085***	0.084***
Size of Government	0.111***	0.112***	0.107***			
Fiscal Freedom				-0.12***	-0.123***	-0.121***
Rule of Law	-0.026			-0.046**		
Control of Corruption		-0.029			-0.039*	
Government Stability			-0.059***			-0.015
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.499***	-0.511***	-0.464***	-0.421***	-0.441***	-0.446***
Growth of GDP per capita	-0.442***	-0.434***	-0.545***	-0.113	-0.462***	-0.433***
Statistical Tests						
RMSEA	0.084	0.087	0.068	0.087	0.086	0.062
Chi-square	309.936	306.792	471.032	302.157	297.42	387.446
Observations	1309	1304	1687	1206	1205	1406
Countries	105	105	84	98	98	82

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

Finally, results for 26 advanced countries are presented in table 3.3. Here trade openness is not in all specifications statistically significant, but in all other specifications most cause variables have the expected sign and are statistically significant, except government stability and size of government.¹⁵ The indicator variables are all statistically significant and have the expected signs.

Table 3.3: MIMIC Model Estimation Results: 1991-2015, Advanced Countries

	1	2	3	4	5	6
Causes						
Trade Openess	0.022	0.031	-0.16139***	0.013	0.025	-0.084
GDP per capita	-0.6***	-0.641***	-0.559***	-0.494***	-0.534***	-0.474***
Unemployment Rate	0.099**	0.089*	0.104**	0.056	0.043	0.049
Size of Government	-0.151***	-0.158***	-0.122**			
Fiscal Freedom				-0.138***	-0.166***	-0.168***
Rule of Law	-0.026			-0.084*		
Control of Corruption		-0.0972094**			-0.126***	
Government Stability			-0.0182766			-0.015
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.618***	-0.606***	-0.319***	-0.582***	-0.571***	-0.259***
Growth of GDP per capita	0.279*	0.252*	0.104	-0.113	0.114	0.189*
Statistical Tests						
RMSEA	0.103	0.102	0.117	0.079	0.081	0.083
Chi-square	159.688	164.678	197.819	144.259	152.109	147.31
Observations	274	274	416	265	265	359
Countries	26	26	25	25	25	22

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

¹⁵ This is intuitive, as in advanced countries one would expect already good institutions.

4 Addressing Potential Shortcomings

4.1 Night Lights Intensity Approach

Even though the standard MIMIC model a la Schneider (2010) has been widely used by the literature for many years, it has also been subject of criticism. Mainly on: (i) the use of GDP (GDP per capita and growth of GDP per capita) and cause and indicator variables, (ii) the fact that the methodology relies on another independent study to calibrate from standardized values to size of informal economy in percent of GDP, and (iii) the estimated coefficients are sensitive to alternative specifications, the country sample and time span chosen. Points (ii) and (iii) will not be discussed in our paper; they are extensively discussed in Schneider (2016).

We address the main criticism of (i) as follows:

Instead of using GDP per capita and growth of GDP per capita as cause and indicator variables, we use the night lights approach by Henderson, Storeygard, and Weil (2012) to independently capture economic activity. In their paper, they use data on light intensity from outer space as a proxy for the “true” economic growth achieved by countries. They also use the estimated elasticity of light intensity with respect to economic growth to produce new estimates of national output for countries deemed to have low statistical capacity. Therefore, by using the night lights approach we address MIMIC criticisms related to the endogeneity of GDP in a novel way, which is totally independent from problematic GDP measures traditionally used.

4.2 Estimation Results using the Night Lights Intensity Approach

In tables 4.1 to 4.3, which include five alternative specifications per table, the MIMIC estimation results over the period 1991-2015 different country samples depending on data availability. Table 4.1 contains the estimation results for all countries, and uses as one indicator variable, the light intensity. All cause variables (trade openness, unemployment, size of government, fiscal freedom, rule of law, control of corruption, government stability, have the theoretically expected signs, and most of them are highly statistically significant, except control of corruption. Also the indicator variables have the theoretical expected signs and are highly statistically significant. The test statistics are satisfactory.

Table 4.1. MIMIC Model Estimation Results (night lights instead of GDP): All Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.172***	-0.167***	-0.106***	-0.178***	-0.175***	-0.161***
Unemployment Rate	0.062**	0.061**	0.008	0.067**	0.068**	0.056**
Size of Government	0.106***	0.101***	0.036*			
Fiscal Freedom				-0.15***	-0.153***	-0.162***
Rule of Law	-0.065**			-0.068**		
Control of Corruption		-0.026			-0.035	
Government Stability			-0.183***			-0.132***
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.457***	-0.503***	-0.478***	-0.226*	-0.244*	-0.23**
Lights (GDP)	-0.346***	-0.372***	-1.838***	-0.275***	-0.289***	-0.661***
Statistical Tests						
RMSEA	0.023	0.027	0.079	0.052	0.053	0.082
Chi-square	125.015	116.891	548.593	158.781	151.93	307.091
Observations	1341	1336	1767	1211	1210	1498
Countries	148	148	120	139	139	116

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 4.2 contains the estimation results of 103 developing countries. Here the cause variable unemployment is not statistically significant as well as rule of law and control of corruption. The indicator variable labor force is again highly statistically significant.

Table 4.2. MIMIC Model Estimation Results (night lights instead of GDP): Developing Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.159***	-0.155***	-0.076***	-0.139***	-0.136***	-0.08***
Unemployment Rate	0.029	0.029	-0.007	0.047	0.047	0.006
Size of Government	0.094**	0.092**	0.026*			
Fiscal Freedom				-0.129***	-0.128***	-0.104***
Rule of Law	-0.021			-0.009		
Control of Corruption		-0.004			-0.009	
Government Stability			-0.192***			-0.164***
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.419**	-0.427**	-0.518***	-0.311*	-0.313*	-0.323**
Lights (GDP)	-0.636***	-0.657***	-2.389***	-0.694***	-0.704***	-1.426***
Statistical Tests						
RMSEA	0.01	0.014	0.072	0.04	0.04	0.073
Chi-square	89.64	87.74	527	113.669	110.397	290.032
Observations	957	952	1304	850	849	1088
Countries	103	103	83	96	96	80

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

Considering the 24 advanced countries the results are presented in table 4.3. Here trade openness is not in all specifications statistically significant, but in all other specifications most cause variables are statistically significant, except government stability. The indicator variables are all statistically significant and have the expected signs.

**Table 4.3. MIMIC Model Estimation Results (night lights instead of GDP):
Advanced Countries**

	1	2	3	4	5	6
Causes						
Trade Openness	0.132	0.204**	0.229***	0.075	0.108	0.174**
Unemployment Rate	-0.352***	-0.36***	-0.41***	-0.3***	-0.295***	-0.34***
Size of Government	-0.098	-0.158*	-0.165**			
Fiscal Freedom				-0.247***	-0.293***	-0.23***
Rule of Law	-0.24***			-0.186**		
Control of Corruption		-0.117*			-0.092	
Government Stability			-0.064			0.024
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.329*	-0.363*	-0.462***	-0.308*	-0.329**	-0.316**
Lights (GDP)	0.467**	0.366*	-0.0661817	0.553***	0.51***	0.381**
Statistical Tests						
RMSEA	0.068	0.067	0.122	0.052	0.056	0.086
Chi-square	76.456	64.922	136.547	89.16	82.642	113.695
Observations	189	189	302	189	189	263
Countries	24	24	24	24	24	24

Source: Own calculations.

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3 Additional Robustness Tests

This section further tests the robustness of the results by fully removing the effects of GDP, by dropping both GDP per capita as cause and growth of GDP per capita as indicator.

The results are presented in tables 4.4 to 4.6, which include six alternative specifications per table, the MIMIC estimation results over the period 1991-2015 for different country samples depending on data availability. These results are consistent with those in the previous sections.

Table 4.4: MIMIC Model Estimation Results (Excluding GDP and GDP per capita), All Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.138***	-0.133***	-0.237***	-0.133***	-0.133***	-0.19***
Unemployment Rate	0.113***	0.115***	0.12***	0.099***	0.104***	0.125***
Size of Government	0.073***	0.067**	0.086***			
Fiscal Freedom				-0.199***	-0.209***	-0.228***
Rule of Law	-0.095***			-0.095***		
Control of Corruption		-0.041*			-0.048*	
Government Stability			-0.024			0.028
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.642***	-0.746***	-0.48***	-0.391***	-0.416***	-0.323***
Statistical Tests						
RMSEA	0.032	0.019	0.018	0.062	0.061	0.047
Chi-square	183.492	153.806	250.361	263.345	243.527	331.241
Observations	1901	1896	2329	1761	1760	1963
Countries	151	151	122	144	144	120

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 4.5: MIMIC Model Estimation Results: (Excluding GDP and GDP per capita), Developing Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.125***	-0.123***	-0.189***	-0.117***	-0.116***	-0.17***
Unemployment Rate	0.099***	0.098***	0.092***	0.098***	0.099***	0.108***
Size of Government	0.094***	0.091***	0.082**			
Fiscal Freedom				-0.174***	-0.173***	-0.196***
Rule of Law	-0.028			-0.041		
Control of Corruption		0.001			-0.012	
Government Stability			-0.068**			0.0026759
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.587***	-0.61***	-0.568***	-0.41***	-0.44***	-0.393***
Statistical Tests						
RMSEA	0.018	0.009	0.054	0.039	0.032	0.054
Chi-square	87.747	81.821	155.224	121.97	115.142	180.803
Observations	1309	1304	1670	1206	1205	1384
Countries	105	105	84	98	98	82

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 4.6: MIMIC Model Estimation Results: (Excluding GDP and GDP per capita), Advanced Countries

	1	2	3	4	5	6
Causes						
Trade Openess	-0.211***	-0.231***	-0.401***	-0.151**	-0.153**	-0.251***
Unemployment Rate	0.212***	0.222***	0.192***	0.145**	0.141**	0.174***
Size of Government	-0.105	-0.132*	-0.12*			
Fiscal Freedom				-0.231***	-0.287***	-0.258***
Rule of Law	-0.18***			-0.161**		
Control of Corruption		-0.145**			-0.169***	
Government Stability			-0.008			0.036
Indicators						
Currency	1	1	1	1	1	1
Labor Force Participation Rate	-0.63***	-0.683***	-0.558***	-0.596***	-0.632***	-0.528***
Statistical Tests						
RMSEA	0.07	0.072	0.095	0.064	0.067	0.116
Chi-square	78.546	75.321	150.647	93.674	98.075	134.892
Observations	274	274	408	265	265	351
Countries	26	26	25	25	25	25

Source: Own calculations.

Note: *** p<0.01, ** p<0.05, * p<0.1

5 Results of the Size of the Shadow Economy of 158 Countries

In table 5.1 the most important results of the 158 countries listed in alphabetical order are shown. The average value of the size of the shadow economy of the 158 countries is 32.3. The average median is 32.7 and shows that both values are quite close to each other, so there is not such a strong deviation. The three highest shadow economies have Zimbabwe with 60.6, Bolivia with 62.3 and Georgia with 64.9. The three lowest shadow economies have Austria with 9.9, the United States with 9.4 and Switzerland with 9. The average shadow economy comes close to Mauritania and the Dominican Republic which both also have a shadow economy of 32.3% of official GDP.

Table 5.1: Summary Statistics of the Shadow Economies of 158 Countries from 1991 to 2015

No.	Country	ISO	Average	Stand. Dev.	Median	Minimum	Maximum
1	Albania	ALB	32.7	5.8	32.6	25.4	43.2
2	Algeria	DZA	30.9	5.6	29.6	24.0	38.9
3	Angola	AGO	44.0	6.6	46.3	34.5	55.4
4	Argentina	ARG	24.1	2.0	24.4	20.8	27.2
5	Armenia	ARM	42.6	4.8	43.6	34.6	49.5
6	Australia	AUS	14.1	1.6	13.4	12.1	17.8
7	Austria	AUT	9.9	0.6	9.9	8.7	11.0
8	Azerbaijan	AZE	52.2	7.4	53.7	42.2	64.7
9	Bahamas, The	BHS	33.5	5.1	35.6	26.2	39.5
10	Bahrain	BHR	19.3	1.4	19.2	16.6	22.5
11	Bangladesh	BGD	33.6	3.3	35.1	27.2	37.1
12	Belarus	BLR	44.5	7.1	47.8	32.3	53.6
13	Belgium	BEL	23.6	1.3	23.4	21.6	25.8
14	Belize	BLZ	46.8	4.3	45.4	40.7	53.7
15	Benin	BEN	53.7	3.4	53.5	46.3	60.8
16	Bhutan	BTN	26.9	3.3	27.8	20.3	31.2
17	Bolivia	BOL	62.3	8.4	66.7	46.0	71.3
18	Bosnia and Herzegovina	BIH	34.2	3.5	33.2	29.9	44.5
19	Botswana	BWA	30.3	4.5	31.4	22.1	36.4
20	Brazil	BRA	37.6	2.8	38.5	32.6	41.7
21	Brunei Darussalam	BRN	29.8	1.2	29.8	27.0	31.8
22	Bulgaria	BGR	30.8	5.5	32.3	22.4	37.7
23	Burkina Faso	BFA	38.4	4.9	38.8	29.6	44.9
24	Burundi	BDI	36.7	3.5	38.0	26.9	40.0
25	Cabo Verde	CPV	35.8	5.8	36.0	29.2	47.2
26	Cambodia	KHM	46.0	6.8	45.4	33.9	56.7
27	Cameroon	CMR	32.4	2.3	32.5	28.1	37.9
28	Canada	CAN	17.5	2.0	16.8	15.5	22.1
29	Central African Republic	CAF	41.9	4.7	41.4	36.9	56.0
30	Chad	TCD	40.1	6.0	40.3	28.8	48.9
31	Chile	CHL	18.2	1.9	18.7	15.5	20.7
32	China	CHN	11.2	1.9	11.7	8.3	14.1
33	Colombia	COL	33.3	4.3	34.9	25.3	39.1
34	Comoros	COM	39.1	1.9	39.1	35.8	43.2
35	Congo, Dem. Rep.	COD	46.4	1.8	46.5	41.1	49.3
36	Congo, Rep.	COG	45.1	6.3	47.3	33.2	52.9
37	Costa Rica	CRI	26.7	2.1	26.4	21.5	30.9
38	Cote d'Ivoire	CIV	43.4	2.4	43.6	38.9	48.4
39	Croatia	HRV	30.3	4.9	28.5	23.0	38.7
40	Cyprus	CYP	31.3	2.4	30.8	27.9	36.2
41	Czech Republic	CZE	17.1	2.7	18.1	12.8	20.7
42	Denmark	DNK	18.6	1.4	18.6	15.9	21.5
43	Dominican Republic	DOM	32.3	2.2	32.3	27.6	35.8
44	Ecuador	ECU	33.6	2.8	34.4	28.5	37.0
45	Egypt, Arab Rep.	EGY	34.2	2.2	35.1	28.9	36.8
46	El Salvador	SLV	45.6	3.9	44.7	40.1	53.0
47	Equatorial Guinea	GNQ	31.8	3.3	31.4	27.2	38.1
48	Eritrea	ERI	39.3	4.2	38.7	31.4	48.9
49	Estonia	EST	28.8	4.3	29.6	22.5	35.5
50	Ethiopia	ETH	34.3	5.0	36.4	24.5	40.3
51	Fiji	FJI	32.5	3.4	32.3	25.4	38.9
52	Finland	FIN	19.1	1.9	18.6	16.5	22.7
53	France	FRA	16.0	1.1	15.8	14.0	18.2
54	Gabon	GAB	52.4	6.1	53.5	41.6	63.5

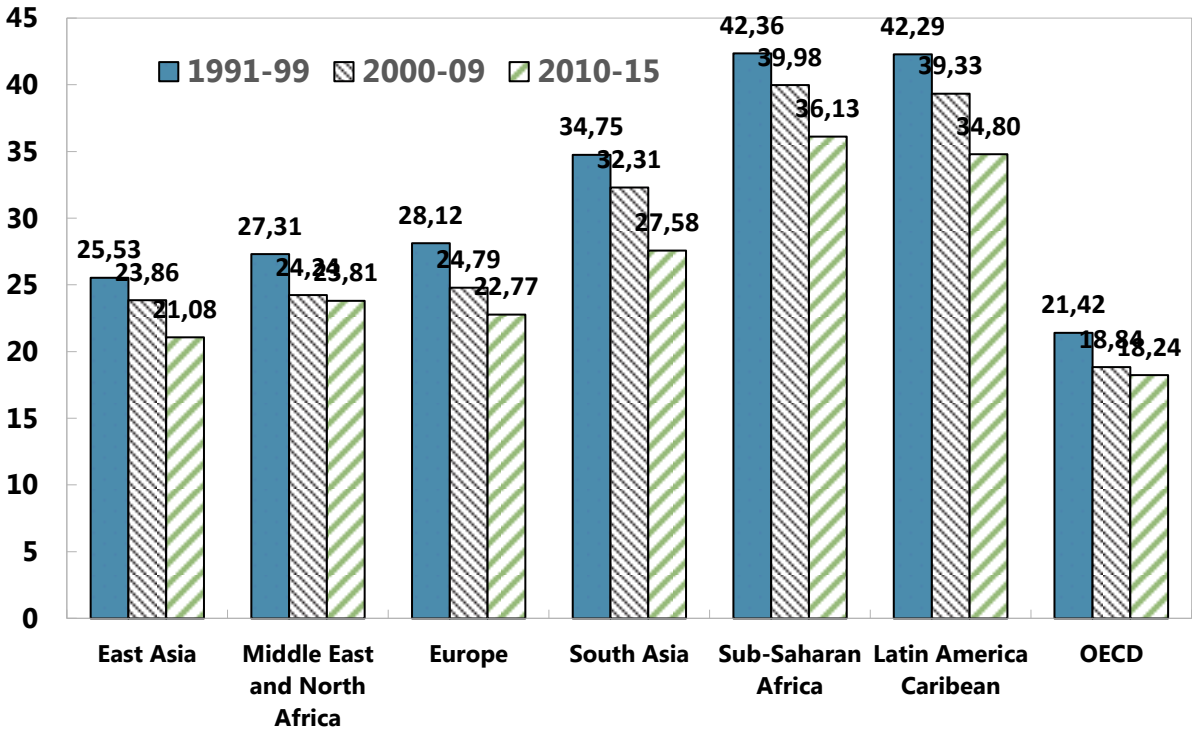
No.	Country	ISO	Average	Stand. Dev.	Median	Minimum	Maximum
55	Gambia, The	GMB	46.9	5.5	47.9	35.2	56.7
56	Georgia	GEO	64.9	5.1	65.3	53.1	71.9
57	Germany	DEU	15.6	1.4	15.9	13.3	17.7
58	Ghana	GHA	42.9	2.6	42.6	38.5	47.7
59	Greece	GRC	30.3	1.8	30.9	26.8	33.0
60	Guatemala	GTM	54.7	4.9	53.5	46.9	63.9
61	Guinea	GIN	39.9	1.8	39.7	37.4	43.9
62	Guinea-Bissau	GNB	36.4	5.2	38.6	22.0	42.8
62	Guyana	GUY	31.8	3.3	32.1	26.0	36.5
64	Haiti	HTI	53.3	4.0	54.2	42.1	59.1
65	Honduras	HND	46.3	4.3	47.4	37.7	53.7
66	Hong Kong SAR, China	HKG	14.7	1.8	15.4	11.9	17.0
67	Hungary	HUN	25.2	4.2	24.1	20.4	33.7
68	Iceland	ISL	15.8	1.1	15.8	14.1	17.6
69	India	IND	20.3	3.5	21.2	14.3	24.8
70	Indonesia	IDN	19.8	1.6	19.8	16.8	22.7
71	Iran, Islamic Rep.	IRN	17.9	2.2	18.4	14.5	21.1
72	Ireland	IRL	16.9	2.0	16.0	14.7	20.9
73	Israel	ISR	22.0	1.7	22.3	19.4	25.0
74	Italy	ITA	29.6	1.8	29.0	26.8	33.5
75	Jamaica	JAM	34.1	2.1	34.8	30.4	36.9
76	Japan	JPN	10.8	0.5	10.8	9.7	11.8
77	Jordan	JOR	17.4	2.7	18.3	13.4	21.1
78	Kazakhstan	KAZ	38.9	5.8	39.6	30.1	47.4
79	Kenya	KEN	33.1	2.1	33.4	28.7	36.2
80	Korea, Rep.	KOR	26.4	2.2	26.8	22.8	30.0
81	Kuwait	KWT	19.3	1.8	19.7	15.7	22.1
82	Kyrgyz Republic	KGZ	37.9	4.5	38.0	30.0	45.9
83	Lao PDR	LAO	30.3	3.8	30.6	24.1	36.2
84	Latvia	LVA	26.0	4.2	25.9	19.7	32.4
85	Lebanon	LBN	31.6	3.5	33.0	24.6	36.7
86	Lesotho	LSO	31.3	2.9	31.3	24.6	35.8
87	Liberia	LBR	43.2	1.6	43.0	40.0	46.7
88	Libya	LBY	33.6	3.9	34.9	25.9	38.8
89	Lithuania	LTU	27.7	4.8	26.9	20.2	35.1
90	Luxembourg	LUX	10.7	0.6	10.7	9.4	12.0
91	Madagascar	MDG	42.6	2.4	41.7	38.7	47.4
92	Malawi	MWI	38.5	2.3	38.8	33.6	43.7
93	Malaysia	MYS	31.5	2.8	30.6	26.4	37.5
94	Maldives	MDV	27.4	2.8	27.8	20.7	31.5
95	Mali	MLI	38.7	4.9	39.6	29.5	45.3
96	Malta	MLT	29.8	1.8	30.6	27.0	33.1
97	Mauritania	MRT	32.3	4.8	33.4	24.4	38.6
98	Mauritius	MUS	22.6	2.4	22.7	19.2	26.2
99	Mexico	MEX	31.7	2.7	31.0	28.4	38.2
100	Moldova	MDA	43.4	3.1	43.8	37.4	49.1
101	Mongolia	MNG	17.3	2.5	17.7	12.0	21.1
102	Morocco	MAR	34.0	4.0	34.7	27.1	40.4
103	Mozambique	MOZ	37.2	5.1	36.6	30.1	46.9
104	Myanmar	MMR	51.4	6.9	49.3	39.9	63.8
105	Namibia	NAM	28.1	3.8	28.8	21.8	32.1
106	Nepal	NPL	37.5	2.7	37.3	30.2	43.4
107	Netherlands	NLD	14.2	1.0	14.0	13.0	16.0
108	New Zealand	NZL	13.4	1.1	13.2	12.0	16.1
109	Nicaragua	NIC	42.6	1.9	43.0	38.5	45.2
110	Niger	NER	39.7	2.7	40.2	34.1	43.1
111	Nigeria	NGA	56.3	4.8	57.0	44.5	66.6

No.	Country	ISO	Average	Stand. Dev.	Median	Minimum	Maximum
112	Norway	NOR	20.5	1.8	20.2	16.9	23.7
113	Oman	OMN	19.9	2.1	19.9	15.5	23.9
114	Pakistan	PAK	33.1	2.2	33.6	30.3	37.5
115	Papua New Guinea	PNG	34.0	4.2	35.1	23.3	42.0
116	Paraguay	PRY	34.5	3.0	34.5	29.4	40.3
117	Peru	PER	52.4	7.8	56.4	39.5	61.0
118	Philippines	PHL	39.3	5.5	41.4	28.0	45.5
119	Poland	POL	26.5	4.6	27.5	19.1	34.5
120	Portugal	PRT	23.8	0.9	23.7	22.1	25.7
121	Qatar	QAT	15.9	2.1	16.7	12.1	19.0
122	Romania	ROM	30.1	4.2	31.1	22.4	36.0
123	Russian Federation	RUS	42.6	5.6	41.9	35.2	52.9
124	Rwanda	RWA	36.3	5.0	38.7	26.7	41.7
125	Saudi Arabia	SAU	16.7	2.0	17.9	13.3	19.2
126	Senegal	SEN	43.3	6.4	41.5	33.7	53.4
127	Sierra Leone	SLE	41.5	6.4	43.2	25.7	50.1
128	Singapore	SGP	11.9	1.3	12.2	9.9	13.8
129	Slovak Republic	SVK	16.6	2.8	17.9	12.5	20.8
130	Slovenia	SVN	26.0	3.2	26.3	19.5	31.4
131	Solomon Islands	SLB	30.4	4.1	30.2	24.9	37.4
132	South Africa	ZAF	25.9	3.6	27.6	20.3	31.2
133	Spain	ESP	25.2	1.9	25.6	22.7	28.7
134	Sri Lanka	LKA	45.5	4.7	46.3	35.5	52.9
135	Suriname	SUR	32.2	6.4	35.3	22.5	39.8
136	Swaziland	SWZ	40.0	2.7	39.6	34.7	44.1
137	Sweden	SWE	19.9	2.2	19.2	16.7	24.5
138	Switzerland	CHE	9.0	0.6	9.1	8.0	10.0
139	Syrian Arab Republic	SYR	19.6	2.0	19.2	15.7	24.2
140	Taiwan	TWN	26.9	2.2	27.1	22.3	30.2
141	Tajikistan	TJK	43.0	3.3	43.4	35.4	47.4
142	Tanzania	TZA	52.2	6.3	54.3	38.9	60.3
143	Thailand	THA	50.6	3.4	50.5	43.1	56.6
144	Togo	TGO	37.3	3.8	37.3	31.5	50.5
145	Trinidad and Tobago	TTO	34.4	5.9	33.1	26.1	44.8
146	Tunisia	TUN	35.3	4.4	36.3	27.2	42.0
147	Turkey	TUR	31.3	2.7	32.0	27.3	36.0
148	Uganda	UGA	38.7	4.0	40.7	31.9	43.2
149	Ukraine	UKR	44.8	5.7	42.9	36.7	57.0
150	United Arab Emirates	ARE	28.7	1.6	28.1	26.4	32.1
151	United Kingdom	GBR	13.3	1.0	13.1	11.7	15.8
152	United States	USA	9.4	0.9	9.3	8.1	11.2
153	Uruguay	URY	45.7	6.1	47.2	35.6	53.7
154	Venezuela, RB	VEN	31.4	2.8	30.3	27.2	37.6
155	Vietnam	VNM	15.1	2.3	15.3	11.2	18.6
156	Yemen, Rep.	YEM	28.3	4.0	28.4	22.9	35.0
157	Zambia	ZMB	45.3	7.5	48.5	30.7	54.2
158	Zimbabwe	ZWE	60.6	4.3	60.6	52.1	69.1
	Averages		32.3	3.4	32.7		

Source: Own calculations.

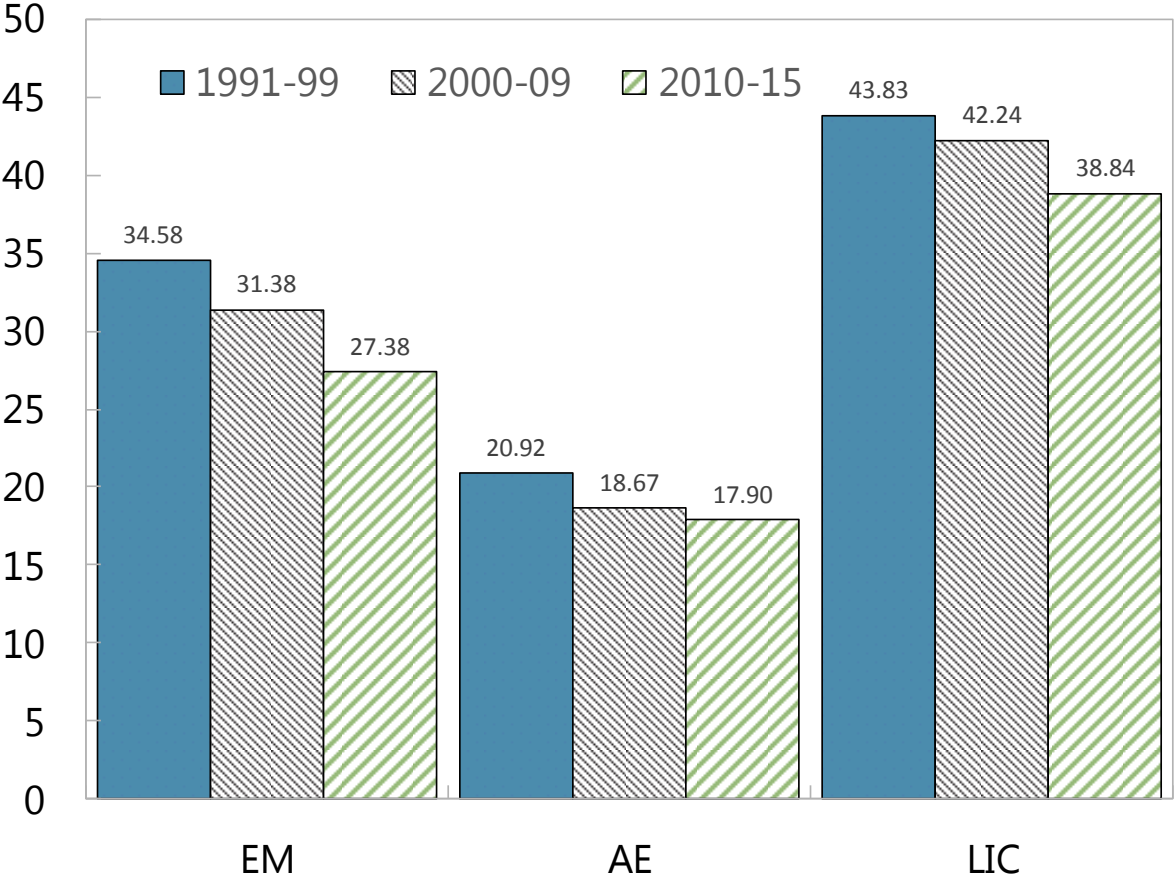
In figures 5.1 and 5.2 some disaggregated results are shown. Figure 5.1 presents the shadow economy by region; the OECD countries are by far the lowest with an average value of 20% and the Sub-Saharan African countries the highest with an average value of 39% (both averages over 1991-2015). In all country groups we have a significant decline of the size of the shadow economy over time; average decline from 1991 to 2015 5.3 percentage points. Figure 5.2 presents the results grouped by income. High income countries have the lowest shadow economy and low income countries vice versa.

Figure 5.1 Shadow Economy by Region (average, percent of GDP)



Source: Own calculations.

Figure 5.2 Shadow Economy by Income Level (average, percent of GDP)



Source: Own calculations.

6 Summary and Concluding Remarks

6.1 Summary

In this paper we undertake a first attempt to estimate the size and development of the shadow economies of 158 countries over the period 1991 to 2015. Using a MIMIC method we apply for the first time (i) the light intensity approach instead of GDP avoiding the problem that quite often GDP is used as a cause and indicator variable.

The robustness tests clearly show that in most cases trade openness, unemployment rate, GDP per capita, size of government, fiscal freedom, control of corruption are highly statistically significant. The results are robust when using the light intensity approach. Results are also robust to dropping GDP and GDP per capita, again the results show that trade openness unemployment rate, size of government, fiscal freedom, rule of law and corruption are statistically significant. This holds also for the

sub-samples. Hence, these two kinds of robustness tests demonstrate that the MIMIC results lead to quite robust results.

6.2 What type of policy conclusions can we draw from these results?

1. The MIMIC estimations of the 158 countries over 1991 to 2015 produce quite stable results which are comparable to Schneider (2010), Hassan and Schneider (2016) and other studies.
2. Using as an indicator variable the lights approach proved to be an alternative instead of GDP per capita or GDP growth rate. Hence, if we have more or better data from this variable it might be used as an indicator.
3. In order to avoid the problems of calibrating the relative estimates of the MIMIC methodology we used a new method, the Predict Mean Matching one, developed by Rubin (1987). This method produced quite plausible results and avoids the problems one has with the usual calibration methods done in Schneider (2010), Hassan and Schneider (2016) and in other papers.
4. Over all, we again find one stable result, a declining size and development of the shadow economy from 1991 to 2015. The continuous decline is only interrupted in the year 2008 due to the world economic crisis.

7. References

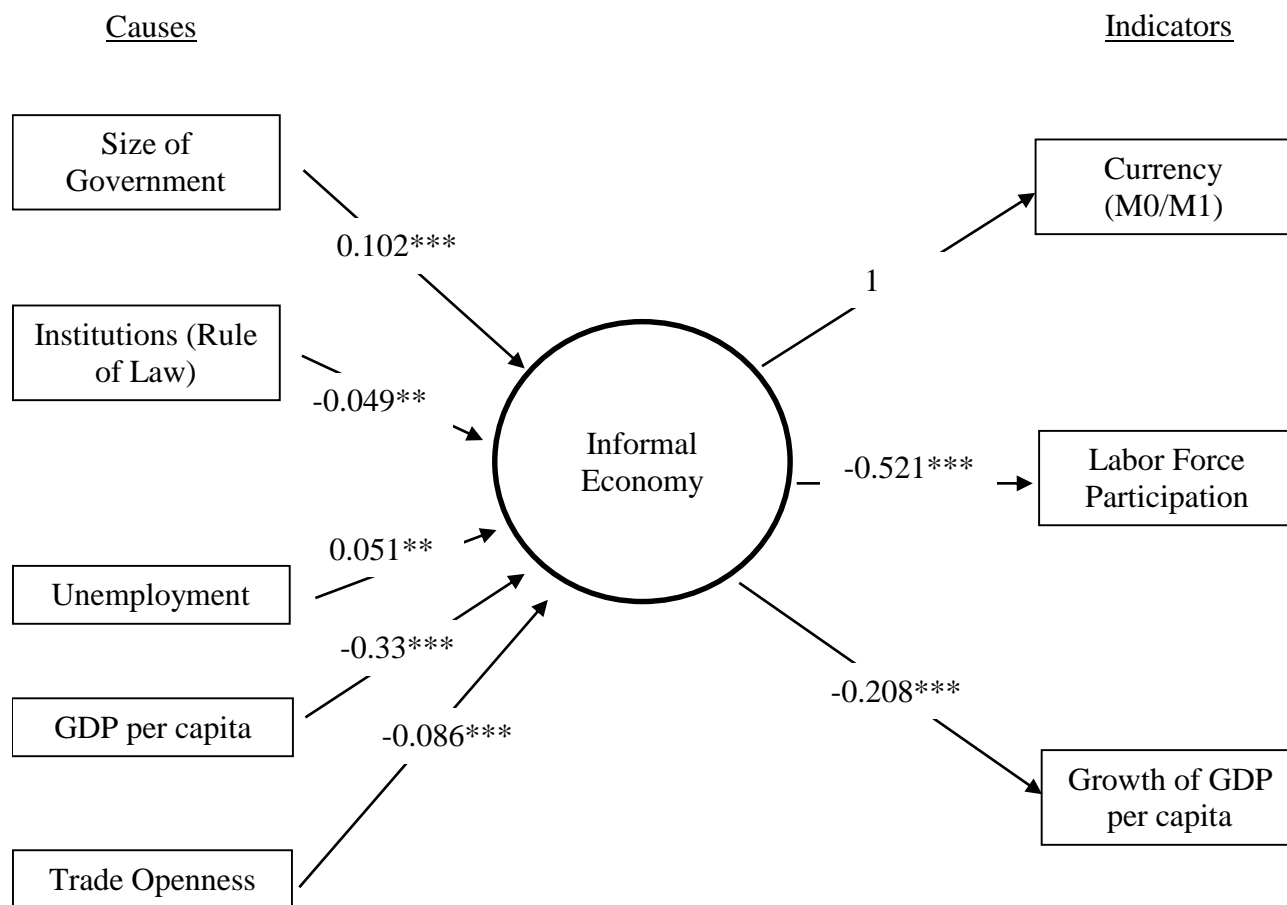
- Abdih, Y. and Medina, L. (2013), Measuring the Informal Economy in the Caucasus and Central Asia, *International Monetary Fund*, WP/13/137.
- Breusch, V. (2016), Estimating the Underground Economy using MIMIC models, *Journal of Tax Administration*, Vol. 2, No. 1.
- Boeschoten, W.C. and M.M.G. Fase (1984), *The Volume of Payments and the Informal Economy in the Netherlands 1965–1982*. M. Nijhoff, Dordrecht.
- Buehn, A., Karmann, A. and Schneider, F. (2009), Shadow Economy and Do-it-Yourself Activities: The German Case, *Journal of Institutional and Theoretical Economics (JITE)* 165/4, 701–722.
- Cagan, P. (1958), The demand for currency relative to the total money supply, *Journal of Political Economy*, 66, pp. 302–328.
- Contini, B. (1981), Labor market segmentation and the development of the parallel economy: the Italian experience, *Oxford Economic Papers*, 33, pp. 401–412
- Del Boca, D. (1981), Parallel economy and allocation of time, *Micros (Quarterly Journal of Microeconomics)*, 4, pp. 13–18.
- Del Boca, D. and F. Forte (1982), Recent empirical surveys and theoretical interpretations of the parallel economy in Italy, in: V. Tanzi (ed.), *The Underground Economy in the United States and Abroad*, Lexington Books, Lexington, MA, pp. 160–178.
- Feige, E. (1979), How Big is the Irregular Economy?, *Challenge*, 22(1).
- Feige, E.L. (1996), Overseas holdings of U.S. currency and the underground economy. In: Pozo, S. (Ed.), *Exploring the Underground Economy*. W.E. Upjohn Institute for Employment Research, Kalamazoo, MI, pp. 5–62.
- Feige, E.L. (2016), Reflections on the Meaning and Measurement of Unobserved Economies: What do we really know about the “Shadow Economy”?, *Journal of Tax Administration*, Vol 2:2.
- Feld, L. and Schneider, F. (2010). Survey on the Shadow Economy and Undeclared Earnings in OECD Countries. *German Economic Review*, 11(2), 109-149.
- Gerxhani, K. (2003), The informal sector in developed and less-developed countries: A literature survey, *Public Choice*, 114/3-4, pp. 295–318.
- Gutmann, P.M. (1977), The subterranean economy, *Financial Analysts Journal*, 34/1, pp. 24–27.
- Hashimzade, N. and Heady C. (2016), Reflections on the meaning and measurement of unobserved economies: An editorial comment, *Journal of Tax Administration* 2:2.
- Hassan, M. and Scheider, F. (2016), Size and development of the shadow economies of 157 worldwide countries: Updated and new measures from 1999 to 2013, *Journal of Global Economics* 4:3.
- Henderson, V. J., Storeygard, A. and Weil, D. N. (2012), Measuring Economic Growth from Outer Space, *American Economic Review*, 102(2): 994–1028.
- Isachsen, A.J. and S. Strøm (1985), The Size and Growth of the Hidden Economy in Norway, *Review of Income and Wealth*, 31/1, pp. 21–38.
- Johnson, S., Kaufmann, D. and A. Shleifer (1997), The unofficial economy in transition, *Brookings Papers on Economic Activity*, Fall, Washington D.C.
- Johnson, S., Kaufmann, D. & Zoido-Lobaton, P. (1998a). Regulatory Discretion and the Unofficial Economy. *The American Economic Review*, 88(2): 387–392.

- Joreskog, K.G., and Goldberger, A.S. (1975), Estimation of a model with multiple indicators and multiple causes of a single latent variable, *Journal of the American Statistical Associations*, 70, 631-639.
- Kaufmann, D. and A. Kaliberda (1996), Integrating the unofficial economy into the dynamics of post socialist economies: a framework of analyses and evidence, in: Kaminski, B. (ed.), *Economic Transition in Russia and the New States of Eurasia*. M.E. Sharpe, London, pp. 81–120.
- Langfeldt, E. (1984), The unobserved economy in the Federal Republic of Germany, in: Feige, E.L. (ed.), *The Unobserved Economy*, Cambridge University Press, Cambridge, UK, pp. 236–260.
- Little, R. J. A. (1988), Missing-Data Adjustments in Large Surveys, *Journal of Business and Economic Statistics*, Vol. 6, No. 3, pp. 287-296.
- Loayza, N. V. (1996), The economics of the informal sector: a simple model and some empirical evidence from Latin America, *Carnegie-Rochester Conference Series on Public Policy*, 45, pp. 129–162.
- MacAfee, K. (1980), A glimpse of the hidden economy in the national accounts, *Economic Trends*, 136, pp. 81–87.
- Mogensen, G.V., Kvist, H.K., Kfirmendi, E. and S. Pedersen (1995), The Shadow Economy in Denmark 1994: Measurement and Results, Study no. 3, The Rockwool Foundation Research Unit, Copenhagen.
- O'Neill, D.M. (1983), Growth of the underground economy 1950–81: some evidence from the current population survey, Study for the Joint Economic Committee, U.S. Congress Joint Committee Print, U.S. Gov. Printing Office, Washington, DC, pp. 98–122.
- Portes, A. (1996), The informal economy, in: Pozo, S. (ed.), *Exploring the Underground Economy*, W.E. Upjohn Institute for Employment Research, Kalamazoo, pp. 147–165.
- Rubin, D.B. (1976), Inference and Missing Data, *Biometrika*, Vol. 63, No. 3, pp.581-592
- Rubin, D.B. (1987), *Multiple Imputation for Nonresponse in Surveys*, Wiley.
- Schneider, F. (1997), The shadow economies of Western Europe, *Journal of the Institute of Economic Affairs*, 17/3, pp. 42–48.
- Schneider, F. (ed.) (2011), *Handbook on the Shadow Economy*, Edward Elgar, Cheltenham.
- Schneider, F. (2015), Schattenwirtschaft und Schattenarbeitsmarkt: Die Entwicklungen der vergangenen 20 Jahre, *Perspektiven der Wirtschaftspolitik*, 16/1, pp. 3–25.
- Schneider, F. (2016), Comment on Feige's Paper, Reflections on the Meaning and Measurement of Unobserved Economies: What do we really know about the „Shadow Economy?“, *Journal of Tax Administration*, Vol 2:2, pp. 82-92.
- Schneider, F. and D. Enste (2002), *The Shadow Economy: Theoretical Approaches, Empirical Studies, and Political Implications*, Cambridge University Press, Cambridge (UK).
- Schneider, F., Buehn, A., & Montenegro, C. E. (2010). New Estimates for the Shadow Economies all over the World. *International Economic Journal*, 24(4), 443–461.
- Schneider, F. and C.C. Willams (2013), *The Shadow Economy*, IEA, London.
- Tanzi, V. (1980), The underground economy in the United States: estimates and implications, *Banca Nazionale del Lavoro*, 135, pp. 427–453.
- Tanzi, V. (1983), The underground economy in the United States: annual estimates, 1930–1980, *IMF Staff Papers*, 30, pp. 283–305.
- Thomas, J. J. (1992), *Informal Economic Activity*, LSE, Handbooks in Economics, Harvester Wheatsheaf, London.

- Vuletin, G.J. (2008), Measuring the Informal Economy in Latin America and the Caribbean, *International Monetary Fund*, Working Paper No. 08/102.
- Williams, C. C. and Schneider, F. (2016). *Measuring the Global Shadow Economy The Prevalence of Informal Work and Labour*. Edward Elgar Publishing, UK.
- Witte, A.D. (1987), The nature and extent of unreported activity: a survey concentrating on a recent US research, in: Alessandrini, S. and B. Dallago (eds.), *The Unofficial Economy: Consequences and Perspectives in Different Economic Systems*, Gower, Aldershot.
- Yoo, T. and Hyun, J. K. (1998), International Comparison of the Black Economy: Empirical Evidence Using Micro-Level Data, paper presented at 1998 Congress of Int. Institute Public Finance, Cordoba, Argentina.
- Zellner, A. (1970). Estimation of Regression Relationships Containing Unobservable Independent Variables. *International Economic Review*, 11(3), 441–454.

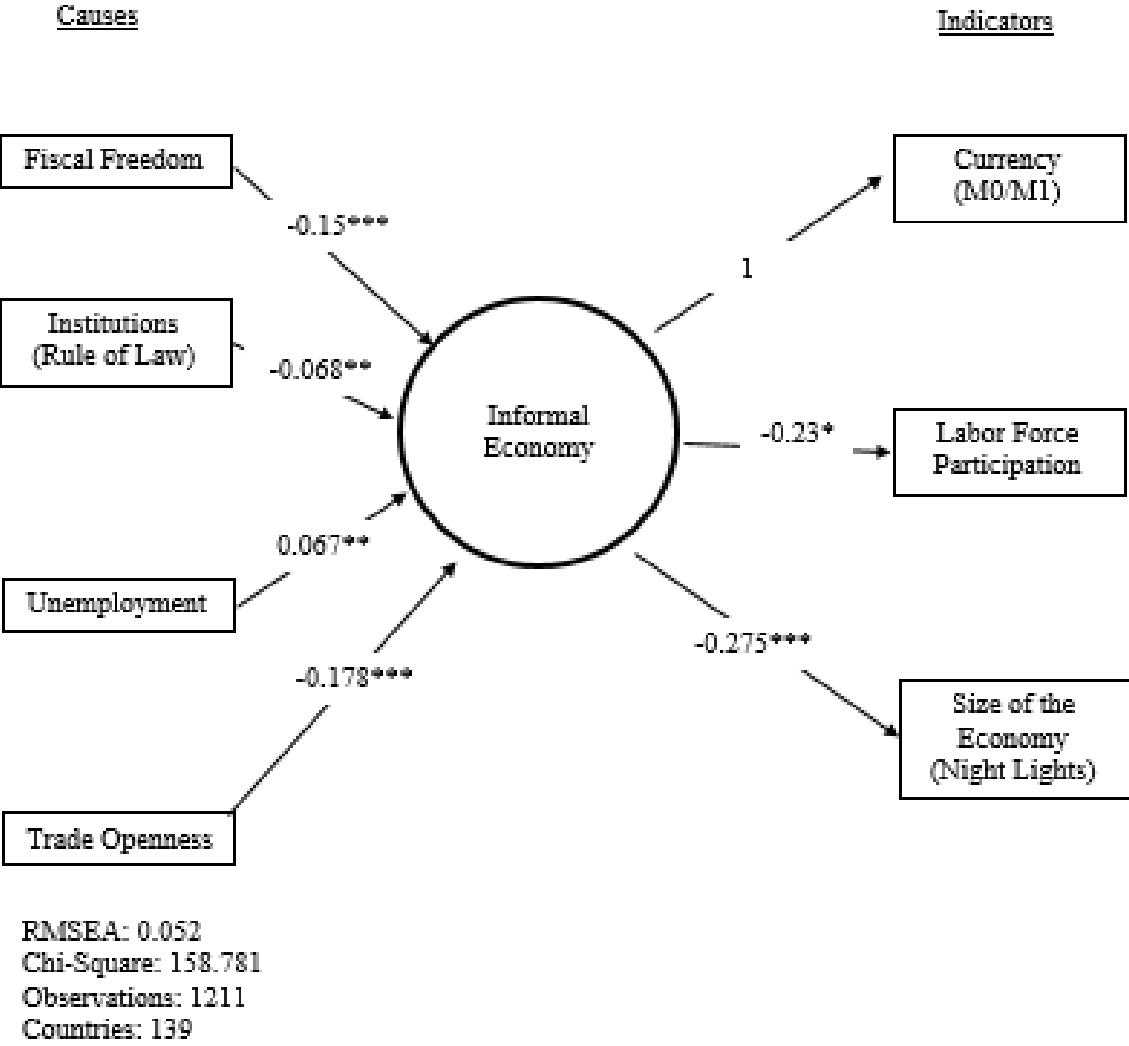
Appendix

Figure A.1: Informal Economy Estimation: The MIMIC Model



RMSEA: 0.073
Chi-Square: 513.407
Observations: 1897
Countries: 151

Figure A.2: Informal Economy Estimation: The MIMIC Model using alternative measures of economic growth



Source: Own calculations.