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Article

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Provided in Cooperation with:
KSP Journals, Istanbul

Reference: Hassan, Mai Modelling the Egyptian shadow economy.

This Version is available at:
http://hdl.handle.net/11159/288

Modelling the Egyptian Shadow Economy: A MIMIC model and A Currency Demand approach

By Mai HASSAN [a†] & Friedrich SCHNEIDER [b]

Abstract. We estimate the size and trend of the Egyptian shadow economy using two of the most commonly used methods: the currency demand approach and the structural equation MIMIC model. To the best of our knowledge, this is the first study to estimate an index of the size of the shadow economy in Egypt during the last four decades (1976 to 2013). We address the long term association between the variables, relax the assumption of multivariate normality and demonstrate different scenarios of constraining the reference variable in the MIMIC model. In addition to the standard explanatory variables used in the literature, we consider variables that are specifically related to the Egyptian economy such as self-employment, agricultural importance and a proxy for institutional quality of democratic institutions. Our results indicate a decreasing trend of the size of the shadow economy, yet it still has a huge weight on the official GDP for a developing country like Egypt leading to some negative externalities and thus hindering the development of the country.

Keywords. Shadow economy of Egypt, MIMIC, CDA.

JEL. C32, H26, I2, O17, P48.

1. Introduction

Most countries around the world have sizeable shadow economies, particularly in the developing world. The shadow economy has diverse effects on the country's social and economic life which threaten the country's stability and growth prospects. The shadow economy creates a vicious cycle of continuous increase in taxes, absorbs human capital and resources from the formal economy and leads to distortions in official statistics hindering the success of official policies. (Schneider & Enste, 2013; Dell'Anno, 2007). However, the shadow economy is not necessarily seen as an enemy to the overall economy. The shadow economy can act as an employer of last resort, create markets that otherwise not possible adding to the dynamics of the formal economy and can have positive stimulating effects. Given this complexity of our unobserved economy, general interest in understanding the nature of the shadow economy increased throughout the years.

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For the case of a developing country like Egypt, this is the first study to analyze the shadow economy generally and to estimate its size particularly. Our study, to the best of our knowledge, is the first study to provide a time series index of the size of the Egyptian shadow economy. On one side, the contribution of the paper is to understand the development of the size of the shadow economy. On the other side, our time series index adds to the literature of shadow economy by allowing further analysis of the different aspects of informality in Egypt. Hence, our annual estimates of the size of the shadow economy is the first step closer to understand the development of the unexplored existence of the shadow economy in Egypt. Since that there are neither direct measures (survey analysis) nor econometric estimates of the size of the shadow economy in Egypt, then the failure of the government policiesi to promote growth and stability can be highly attributed to the lack of knowledge about the size of the Egyptian shadow economy.

Egypt is an interesting case to focus on given its highly strategic location in the MENA region and given the recent events that occurred in the region. In the aftermath of the 2011 revolution, policy makers are working with economic planners to execute major reforms to promote economic development and stabilize the political system in Egypt. Amongst the objectives of these reforms is tackling the shadow economy. However, the government efforts to tackle informality and other legal measures are limited. Their approach is either to evacuate street vendors by brutal police force or to intensify regulations by increasing jail times from 1 month to 3 months and penalties from 1000 LE to 5000 LE (112 to 560 US dollars) for involvement in informal economic activities (FEDA, 2009). Needless to say, these efforts have backfired by rising instability. Not only that, but also the more recent initiatives to license street vendors have failed to regulate the shadow economy. Therefore, knowledge on the size and the main causes of the Egyptian shadow economy becomes essential for policymakers to have a coherent plan of reforms and policies to formalize the shadow economy in order to be able to restore fiscal stability and drive economic growth. Until today not much research has been done to analyze and econometrically estimate the Egyptian shadow economy over a long period of time.

The present study adds to the literature an understanding of the evolution of the shadow economy in Egypt from 1976 to 2013. To the best of our knowledge, this is the first comprehensive study to apply the Currency Demand Approach as well as the MIMIC model to estimate the size of the shadow economy in Egypt. A few studies, which are shown in Table-1, investigating the shadow economies around the world have also included Egypt. They show a wide range of the size of the Egyptian shadow economy. Yet, these studies were done using a general cross section analysis for shorter periods of time. Additionally, they do not take into account the specific social, economic and political structures that significantly influence the Egyptian shadow and official economy.

Our paper is organized as follows. In section 2, we present the MIMIC and CDA models as well as our results. In section 3, an analysis of the shadow economy and policy implications are undertaken. In section 4, we critically outline the challenges of modelling the unobserved shadow economy. Finally, a conclusion is provided.

Table 1. *Previous estimates of the Egyptian shadow economy*

Author(s)	Method	SE % of GDP
Schneider & Enste (2000) (Table 4 page 100). Lacko (1996) (Table 18)	Physical Input Method	Average 1989-1999:68%
Schneider (2005) (Table 2 page 118)	Dynamic Panel MIMIC model	2000:35.1%
	CDA	2002:36%-2003:36.9%,
Schneider et al. (2010) (Table 3.3.2 page 23)	Dynamic Panel MIMIC model	1999:35.4%-2006:36.7%
Alm & Embaye (2013) (Appendix page 534)	Dynamic Panel CDA	1984:48.7%-2006:30.4%

Notes: Source: see column 1 "Author(s)"

2. Modelling the Egyptian Shadow Economy

It is important to define the shadow economy that shall be estimated by the models. Although many studies attempted to investigate the shadow economy but reaching a unified definition is still an unresolved issue. For the purpose of this study, the adopted definition is that the shadow economy involves all currently unrecorded economic (market-based) activities which, if registered, would contribute to the officially calculated national income (GDP). Since the focus of this paper is on the productive economic activities that are usually included in the national accounts, this definition excludes illegal activities such as criminal activities, human trafficking, or smuggling. Also, undeclared activities such as charitable, household or Do-it-Yourself activities are excluded (Schneider et al., 2010). Given the fact that illegal and undeclared activities are not accounted for in the national accounts statistics and since that our focus is on the development of an economy that is distorted by the shadow economy. Thus, we direct our attention to the macroeconomic variables leading to the proliferation of the shadow economy in Egypt.

In the literature there are various methods to measure the extent of the shadow economy over time, yet it is still a difficult task because the shadow economy is untraceable and unrecorded. Those methods are divided into direct, indirect and model approaches[ii]. Due to the complex nature of the shadow economy and since there is no consensus in the literature on which method is better, we apply two of the most widely used methods to estimate the shadow economy in Egypt. The first one is based on the Structural Equation Model known as the Multiple Indicator Multiple Causes (MIMIC) Model. The second method is the Currency Demand Approach (CDA).

2.1. Structural Equation (MIMIC) model

The MIMIC model is a special type of structural equation modelling (SEM) based on the statistical theory of unobserved variables. The MIMIC model is a theory-based approach[iii] 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 (Farzanegan, 2009). Therefore, the MIMIC model is rather a confirmatory than explanatory method (Schneider et al., 2010). The hypothesized path of the relationships between the observed variables and the latent shadow economy based on our theoretical considerations is being visualized in graph (A.1) in the appendix.

Formally, the MIMIC model has two parts: the structural model and the measurement model[iv]. The structural model shows that the latent variable η is linearly determined by a set of exogenous causal variables which can be illustrated as follows:

$$\eta = \gamma' \chi + \varsigma \qquad (1)$$

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

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

$$y = \lambda\eta + \varepsilon \qquad (2)$$

where y is a vector of indicator variables, 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.

First of all, it is important to establish a well-grounded economic theoretical model explaining the expected relationship between the latent variable and the observed variables. The MIMIC model tests this economic theory and confirms the hypothesized relationships between the latent variable η (shadow economy) and its causes and indicators by examining the consistency of the actual data with the hypothesized relationships. The Maximum Likelihood method (ML) shall be applied to estimate the parameters of the MIMIC model. Then, the time series index of the Egyptian shadow economy is calculated. This time series MIMIC index based on equation (1) is calculated by multiplying the coefficients of the significant causal variables with the respective time series. The MIMIC model produces only an index of the trend of the size of the shadow economy, thus an additional step is required to calibrate this index in order to calculate the size of the shadow economy as percentage of GDP. This step is called the benchmarking step[v] which requires an exogenous estimate of the size of the shadow economy at a certain point, preferably by another estimation method. Given the fact that there are no survey analyses and estimates on the shadow economy, we calibrate the MIMIC index by applying the CDA.

It is important to note that in the MIMIC model estimation, we need to fix an indicator variable in the measurement equation (2) (Bollen, 1989). This is required in order to have a reference variable to set a measurement scale for the shadow economy because it is, by nature, unobserved.

The MIMIC approach considers various causes that influence the development of the shadow economy and also considers multiple traces over time. There is a large body of literature providing a theoretical explanation of the causal and indicator variables, which directly influence the size and development of the shadow economy over time. However, those variables differ from country to country. For the case of Egypt, the causal variables are discussed in the following section.

2.1.1. Causal variables

i. Tax burden

The most widely accepted and important cause affecting the size of the shadow economy is the tax burden. Numerous empirical studies confirm a statistically significant effect of the tax burden on the shadow economy. Among others are Schneider (2010) for 21 OECD countries, Tanzi (1999), Alanon & Go'mez (2005) for the Spanish shadow economy and Buehn (2012).

The tax burden is of major interest to economists because taxes influence the labor-leisure choices and stimulate labor supply in the shadow economy. The higher the difference between total costs of labor in the formal economy and net income, the stronger the incentives to operate in the shadow economy in order to evade paying those taxes (Loayza, 1996; Schneider, 2005). Additionally, the tax

burden increases the production costs of goods and services which increase their price in the formal market. Therefore, firms operating in developing countries like Egypt have higher incentives to engage in informal activities in order to evade taxes and to reduce production costs to be able to sell their products at lower prices given the competition in the shadow and official economy. Moreover, the government burden the people with high tax rates to finance its activities and its debt. Tax revenues are a major source of finance to the government to the extent that the weight of tax revenues is on average more than 60% of total revenues. In the econometric analysis, the tax burden is measured by the share of total tax burden to GDP.

Hypothesis 1: The higher the tax burden, the larger the size of the shadow economy is, ceteris paribus.

ii. Institutional quality of democratic institutions

It is quite important to analyze the effect of the quality of public institutions on the size and development of the shadow economy. Good rule of law, by securing property rights and enforceability of contracts, increases the benefits to remain in the official economy and increases the costs of informality. On the other hand, corruption of bureaucracy and public servants along with a weak rule of law are associated with large shadow economies (Schneider, 2010).

Various authors have studied the quality of public institutions as a determining variable of the shadow economy. Based on a study of 21 OECD countries, Schneider (2010) found out that the quality of institutions is statistically significant affecting people's incentives to operate in the shadow economy. Razmi et *al.* (2013) also concluded a statistically negative relationship between the quality of institutions and the size of the underground economy in OIC countries.

As an approximation of institutional quality, we use a variable measuring the quality of democratic institutions, namely the Polity IV index. Recent studies by various scholars highlighted the negative relationship between democracy and the size of the shadow economy. Teobaldelli & Schneider (2013) confirmed a negative relationship between democracy and the size of the shadow economy. Also, Solomon & Schrestha (2014) concluded that a high degree of democracy reduced the informal economy in Nepal by 10%. In many developing countries mistrust in the government and inadequate democratic institutions providing poor and inefficient public goods and services influence people's incentives to operate in the shadow economy (Petersen et *al.*, 2010).

To capture this effect, the *PolityIV* index is used as a proxy of the quality of democratic institutions. The *PolityIV* index ranges from -10 to +10, representing autocratic to democratic states, respectively. Hence, the higher the score, the better is the quality of institutions representing the extent of democratic institutions in a country. We expect a negative sign associated with this variable.

Hypothesis 2: The better the quality of democratic institutions, the smaller the size of the shadow economy is, *ceteris paribus*.

iii. Size of the agricultural sector

The importance of the agricultural sector plays a significant role in affecting the size and development of the shadow economy. Vuletin (2008) concluded that the dominance of the agricultural sector has a significant effect on the size of the shadow economy in Latin America and the Caribbean. Similarly, almost 45% of the agricultural sector in Jamaica is conducted informally (Wedderburn et *al.*, 2011). Also, countries like Yemen and Morocco have high levels of informality due to the large share of agricultural employment relative to total employment (Angel-Urdinola & Tanabe, 2012). It is argued that informality is segmented by sectors with clear dominance of the agricultural and related sectors. The reason

behind the concentration of informal work in the agricultural sector is the weak control and governance capacity of the local government, especially in rural areas which in return creates the perfect environments for shadow economic activities. The agricultural sector is difficult to regulate which indicates that the higher the importance of this sector, the larger is the shadow economy (Vuletin, 2008).

In many studies, agriculture is excluded from the measurement of the size of the shadow economy. However, the majority of informal employment and work can be concentrated in agriculture, especially for developing countries (Chen, 2007). Therefore, for the first time we include this variable as a causal factor of the shadow economy which is highly relevant to the case of Egypt since the agricultural sector plays a significant role in the Egyptian economy. Egypt has an agricultural sector based on its climate, landscape and geographical location on the river Nile. Using statistics, agricultural employment in Egypt is larger compared to employment in the industrial sector. In 1980, employment in agriculture reached 42% compared to 20% employment in the industrial sector. The share of agricultural employment continued to be larger throughout the years, reaching in 1994 38% compared to 22% in industry, 32% in 2007 compared to 22% and 30% in 2011 compared to 24% in the industrial sector. In the MIMIC model the agricultural value-added as % of GDP is used to reflect the importance of the agricultural sector in Egypt.

Hypothesis 3: The more dominant the agriculture sector, the larger the size of the shadow economy is, *ceteris paribus.*

iv. Unemployment rate

Despite a large literature, the causal relationship between unemployment and the shadow economy is still ambiguous. The widely accepted hypothesis is that an increase in unemployment leads to an increase in shadow economy activities because unemployed people have a strong incentive to find jobs in the informal economy. Thus, the expected sign for the effect of unemployment on the shadow economy is positive. Schneider et al. (2010) concluded that the unemployment rate plays a significant role in affecting the size of the shadow economies in Transition countries as well as in the High Income OECD countries. The same conclusion had been made by Dell'Anno et al. (2007) for the cases of Spain, Greece and France. However, it is counter argued that the availability of informal jobs becomes limited when there is a contraction in the overall economy and when unemployment remains very high, because the availability of jobs, either formal or informal, decreases. Based on their findings, Alanon & Go'mez-Antonio (2005) as well as Macias & Cazzavillan (2010) concluded that the unemployment rate is a significant factor that negatively influences the size and development of the shadow economy in Spain and Mexico, respectively. Also, Buehn & Schneider (2008) concluded that unemployment, in the long run, has a negative effect on the French shadow economy. With reference to the overwhelming evidence, we argue that there is a positive relationship between unemployment and the shadow economy.

Hypothesis 4: The higher the unemployment, the larger the size of the shadow economy is, *ceteris paribus.*

v. Self-Employment

As another independent variable we added the self-employment quota as causal factor affecting the development of the shadow economy in Egypt. With reference to the literature, the rate of self-employment as a percentage of the labour force in the official economy is regarded as a cause of the shadow economy. The theoretical assumption is that the self-employed are highly motivated to avoid complying with tax regulations because they have a great number of legal and "illegal" tax deductions. Also, they enjoy direct business relationships with the customers,

which allows them to bargain with their customers to reach a "tax saving" agreement. Last, the self-employed are more inclined to employ irregular and informal employees because they have fewer and lesser auditing controls relative to bigger and formal organizations. Given the economic status in Egypt, in which the private sector grew only by 5% in 12 years, and the abundance of labor, the formal economy can't absorb the increasing number of the self-employed which "drives" them to turn to the shadow economy. Therefore, the expected sign of this variable is a positive sign. Studies by Dell'Anno et al. (2007) and Tedds (2005) found evidence to support the positive relationship between self-employment and the shadow economy.

> Hypothesis 5: The higher the self-employment rate, the larger the size of the shadow economy is, *ceteris paribus.*

2.1.2. Indicators

After considering various causes influencing the size of the Egyptian shadow economy, the MIMIC model requires the selection of different indicators that reflect the existence of the shadow economy.

i.Real GDP (index, base year 2005=100)

According to the literature (see below), the relationship between the shadow economy and the official economy is still ambiguous. On one hand, the correlation between the shadow economy and the official economy is positive, while on the other hand it is found to be negative.

Several scholars including Schneider et *al*. (2010) for 114 countries, Loayza (1996) for 14 Latin American counties, Buehn & Schneider (2008), Schneider & Williams (2013), Buehn & Farzanegan (2012) as well as Dell'Anno et *al.* (2007) for France, Greece and Spain have concluded that there is a negative relationship between the size of the shadow economy and the official one. An increase in the size of the shadow economy leads to a decrease in the official economy because productive resources and factors are absorbed by the shadow economy creating a depressing effect on the growth of the official economy (Schneider & Enste, 2013; Alanon & Go'mez-Antonio, 2005).

However, other scholars argued that there is a positive relationship between the growth of the shadow economy and the official economy. The shadow economy might allow poor people to find ways to produce and sell cheap products as a way of generating income. Hence, it is argued that the shadow economy grows along with the expansion in economic activities because the increased demand in the formal economy spills over into the informal economy leading to greater competitiveness and entrepreneurship. Based on their findings for Asian countries Schneider et al. (2003) concluded that there is a positive relationship between the growth in the shadow economy and the official economy. It is important to note that either way, the relationship between the shadow economy and the official one is not linear, yet the researchers must take care of the level of the development of the country at hand. Schneider (2005) argued that the relationship is negative for the case of developing, while it is positive for the case of developed and transition countries.

In our MIMIC model, the real GDP index (base year 2005=100) is used as an indicator to reflect the existence of the shadow economy in Egypt and to test the relationship between the shadow and the official economy. Since the shadow economy is not directly measured (latent variable), we will set the real GDP index as our reference variable and it is expected to have a negative sign. The value of the variable is fixed to -1 throughout the different model specifications.

> Hypothesis 6: The larger the size of the shadow economy, the lower the GDP is, *ceteris paribus.*

ii. Money in the hands of the public

Irregular and informal transactions are highly expected to be conducted mostly in cash rather than with credit/debit cards, checks or bank transactions in order to avoid detection by auditing controls and government officials. According to the Central Bank of Egypt, money supply increased as a result of an increase in the currency in circulation outside the banking system which rose by 24.2% in 2013 compared to 15.6% a year earlier and to 8.7% in 2009. Studies by various scholars such as Alanon & Go´mez-Antonio (2005), Buehn (2012), Dell'Anno et *al.* (2007), and Schneider et *al.* (2010) concluded that there is a significant and positive relationship between size of the shadow economy and currency held by the public. Therefore, in the MIMIC model, money growth is used as an indicator.

Hypothesis 7: The larger the size of the shadow economy, the larger the money held by the public is, *ceteris paribus*

iii. Total employment

The third indicator considered in the MIMIC model is total employment as a share of the total population. The shadow economy absorbs the economic agents from the formal ("official") economy to work informally leading to a reduction in the availability of human resources in the formal economy. Several authors, including Bajada & Schneider (2005), Dell'Anno et *al.* (2007) and Schneider et al. (2010), included the total labor force participation rate as an indicator of the increased informal activity reflected in the reduction of the labor force rate. However, the general definition of the labor force rate includes the total workforce legible and willing to work; hence employed and unemployed. Thus, we argue that focusing only on total employment gives us a more precise indicator of the shadow economy due to the movement of the economic agents to participate in informal activities. The existence of a relatively large shadow economy in Egypt might lead to the transfer of labour from the formal economy to the shadow economy.

Hypothesis 8: the larger the shadow economy, the lower total employment is, *ceteris paribus.*

To summarize, further causal and indicator variables have been used to estimate the size of the shadow economy around the globe[vi]. Those variables include labor force statistics (working hours, salaries and wages), government subsidies, social security contributions, or disposable income. Due to a lack of information for the period of our study (1976 to 2013) and for the case of Egypt, such variables were not included in the MIMIC model.

2.1.3. Estimation of the MIMIC model

For the case of Egypt, we use annual data from 1976 to 2013 for
(1) the share of total taxes in GDP,
(2) the polity IV index as a proxy for institutional quality,
(3) agricultural value-added as % of GDP,
(4) the unemployment rate and
(5) the self-employment rate

as the major causal variables affecting the size of the shadow economy in Egypt. In order to reflect the shadow economy activities, we use
(1) the real GDP index,
(2) currency outside the banking system and
(3) total employment as percentage of the total population

as indicators in our MIMIC model[vii.]

Before we conducted the MIMIC estimation, we tested our time series for unit root and co-integration. All of our time-series are non-stationary[viii], and they are co-integrated of order I=1. Based on the Johannsen Cointegration test, the Trace test indicates 4 cointegrating equations, and also the Max Eigen-value test indicates 1

cointegrating equation. Therefore, we use the time-series at levels in order not to lose the long-run association between the variables and to be able to estimate a long-run MIMIC model. Additionally, there are some assumptions that are violated by our time series. Firstly, based on the Mardia's normality test[ix], the assumption of multi-variate normality is violated. Secondly, the sample size is not large enough (n=38) which strongly influences the chi-square statistic[x]. In return, we used certain options in STATA 14 module in order to accommodate for these violations. In order to be able to relax the assumption of multi-variate normality, we used the Satorra-Bentler as a special option with the ML estimation to improve the chi-square statistic of goodness of fit in case of non-normal time-series (Satorra & Bentler, 1994). The Satorra-Bentler gives us the same parameters as the default ML estimation. Since the chi-square fit statistic is highly influenced by the sample size, we used the Swain scaling factor in the STATA 14 software to correct for the chi-square statistic in small samples and complex models.

Four different specifications of the MIMIC results are presented in Table- 2. Different specifications have been estimated in order to capture the magnitude and the effect of different causal variables on the size of the shadow economy. In specification 1, we start with a general specification including all the causal variables. While in specifications 2 and 3, we remove the insignificant variables in order to determine the most important variables that lead to the existence of the shadow economy in Egypt. In the last specification, we focus on the effect of total taxes along with other causal variables including agricultural importance and institutional quality.

Since that the shadow economy is a latent variable, then it is important to define a unit of measurement which is as percentage of GDP in order to have a meaningful interpretation of the how big the size of the shadow economy is. As being aforementioned, we fix the real GDP index to -1 along all MIMIC specifications. The choice of the sign of the reference variable is not arbitrary. There must be a theoretical logic behind choosing the reference indicator and its associated sign. The strategy to determine the sign of the coefficient of the reference variable is called ‚reductio ad absurdum' which is affected by theoretical assumptions. The importance of fixing this variable is to have unit of measurement to estimate the other variables as a function of this scale variable and to make the estimated coefficients more comparable (Dell'Anno et al., 2007). In our estimations, the reference variable is Real GDP index and is set to a value of -1.

To confirm that the associated sign (-1) of our reference variable in our MIMIC specifications is the correct sign, we have replicated the MIMIC specifications in Table- 2 while fixing the reference indicator (Real GDP index) to +1 and also relaxing our reference variable and constraining Money_Growth to +1[xi]. Firstly, we fix the reference indicator (Real GDP index) to +1. As a result, the signs of the causal coefficients change while keeping the same absolute values and significance levels. At this point, we, as researchers, have to make sure whether these signs are theoretically accepted and whether they agree with the empirical evidence in the literature of the shadow economy or not. Thus, the choice of normalizing the Real GDP index to -1 or +1 is based ontheoretical assumptions of the observed variables. In the specifications mentioned in Table-2, if we normalize the reference variable to +1, the signs of the observed causal variables change to be against the most widely accepted theoretical and empirical evidence in the literature of the shadow economy. This confirms that the choice of -1 is the right sign of the reference variable. Especially that it is rational to expect that the shadow economy absorbs human capital and resources from the official economy leading to negative externalities.

Instead of constraining Real GDP index to -1 as being our reference indicator, we further conducted another estimation while normalizing Money_Growth to +1 and leaving Real GDP index unconstrained in all the MIMIC specifications summarized in Table-2. Based on the outcomes, we confirm that the MIMIC results are robust when we fix the Money_Growth to +1 because the observed variables keep the same signs, coefficient values and significance levels. But for interpretation reasons, we normalize the Real GDP index to -1 as being our reference indicator to provide a meaningful interpretation of the shadow economy i.e. as % of GDP.

To summarize the MIMIC results, we can conclude that the causal variables behave as expected based on our theoretical considerations except for the unemployment rate and self-employment rate, which turned to be insignificant causes of the Egyptian shadow economy. The main driving factors of the shadow economy in Egypt are the tax burden, institutional quality measured by the polity index and the importance of the agricultural sector.
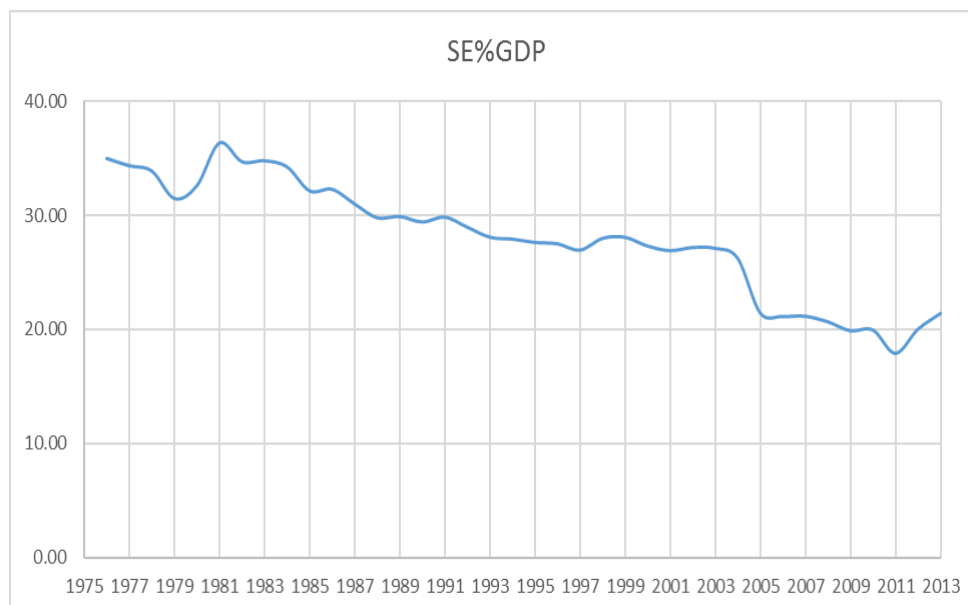
Table 3.*MIMIC estimation of the size of the shadow economy from 1976 to 2013, yearly data*

Variables/specifications	MIMIC1 5-1-3	MIMIC2 4-1-3	MIMIC3 4-1-3	MIMIC4 3-1-3
Causes				
Total Tax Burden	0.26***	0.29***	0.28***	0.33***
	(3.99)	(6.38)	(3.76)	(8.54)
Institutional Quality	-0.48***	-0.46***	-0.48***	-0.46***
	(-9.01)	(-9.34)	(-8.94)	(-9.29)
Agriculture Importance	0.26*	0.35***	0.33***	0.46***
	(1.75)	(2.67)	(2.44)	(7.48)
Unemployment Rate	-0.10	-0.13		
	(-0.70)	(-0.94)		
Self Employment	0.15		0.17	
	(1.07)		(1.17)	
Indicators				
Real GDP Index	-1	-1	-1	-1
Money	0.66***	0.65***	0.67***	0.65***
	(13.01)	(11.38)	(13.43)	(11.65)
Total Employment	-0.86***	-0.81***	-0.82***	-0.82***
	(-14.28)	(-14.51)	(´14.27)	(-14.54)
Statistical tests				
Chi2	25.98	14.63	22.93	11.55
Pvalue	(0.0038)	(0.0668)	(0.0035)	(0.0728)
Swain corrected chi2	23.44	13.37	25.59	10.69
Pvalue	(0.0092)	(0.0996)	(0.0012)	(0.0983)
GFI	0.87	0.93	0.90	0.95
AGFI	0.94	0.97	0.97	0.99
CFI	0.911	0.961	0.917	0.967
SRMR	0.053	0.050	0.058	0.053
CD	0.986	0.973	0.987	0.973
Degrees of freedom	35	27	27	20

Notes: Absolute z-statistics are reported in parenthesis. *, **, *** denote significance at 1, 5 and 10% significance levels. [1]The statistical test reflecting the quality of models (2 and3) are highly acceptable. Goodness of fit index (GFI): values closer to 0.90 reflect a perfect fit. Adjusted GFI: GFI corrected for degrees of freedom. CFI: when the comparative fit index is closer to one, it indicates a good model fit. SRMR: The values less than 0.08 indicate a good model fit. Coefficient of Determination (CD): A perfect fit corresponds to a CD=1 (Kline, 2011). Degrees of freedom=0.5(p+q)(p+q+1)-t, where p:number of causes, q=number of indicators, t=number of free parameters.Source: Own calculations

Based on the MIMIC specification (MIMIC4), we are able to calculate the size of the shadow economy in Egypt from 1976 to 2013[xii] and to visualize the trend and development of the shadow economy as being shown in graph 1. The trend of the shadow economy is decreasing from 35% of official GDP in 1976 to 21% in

2013. On average, the size of the shadow economy based on the MIMIC model during the period under study is equal to 30% of GDP.

Graph 1. *Size and development of the Egyptian shadow economy using the MIMIC model, in % of GDP.*
Source: Own Calculations

2.2. The Currency Demand Approach

2.2.1. Currency Demand Model

The second method applied to estimate the size of the shadow economy is the currency demand approach (CDA) which is one of the most widely-used[xiii] indirect methods. The CDA is a monetary approach, mostly referred to as the indicator approach, which measures the discrepancy between the declared/official income and the income covered by the currency demand. The CDA is a macroeconomic approach, too, that uses various variables containing information on the development of the shadow economy over time. The CDA is different from the MIMIC model in the way that the former measures the shadow economy indirectly by focusing on traces that the shadow economy leaves in official statistics, while the latter deals with the shadow economy as a latent variable that is directly influenced by different observable variables.

The pioneers to apply this method were Cagan (1958) for the case of the United States followed by Gutmann (1977) and Feige (1979). Tanzi (1983) further developed this approach by assuming that the tax burden is one of the core causes of the shadow economy which is then channeled through the excessive demand and use of cash. The main assumption of the CDA is that informal transactions conducted in the shadow economy are mainly in cash in order to avoid any trace of evidence for the official authorities. Any excess demand of cash is then attributed to the variables controlling for the shadow economy. In that sense, an increase in the informal activities in an economy would lead to an excessive use of cash. Therefore, if we can estimate the amount of excessive cash used in the informal activities, then we can estimate the size of the shadow economy by multiplying the amount of cash used in the shadow economy by the income velocity of currency.

Formally, there are two steps when estimating the size of the shadow economy by the CDA. The first step is estimating the demand for currency, both for the formal transactions in an economy and also for the informal ones involving the

motivation to cover up income. Following the typical Cagan (1958) currency demand function,

$$C_0 = a(1 + \Theta)^\alpha Y_0^\beta \exp(-\gamma i) \tag{3}$$

where C_0 is observed cash and Θ represents the incentive variable that motivates individuals to conduct informal activities which can be approximated by the tax burden or the intensity of government regulation. This variable is the key variable in the CDA because an increase in Θ is expected to have a positive impact on currency demand because people are highly motivated to participate in the shadow economy, hence demanding more cash for their informal transactions. Y_0 is the official real GDP which represents the level of transactions in an economy. i is the interest rate or inflation rate representing the opportunity cost of holding cash. Finally, the A, α, β, and γ are the parameters.

From equation (3), we are able to estimate $\hat{C}$ which is the amount of currency demand in both economies, the formal and shadow economies. Then, when we set the incentive variable (Θ) to the minimum values, we are able to obtain $\acute{C}$. The difference between $\hat{C}$ and $\acute{C}$ gives us the extra currency in an economy, i.e. the illegal money used in the shadow economy to conduct informal transactions. By multiplying the extra currency by the income velocity of currency, we are able to estimate the size of the shadow economy.

2.2.2 Estimation of the CDA

For the case of Egypt, we use annual data series to cover the period from 1976 to 2013[xiv]. In order to capture the long-run effect of the explanatory variables on currency demand, we model the following specification:

$$C_t = \beta_0 + \beta_1 Y_t + \beta_2(1 + TAX_t) + \beta_3 REG_t + \beta_4 SELF_t + \beta_5 R_t + \varepsilon_t \tag{4}$$

where C_t is the natural logarithm of currency in circulation outside the banking system normalized by the GDP deflator, Y_t is the natural logarithm of real income (GDP), TAX_t is the natural logarithm of total tax revenues normalized by real GDP, REG_t is approximated by public employment in relation to total labour force as being our regulatory indicator in the model, $SELF_t$ corresponds to the ratio of self-employment to labour force, and R_t is the natural logarithm of the nominal deposit interest rate representing the opportunity cost of holding money. ε_t is the error term.

In addition to the typical independent macro-economic variables (tax burden and regulation intensity measured as the share of public employees in % of total employment) related to the size of the shadow economy, we added self-employment as a percentage of total labour force as an additional variable to capture the incentives of people participating in the shadow economy and thus increasing the demand for currency[xv]. Egypt is characterized as being a labor-abundant country with an increasing population. The new phase of industrialization since the 1952 revolution focused solely on the capital intensive industries rather than on the labor intensive industries which in return did not create more employment opportunities neither in the public nor in the private sector which then pushed people to seek self-employment opportunities. Not only that, but also the entry regulation in Egypt is burdensome. Based on a study by Djankov et al. (2002), they concluded that a new entrant to the market in Egypt must at least go through 11 procedures at governmental agencies and wait at least 51 business days to obtain a legal status to operate a business. Due to the bureaucratic environment compared to other countries[xvi], entrepreneurs are motivated to be self-employed

and operate informally. We expect that income, taxes, public employment and self-employment have a positive impact on currency demand while we expect a negative impact of interest rates on currency; encouraging individuals to avoid excessive holdings of currency as the opportunity cost of holding cash increases.

Before starting with the estimation of equation (4), we tested our time series for the presence of unit root and cointegration. Based on the results of the unit root test from the Augmented Dicky-Fuller (ADF) test[xvii], the time series are strongly non-stationary at level but when taking the first differences, the time series become stationary. Since the variables are all integrated of the same order I(1), we further test for cointegration based on the Johansen Cointegration test. Before running the Johansen Cointegration test, we determined the optimal lag length estimating a VAR model using the raw data. The optimal lag length is 1 according to LR, FPE, CS and HQ. With reference to the Johansen Cointegration test, the trace test indicates 2 cointegrating equations at the 5% and the max-eigenvalue test shows 1 cointegrating equation at the 5%. We can then conclude that at least 1 cointegrating relationship exists between the variables in the long-run. Given these results, the non-stationarity of the time series and the presence of a long term association between the variables allow us to estimate the currency demand based on our specification and measure the size of the shadow economy by using the vector error correction model (VECM). This type of VEC model is superior to the standard estimation methods because it allows us to capture the short- and the long-run effects. Several authors, including but not limited to Macias & Cazzavillan (2009) and Hernadez (2009), have used the VEC currency demand model to estimate the size of shadow economy.

As being expected, in model (1), as in Table-3, which corresponds to our specified model in equation (4), the coefficients for income, total tax burden, intensity of regulation and self-employment have a positive and strongly significant long-run effect on currency demand. Also, as expected, interest rates have a significant reducing effect on currency demand. It is important to note that an approximation of currency complements such as the usage of debit/credit cards or an approximation of bank transactions were not controlled for in the CDA specification due to data limitations.

Table 3. *Estimating the currency demand from 1976 to 2013, yearly*

Independent variables	(1)
C_{t-1} (real currency outside banks)	1.00
Y_{t-1} (real income)	1.46***
	(0.056)
	[25.49]
TAX_{t-1} (total tax burden)	0.67***
	(0.093)
	[7.25]
R_{t-1} (interest rate)	-0.15**
	(-0.056)
	[-2.66]
REG_{t-1} (public employmnet)	0.04***
	(0.010)
	[4.13]
$SELF_{t-1}$ (self employment)	0.20***
	(0.013)
	[14.94]
Constant	-18
ECT_{t-1}	-0.27*
	(0.16)
	[1.65]
Adj R^2	0.40
Autocorrelation LM test	22.23
	Pvalue 0.9650
White test	288.82
	Pvalue 0.5744

Notes: All variables are in natural logarithm. The models are estimated with one cointegrating equation. Standard errors are in parentheses () and T-statistics in []. ***, **, * significant at the 1%, 5% and 10% level. The autocorrelation LM test indicates that there is no residual serial autocorrelation since that the p-value is greater than 5%. Source: Own calculations

After estimating the VEC currency demand model, we are able now to calculate the size of the shadow economy. The first step is to calculate currency demand in both formal and shadow economies $\hat{C}$, then we set the tax burden, public-employment and self-employment to the minimum level while keeping all else unchanged to estimate ($\acute{C}$). The difference between $\hat{C}$ and $\acute{C}$ gives us the extra currency (EC) in the economy. Assuming equal income velocity of currency (*V*) in both the formal and the shadow economies (Tanzi, 1983), the size of the shadow economy is estimated by multiplying the EC with the velocity[xviii].

$$Yinformal \ = \ EC * V \tag{5}$$

Based on equation (5), we can then infer the size of the shadow economy in Egypt as a percentage of official GDP and approximate the evolution of the size of the shadow economy in Egypt from 1976 to 2013.

It is important to note that the key assumption that the velocity is equal in both economies only holds when the coefficient of Y is equal to one ($\beta=1$). However, as being reported in Table-3, the coefficient of Y in our specification is different from one ($\beta=1.46$). As a result, we need to correct our results following the proposed method by Ahumada et al. (2007).

$$\frac{Y_{informal}}{Y_{formal}} = (\frac{C_{informal}}{C_{formal}})^{\frac{1}{\beta}} = (\frac{\hat{Y}_{informal}}{\hat{Y}_{formal}})^{\frac{1}{\beta}} \tag{6}$$

where Y and C are GDP and money, respectively, while β is the income elasticity. Based on this method, the estimates of the size of the shadow economy are corrected when β is not equal to 1. This correction method has been applied in recent studies including Macias & Cazzavillan (2009), Hernandez (2009) and Pickhardt & Sarda (2010; 2011). Based on this modified CDA, the size of the shadow economy in Egypt in % of GDP based on model (1) is shown in the following graph2.
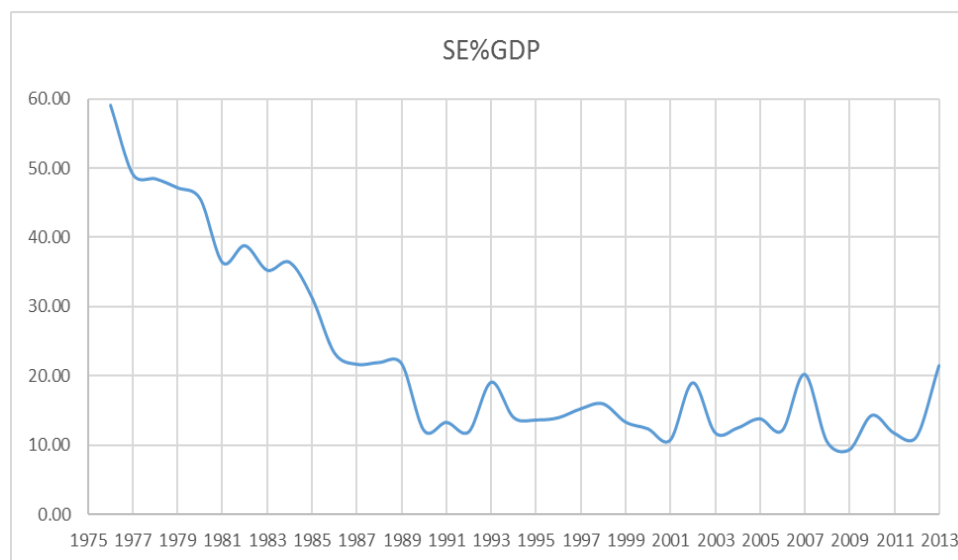
Graph 2. *Size and development of the Egyptian shadow economy in % of GDP using CDA*
Source: Own calculations

As can be seen from graph 2, the shadow economy in Egypt constituted a major portion of official GDP until the mid-1980s with a decreasing tendency. However, starting in the early 90s, it stabilizes on average between 20%-15% of GDP.

3. Analysis and Implications

As can be seen from the trend of the shadow economy in Egypt[xix] in graph3, the largest size of the shadow economy based on the MIMIC and CDA models was evidenced at the beginning of the period under study reaching on average 33% and 50% of GDP, respectively. This large value can be explained by the major recessions of the economy after the 1973-war with Israel. During the 70s (from 1973 to 1978), the Egyptian economy was still suffering from the war time. The Egyptian government had focused on funding the military expenditure by purchasing weapons and rebuilding as well as improving the military infrastructure that was destroyed in the defeat of the 1967 war and also many Egyptians had left their employment positions in order to join the military and fight in the war. The Egyptian economy was burdened not only because of the shift of funding to the military but also due to the major economic losses during the war time that included losses in tourism revenues, losses in capital resources and Suez Canal revenues. Therefore, the government needed to undertake necessary policies to restore the military infrastructure and to find ways to fund its military spending. These policies included raising the direct and indirect tax revenues, with direct taxes increasing by 47% and indirect taxes increasing by 22% from 1970 until the early 1980s. Not only that, but also the central bank printed more money to raise funds to cover up military spending. As a result of these policies, the size of the shadow economy in Egypt during this war time and after the war reached its

highest share of GDP of the observed period; reaching on average more than 50% of GDP.

During the 80s and 90s, the size of the shadow economy was fluctuating with a decreasing trend. This decreasing trend is attributed to the major reforms that were executed under the Mubarak regime (1981-2011). Mubarak launched the first five-year plan of reforms in 1982. The aims of this five-year plan were to increase local industrial activity by imposing tariff barriers to protect domestic industries, lower interest rates on industrial loans and lower taxes on industrial projects. These policies helped the industrial sector to grow. Further down the road, in 1991, Egypt signed agreements with the IMF and the World Bank to receive external funding and aid. It is important to note that foreign aid resulted in economic growth in Egypt. Along with growth in industrialization and the manufacturing sector, the role of the dominating agricultural sector decreased over time. The role of the private sector increased due to an attempt to increase privatization of the state-owned companies in order to strengthen industrialization.

Not only that, but also the major drop in the size of the shadow economy starting 2005 is due to the major economic reforms that the Egyptian government executed in 2004/2005. These major economic reforms focused on improving the tax system in Egypt which resulted in initiating a new tax law. The goal of this tax reform was to simplify the tax law and to induce the same and equal tax burden for all businesses and economic units without any exceptions, tax holidays or special considerations in order to create a fair tax treatment for everyone as well as to encourage tax compliance. There was a media campaign by the end of 2004 to inform the public about the major changes and improvements and to create an environment of trust between the tax authority and the tax payer. In 2005, Law 91/2005 was approved by the Egyptian parliament which put into action a reduction of tax rates, a clarification and simplification of the tax law and, most importantly, an improvement of the tax administration to be more transparent. One of the major benefits of this reform was the decrease in tax evasion as the government and the tax authority announced under the new law that there shall be a 'forgiven act' for whoever was evading paying taxes, on the condition that they register themselves in the tax authority within a certain period of time which in return resulted in the formalization of many informal activities. Thus, the reduction in the tax rates along with the major improvements of the tax authority discouraged the public to evade taxes and engage in the shadow economy which can be seen in the reduction of the size of the shadow economy during this period and in the major increase in tax filings by 50%.

Since the 2011 revolution, Egypt has been suffering from political and economic instability, thus we can conclude mixed results. At the year of the revolution, the size of the shadow economy was at its smallest (12% and 18% based on the CDA and MIMIC model, respectively) as the individuals were revolting for better economic performances and development. However, the years following the revolution suffered from the lowest official economic growth (1.7% growth in 2011 followed by a 2% growth in 2012) and many people have lost their jobs due to the contraction in the economy and due to political instability as many, especially international organizations, have closed and moved their operations elsewhere. Given increasing unemployment during those years (from 9% in 2010 to 13.2% in 2013) and a contracting economy, many people were attracted to join the shadow economy as a safe harbor to earn income and to buy cheaper goods. As a result, the shadow economic activity rose in Egypt in the aftermath of the revolution reaching 21% of GDP.
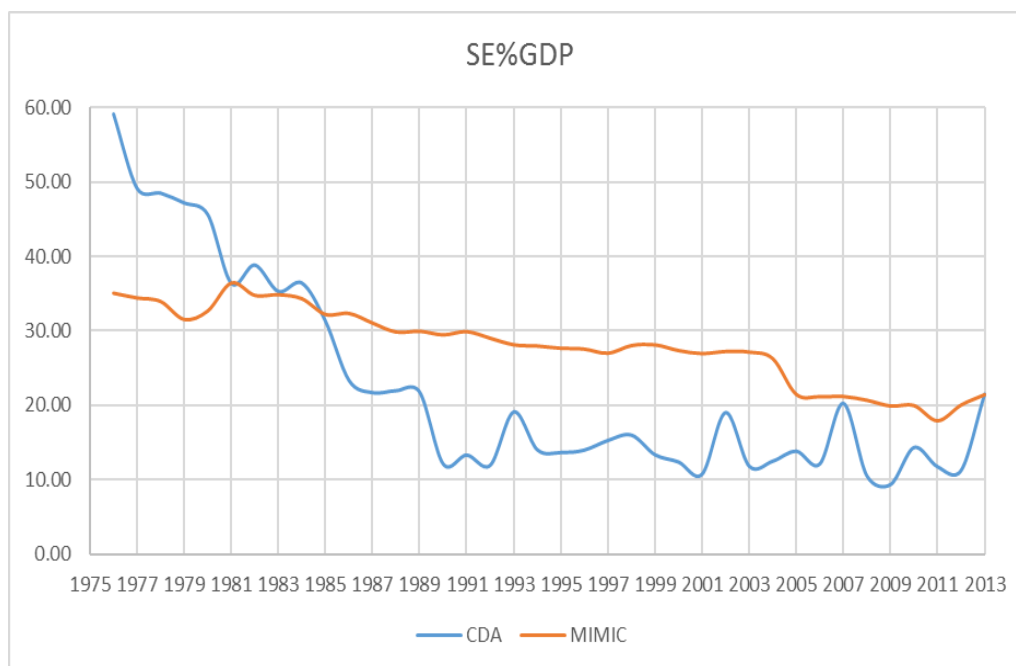
Graph 3. *A comparison of the size and development of the Egyptian shadow economy using the CDA and MIMIC model, 1976 to 2013*
Source: Own calculations

Since the tax burden plays a significant role in influencing participation in the shadow economy, our recommendation is that policy makers should implement major tax reforms and introduce educational campaigns in order to improve tax compliance and increase tax morale. Egypt has the highest tax rate bracket on income (32-40%) compared to its neighboring MENA countries like Lebanon or Jordan (charging 15%). Not only that, Egypt suffers from a lack of trust between the tax payers and the tax authorities. As a result, a new major tax law reform was executed in 2005 to reduce tax rates and to clarify tax rules in order to increase tax payments and compliance. The outcome of this reform was an increase in tax filings by 50% which is also reflected in the downward trend in the size of the shadow economy after the reform was being introduced.

Yet, it is important to highlight that the implementation of tax reforms should be accompanied by improvements in the quality of institutions. Thus, the dynamics of the tax burden with the quality of institutions should not be ignored by the officials. As concluded from the MIMIC findings, the quality of institutions significantly affects the peoples' perceptions and motivation to engage in informal activities. Therefore, we urge the policy makers to increase the quality of institutions by creating a democratic transparent environment and by reducing bureaucracy and over-regulation.

For the case of Egypt, it is the first time to test for the quality of democratic institutions. Based on the MIMIC specification (4), the relative impact of democracy is 46%. Democracy has become an important issue for Egypt since the outbreak of the revolution in 2011, as one of the main goals of the revolution is to create a democratic environment. Not only that, but also democracy plays an important role affecting the citizens' motivation to participate in the shadow economy. Firstly, in a democracy, there is an increased public participation. Democracy grants the public the right to be actively involved in the policy making process through their voting rights. For instance, if tax payers can vote on how taxes will be spent, then they will be less motivated to evade taxes by engaging in

the shadow economy. Democracy ensures that the public's opinions and priorities are heard and most importantly accounted for in the public policies. Therefore, the implemented policies are efficient, reflect public preferences and lead to better public spending on goods and services. This democratic public involvement enhances trust between the government and the public and increases the publics' civic virtue and tax morality which in return reduces shadow economy participation. Secondly, democracy grants the public the 'voice option' to be able to monitor and hold the government liable and accountable. This in return improves the legitimacy of the government through controlling the government's policies via referenda or threat of ballot. Also, the voice option reduces the policy-makers' conflict of interest and rent-seeking activities which in return improves the public's perception of the government (Solomon & Schrestha, 2014; Teobaldelli & Schneider, 2013; Torgler & Schneider, 2007). As being shown in the MIMIC outcomes, we can conclude that democracy lowers the incentives of the individuals to participate in the shadow economy. Therefore, the government needs to improve its quality of institutions and to create a democratic and trustworthy environment between the government officials and the public in order to discourage people to engage in informal activities.

In order to be able to determine the major factors that affect the development and size of the shadow economy in Egypt, the importance of the agricultural sector as measured by agricultural value-added as % of GDP should not be neglected. As per the findings, we can conclude that a large and dominating agricultural sector significantly affects the shadow economy in Egypt. The country's economic structure highly depends on the agricultural sector as a source of growth and support for other economic sectors. Figures show that total agricultural production increased by 20% during the last decades and employment in agriculture is larger compared to employment in the industrial sector. Due to the importance of the agricultural sector, the structural adjustment program in 1987 and the major policy reform in the 1990s focused on increasing agricultural production and income. Given the lack of proper education for Egypt's growing population and the concentration of households in rural areas, individuals highly depend on farming and agriculture-related activities as a source of income. Therefore, we can conclude that given the importance of the agricultural sector in Egypt and given its significant effect on the shadow economy, the government needs to efficiently formalize the agricultural sector by providing incentives for the public engaging in agricultural activities to discourage them from being informal.

It is interesting to note that the unemployment rate has a negative effect on the size and development of the Egyptian shadow economy which is contrary to what we hypothesized. Such a behavior can be explained by the argument that job opportunities are also unavailable in the shadow economy in countries in which unemployment is steadily high. With reference to Egypt, the unemployment rate has been increasing steadily throughout the years from 1.6% in 1973 to 9% in 2000 and to 13% in 2013. This shows that the overall economy has been contracting and in a recession, as being reflected by increasing unemployment, which makes it harder to find employment in both the formal and the informal economy. Also, this effect is reinforced by the study of Schneider et al. (2010) in which they concluded that high unemployment rates for the case of developing countries including Egypt do not necessarily lead to a larger size of the shadow economy.

A final policy implication is based on the finding that the coefficient of the official economy and the shadow economy is negative. This draws our attention to the conclusion that when the official economy grows, then people are discouraged to undertake informal activities resulting in the efficiency of the market economy and in the formalization of the shadow economy.

4. Challenges to estimate the unobservable shadow economy

It is important to note that there is no consensus in the literature on the best method to estimate the size of the shadow economy, therefore we apply two of the most widely used approaches to approximately estimate the size as well as the development of the shadow economy in Egypt by using both the CDA and MIMIC model to capture the dynamics of the complex nature of the shadow economy.

Although the CDA is one of the mostly used methods[xx] to estimate the size of the shadow economy, it has been subject to major criticisms:

(1) The main assumption of the method is that all transactions are conducted in cash to avoid traceability. However, not all informal transactions are made in cash.

(2) The method ignores the possibility of a barter shadow economy leading to the undervaluation of the total size of the shadow economy. Based on their survey, Isachsen and Strom (1985) concluded that approximately 80% of the informal activities in Norway were conducted in cash.

(3) The assumption of no shadow economy in a base year is highly criticized.

(4) The assumption of the equal velocity of money in both the formal and the shadow economies is among the highlighted limitations of the CDA.

(5) Another important criticism is that most of the CDA models consider only one variable, which is the tax burden (Schneider, 1986). Moreover, the CDA considers only one indicator, hence currency, to reflect the shadow economic activities.

Quite often the MIMIC model is considered superior to the CDA because the MIMIC model allows the researcher to consider several causes and indicators at the same time to model the evolution of the shadow economy over time. But like any other econometric model, the MIMIC model face some limitations:

(1) The application of the MIMIC model to small sample sizes and time series analysis due to non-stationarity and non-normality of the time series.

(2) The choice of the observed variables to be a causal or an indicator variable. For instance, unemployment rate can be regarded as a causal variable leading to the development of the shadow economy. At the same time, unemployment rate can be regarded as an effect of the existence of the shadow economy in a certain country.

(3) Since that the shadow economy is a latent variable, it is challenging when it comes to defining the shadow economy and to make sure that the shadow economy defined is the one being measured by the MIMIC model and not a similar variable. In order to address these limitations (2) and (3), the researcher needs to firstly clearly provide a detailed and well-explained theoretical background of choosing the observed variables as causal and indicator variables as well as to provide a clear cut definition of the shadow economy that the researcher is intending to measure by the MIMIC model.

(4) Another complexity of the MIMIC model is that it only provides an index of the size of the shadow economy, therefore an additional step is needed to be conducted to convert this index to actual values of the shadow economy as % of GDP (Dell'Anno, 2007; Dell'Anno & Schneider, 2009; Schneider & Williams, 2013).

Since each method has its own strengths and weaknesses and since the shadow economy is by nature untraceable, the estimates of the shadow economy should be interpreted as an approximation of the size of the shadow economy, rather than being exact measures. We gain information from the methods on the most important factors that influence the proliferation of the shadow economy and about the trend and development of the shadow economy in Egypt.

In conclusion, there is no best or commonly accepted method to estimate the size of the shadow economy. Although that each method has its own limitations, the MIMIC model provides the most extensive reflection of the development of the size of the shadow economy over time while considering various causes and indicators and has been widely used in the last few decades. It is important to acknowledge that there is no exact measure of the shadow economy, in all the cases, we intend to measure economic activities that are, by nature, unrecorded.

5. Conclusion

Both methods; CDA and MIMIC models, came to the same conclusion that the shadow economy accounts for a major proportion of the official economy, yet it has a decreasing trend over time. Our MIMIC results show that the shadow economy in Egypt accounted for more than 35% of GDP by the start of our study (1976) and decreased to 23% of GDP in 2013. As can be seen from Table-4, all of our hypotheses have been confirmed by both the MIMIC and CDA, except for the impact of unemployment on the shadow economy in Egypt. It can be concluded that a high level of unemployment in Egypt does not necessarily lead to a larger size of the shadow economy.

Table 4. *Empirical confirmation of our hypotheses*

Variables (Hypothesized sign)	Method(s)	Result
(1) Total tax burden (+)	MIMIC CDA	Both Confirmed
(2) Quality of democratic institutions (-)	MIMIC	Confirmed
(3) Size of agricultural sector(+)	MIMIC	Confirmed
(4) Self-employment (+)	MIMIC CDA	Both Confirmed
(5) Regulation (+)	CDA	Confirmed
(6) Unemployment (+)	MIMIC	Negative insignificant
(7) Official GDP (-)	MIMIC	Confirmed
(8) Currency (+)	MIMIC	Confirmed
(9) Total employment (-)	MIMIC	Confirmed

Notes: Source: Authors

Our study provides an example of the evolution of the shadow economy in a developing country focusing on the case of Egypt. Our first conclusion is that the shadow economy has a decreasing trend, yet it accounts for a large portion of GDP. Secondly, the stagnation of the shadow economy at a high proportion of GDP during the last decade reflects the failure of public policies to tackle the shadow economy and to drive economic growth. Thirdly, Egypt is a labor-abundant country with an increasing population of 88 million inhabitants and a 610 billion Egyptian Pounds worth of GDP in 2013. The forth conclusion is that the shadow economy accounts for a huge weight on the official economy leading to some negative externalities and thus deterring the development of the country. However, for the case of a developing country like Egypt, the shadow economy is not necessarily seen as a foe to the formal economy. The shadow economy creates stimulating effects because the income earned informally is later spent in the formal economy. Also, the shadow economy adds to the dynamics of the formal economy by creating markets that otherwise would not be possible such as small scale production and services. Additionally, the shadow economy can act as an employer of last resort where people find job opportunities not otherwise possible, for example during recessions and crises. The shadow economy in Egypt acted like a sponge absorbing all the people that were laid off as a result of the economic and political instability that happened in Egypt after the 2011 revolution.

The big challenge for policy makers is to know to what extent they should tackle the shadow economy. It is interesting to note that to some extent the shadow economy is "good" for a developing economy and that the shadow economy provides stability. The Arab Spring movement that started in 2011 was triggered by an informal street vendor who set himself on fire because the police officers detained him from performing his informal activities. From our results, the policy makers can identify the major factors that influence peoples' incentives to participate in the shadow economy in order to be able to correctly channel their policies and reforms and formalize the shadow economy. Most importantly, policy makers need to focus on the quality of institutions by creating democratic and transparent institutions with lower regulatory burden, corruption and bureaucracy in order to be able to restore the trust and confidence of the economic agents in the overall system of the country and to be able to have effective strategies to reduce the Egyptian shadow economy.

We finally recommend that a future line of research should analyze the Egyptian shadow economy from a micro-level approach such as conducting direct surveys in order to provide a deeper understanding of the dynamics of the shadow economy, the profile of the participants and their motivations.

Notes

[i] Egypt continually suffers from an inefficient state control, a dominant public sector, rising debt levels and a stagnant private sector.

[ii] A brief description is given in the appendix (A1).

[iii] For the theoretical explanation of the variable, refer to sections (2.2.2 and 2.2.3)

[iv] For a brief description of the MIMIC model specification, we refer to the appendix (A1.2)

[v] The Benchmarking step is explained in detail in section A1.3 in the Appendix

[vi] To mention a few, Alanon & Go'mez-Antonio (2005), Dell'Anno et al. (2007), Tedds (2005), Schneider et *al.* (2010), Buehn & Schneider (2008) and Loayza (1996).

[vii] A detailed explanation of the variables is provided in the appendix table (A.3).

[viii] The Augmented Dicky Fuller unit root test is provided in the appendix table (A.1)

[ix] Three of the multivariate normality tests reject Ho (multivariate normality) at the 5% significance level.

[x] The chi-square fit statistic will tend to over-reject correctly specified models in case the ratio of the sample size to the number of the parameters is relatively small. Also, multivariate normality is an underlying assumption in the chi-square test (Kline, 2011).

[xi] Details of the specifications and the outcomes are provided in Tables A.5 and A.6 in the Appendix

[xii] The calibrated values of the size of the shadow economy are provided in the appendix table (A.7). For the starting values of the calibration procedure we used our estimates from the CDA approach for the year 2013.

[xiii] See also Tanzi (1983) being the first, Schneider (1986), Schneider & Enste (2000), Caridi & Passerini (2001), Bajada & Schneider (2005), Alm & Embaye (2013) and Ardizzi et al. (2014).

[xiv] A detailed explanation of the variables is provided in the appendix table (A.4).

[xv] Some theoretical considerations about the causal variables of the shadow economy are in section 2.1.1.

[xvi] For example, in Tunisia or Israel, one must go through 9 or 5 procedures and wait 41 or 32 days, respectively.

[xvii] See appendix table (A.2). These tests were run by Eviews 8.

[xviii] The income velocity of currency is extracted from the economic bulletin published by the Central Bank of Egypt.

[xix] Both the CDA and the MIMIC model show a downward trend of the development of the Egyptian shadow economy. The correlation coefficient between the two series is highly significant at 0.7235 (0.0000).

[xx] See also Tanzi (1983) being the first, Schneider (1986), Schneider & Enste (2000), Caridi & Passerini (2001), Bajada & Schneider (2005), Alm & Embaye (2013) and Ardizzi et al. (2014).

Appendices

A1. Measuring the shadow economy

A1.1 General Remarks

There are various ways to estimate the size of the shadow economy for a certain country. These methods include the direct method, indirect method and the model approach. The direct method which is also called the microeconomic approach helps to gather first-hand data about the shadow economy by having contacts with or observations of individuals or firms. This approach is used extensively by various scholars such as Isachsen & Strom (1985), Gërxhani & Van De Werfhorst (2013) or Williams (2006) to understand intensely the nature of the shadow economy. Examples of the direct method are well-designed and sampled surveys as well as auditing of tax returns and other compliance methods. The limitation of this direct method is the cooperation and response of the representatives questioned in the sample. In the case of carrying out direct questionnaires, there is high chance that the respondents are reluctant to answer questions related to informal work and income. Although, the direct method provides detailed information about the structure and composition of the shadow economy in a certain country but their major disadvantage is that they do not reflect all the shadow economic activities and that they result in only point-time estimates of the size of the shadow economy. The direct methods are unable to estimate the development and growth of the shadow economy over a long period of time and are lower-bound estimates for the true size of the shadow economy (Schneider & Enste, 2013; Dell'Anno et *al*., 2007).

The second approach to measure the size of the shadow economy is indirect; mostly referred to as the 'indicator' approach. Indirect methods are macroeconomic approaches capturing the traces that the shadow economy leaves in the official statistics as information on the size of the shadow economy. The major criticism is that they only consider one aspect that is supposed to capture all the effects and the complexity of the shadow economy. The four main indirect methods[xx] are

1. The discrepancy between national expenditure and income statistics.
2. The discrepancy between official and actual labor force.
3. The monetary methods: CDA.
4. The physical input (electrical energy consumption) method.

The last method to estimate the shadow economy is called the statistical model or Multiple Indicator Multiple Cause (MIMIC)[xx] which will be discussed in detail in the following sections. The MIMIC model is a particular type of structural equation modeling which is commonly applied in social science research such as in psychology or sociology. The model is based on the statistical theory of 'unobserved' variables developed by Zellner (1970) and Joreskog & Goldberger (1975). The pioneers to apply the MIMIC model in their estimation of the shadow economy as a latent variable were Frey & Week-Hannemann (1984) to measure the size of the hidden economy for OECD countries from 1960 to 1973. Following them, various scholars including but not limited to Tafenau et al. (2010); Tedds (2005); Schneider et al. (2010); Dell'Anno (2006); Buehn & Farzanegan (2012), Farzanegan (2009); Chaudhuri et al. (2006) have also applied this model approach in the estimation of the informal economy.

A1.2. MIMIC Model Specification

The MIMIC model is superior to the other methods because various observable and measurable causes and indicators are considered at the same time regarding this complex and unrecorded nature of the shadow economy.

The MIMIC model estimates the relationship between observable variables and a latent variable (shadow economy) by reducing the distance between the sample covariance matrix S and the covariance matrix $\sum (\theta)$ predicted by the model.

Both the structural disturbance term ς and the measurement error term ε_p are independent and are assumed to follow a standard normal distribution with a mean of zero and constant variance (Dell'Anno & Schneider, 2009).

The most widely used estimation method for the MIMIC model is the Maximum Likelihood (ML) estimation. ML estimation a) measures how close is the population covariance matrix to the sample covariance matrix and b) finds the values of the parameters

that produce the population covariance matrix that is as close as possible to the sample covariance matrix. Our aim is to minimize the distance between the population covariance matrix and the sample covariance matrix in order to reach a perfect fit of the model (Schumacker & Lomax, 2010). There are four important assumptions that need to be met when estimating the MIMIC model:

1. The variables must be multi-normally distributed[xx].
2. The variables must have a linear relationship.
3. The distribution of the residuals must be homoscedastic.
4. Large sample sizes. The sample size should not be less than 50.

In addition, one must test whether the time-series is stationary or not. A further step based on the outcome of the unit root test, one must test whether the variables (both the causes and the indicators) are co-integrated or not.

The chosen MIMIC model is based on several model fit characteristics. It is important to note that we should not depend solely on the chi-square fit statistic when evaluating the model fit because it is very sensitive to sample size and the multivariate normality assumption (Singh, 2009, Iacobucci, 2010). In addition to the chi-square statistic, we observe the (adjusted) goodness of fit index and other fit indexes that are based on the covariance residuals including the CD, CFI and standardized RMR (SRMR). The SRMR is a good evaluation of whether the researcher's model captures the data because it is not much sensitive to violation of distribution assumptions (Iacobucci, 2010). There is an agreement in the literature that ideally, the researchers report the chi-square statistic along with the degrees of freedom, CFI and the SRMR (Iacobucci, 2010). For a perfect model fit, the chi-square needs to be insignificant (p>0.05), the GFI to be closer to 1, the CFI closer to 0.95 and the SRMR closer to 0.09 (Hu & Bentler, 1999). Other fit statistics to evaluate the model include the RMSEA. RMSEA is a popular statistic to evaluate the model fit where a value of zero indicators a perfect fit, yet it is not preferable in case of small sample sizes; i.e. N≤200 (Hu & Bentler, 1998). Given the technicality of the RMSEA calculation, the model degrees of freedom and one less than the sample size are in the denominator, therefore the RMSEA value decreases as the sample size increases showing how the RMSEA is influenced by the sample size due to the fact that small sized samples have few degrees of freedom which in return intensifies the RMSEA (Kline, 2011).

A1.3. Benchmarking procedure

Notably, the MIMIC model provides an estimation of a relative evolution of the size of the shadow economy over time; meaning that it only yields ordinal estimates of the size of the shadow economy. Thus, an additional final step is required to calculate the size of the shadow economy in a meaningful way, hence as percentage of GDP. This last step is called a benchmarking step or procedure. In the literature, there is a wide discussion of the different benchmarking procedures to be applied, but there is no agreement on which procedure is superior to the other[xx]. The following benchmarking procedure[xx] is applied to calibrate the ordinal estimates into cardinal values and convert this index to % units (real values). This requires that a prior estimation of the Egyptian shadow economy to be computed. Thus, the exogenous estimation of the relative size of the shadow economy in Egypt used to calibrate the ordinal values is based on our currency demand approach (1976-2013) in the current study.

$$\eta\mathrm{t} = \frac{\tilde{\eta}t}{\tilde{\eta}baseyear} \eta * baseyear \qquad (1)$$

where $\tilde{\eta}t$ denotes the value of the MIMIC index at time t according to the structural equation (1), $\tilde{\eta}baseyear$ is the value of the MIMIC index in the base year which is in our model is 2013, $\eta * baseyear$ is the exogenous (prior) estimation of the size of the shadow economy in Egypt in the base year (=2013) reaching 21.43% of GDP extracted from our CDA results.

Based on the application of this benchmarking procedure, we are able to calculate the final estimates of the size of the shadow economy as percentage of GDP for the given period of our study and to reach a trend of the development of the shadow economy in Egypt from 1976 to 2013.
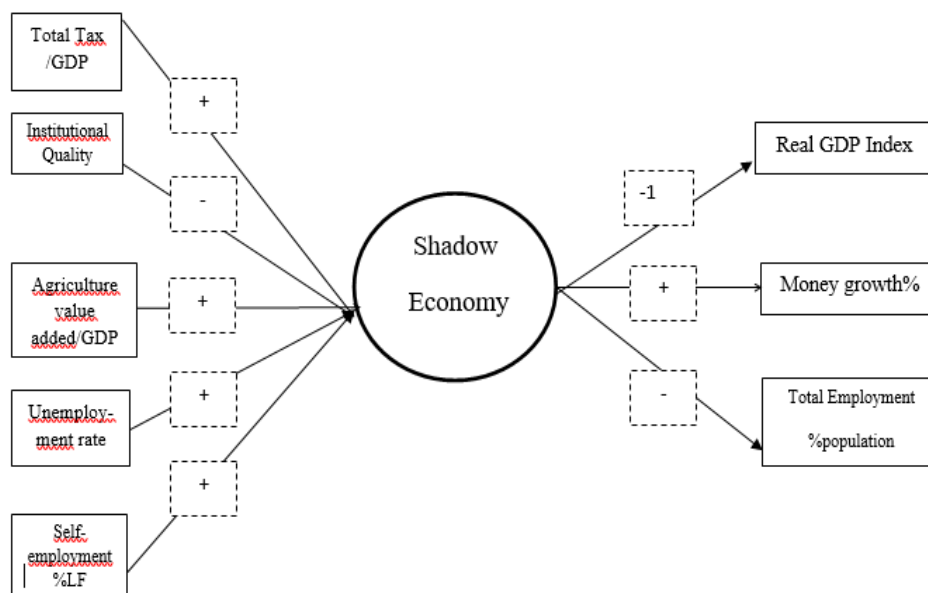
Graph A.1. *Hypothesized MIMIC path*

Table A.1. *ADF Unit root test for MIMIC variables*

Variables	At level			First difference		
	Intercept	Trend and Intercept	No Trend and NoIntercept	Intercept	Trend and Intercept	No Trend and No Intercept
Total_taxes% GDP	-1.30	-2.19	0.59	-5.08***	-5.11***	-5.14***
Institutional Quality	-1.41	-2.06	-1.14	-5.95***	-5.85***	-5.92***
Agriculture-valueadded% GDP	-3.04**	-2.28	-3.14***	-4.47***	-4.90***	-4.08***
Unemployment rate	-1.28	-2.23	1.46	-5.59***	-5.52***	-5.21***
Self-Employment %LF	-1.93	-2.35	-1.48	-8.90***	-9.18***	-8.80***
Real GDP index	2.88	-0.85	3.25	-2.82*	-3.41*	-1.03
Money growth%	-2.56	-3.83**	-1.12	-9.12***	-9.01***	-9.22***
Total emplyoment %population	-1.45	-1.83	0.68	-5.14***	-5.09***	-5.16***

Notes: Reported above are the T-statistics for the Augmented Dicky-Fuller (ADF) test. Null hypothesis: variable has unit root. The lag length was chosen using the Schwarz Information Criterion. *, **, *** indicate significance at the 10%, 5% and 1% respectively. Source: Own calculations

Table A.2. *ADF Unit root test for CDA variables*

Variables	At level			First difference		
	Intercept	Trend and Intercept	No Trend and NoIntercept	Intercept	Trend and Intercept	No Trend and No Intercept
C	-0.07	-0.65	1.44	-3.44**	-3.47*	-3.07***
Y	-3.31**	-2.85	12.76	-5.17***	-5.49***	-2.37**
TAX	-0.98	-2.14	-0.65	-4.45***	-4.48***	-4.48***
R	-1.57	-2.74	-0.29	-4.85***	-4.40***	-5.08***
REG	-1.48	0.40	-0.02	-3.74***	-4.72***	-3.84***
SELF	-2.08	-1.39	-1.58	-7.93***	-8.44***	-7.80***
GOV	-3.07**	-2.27	-1.85*	-7.21***	-7.46***	-3.55***

Notes: Reported above are the T-statistics for the Augmented Dicky-Fuller (ADF) test. Null hypothesis: variable has unit root. The lag length was chosen using the Schwarz Information Criterion. *, **, *** indicate significance at the 10%,5% and 1% respectively. Source: Own calculations

Table A.3. *Variables in the MIMIC model*

Variables	Source	Definition
Total taxes in absolute values in local currency	The series is extracted from the yearly economic bulletin published by the National Bank of Egypt	The total taxes are the total sum in local currency imposed on income, profit and sales. The burden is calculated as % of GDP.
Institutional quality of democratic institutions (PolityIV index)	Polity IV project	The scale ranges from -10 to +10, indicating the extent of autocratic to democratic institutions in a country. Hence, the higher the index, the better.
Unemployment_rate (15+)	International Labour Organisation (ILO)	The unemployment rate is the number of persons who are unemployed as a percent of the total number of employed and unemployed persons (i.e., the labour force).
Agriculture value-added as % of GDP	World Bank Indicators	Agriculture value-added is the net output of the sector calculated as % of GDP.
Self-Employment rate	CAPMAS Labor Sample Survey	An individual who depends on himself solely to perform private business and who does not employ anyone (with salary or without). The rate is calculated as % of total labour force
Real GDP Index	World Bank Indicators	Index of real GDP, base year 2005=100
Money growth (annual %)	World Bank Indicators	Average annual growth rate in money. Money is the sum of currency outside banks and demand deposits.
Total Employment rate	CAPMAS Labor Sample Survey	The total number of people who are formally employed by possessing a formal contract. The rate is calculated as % of total population.

Source: Authors

Table A.4. *Variables used in the CDA*

Variables	Source	Definition
Currency in Circulation (C_t)	The series is extracted from the yearly economic bulletin published by the Central Bank of Egypt	The sum of currency outside banks normalized by GDP deflator.
Real income (GDP) (Y_t)	World Bank Indicators	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. GDP per capita is gross domestic product divided by midyear population.
Total tax burden (TAX_t)	The series is extracted from the yearly economic bulletin published by the National Bank of Egypt	The total taxes are the total sum in local currency imposed on income, profit and sales. Total Tax burden is defined as % of GDP.
Public employment as % of labor force (REG_t)	CAPMAS Labor Sample Survey	Those who are employed, in the work force, receive a salary and characterized according to the type of sector they are working at. Hence, the public sector. It is calculated as a ration to total labour force.
Self-Employment rate ($SELF_t$)	CAPMAS Labor Sample Survey	An individual who depends on himself solely to perform private business and who does not employ anyone (with salary or without). The rat is as % of total labour force
Nominal Deposit Interest rate (R_t)	World Bank Indicators	Deposit interest rate is the rate paid by commercial or similar banks for demand, time, or savings deposits.

Source: Authors

Table A.5. *Fixing reference variable (Real GDP index) to +1*

Variables/specifications	MIMIC1 5-1-3	MIMIC2 4-1-3	MIMIC3 4-1-3	MIMIC4 3-1-3
Causes				
Total Tax Burden	-0.26***	-0.29***	-0.28***	-0.33***
	(-3.99)	(-6.38)	(-3.76)	(-8.54)
Institutional Quality	0.48***	0.46***	0.48***	0.46***
	(9.01)	(9.34)	(8.94)	(9.29)
Agriculture Importance	-0.26*	-0.35***	-0.33***	-0.46***
	(-1.75)	(-2.67)	(-2.44)	(-7.48)
Unemployment Rate	0.10	0.13		
	(0.70)	(0.94)		
Self Employment	-0.15		-0.17	
	(-1.07)		(-1.17)	
Indicators				
Real GDP Index	+1	+1	+1	+1
Money	-0.66***	-0.65***	-0.67***	-0.65***
	(-13.01)	(-11.38)	(-13.43)	(-11.65)
Total Employment	0.86***	0.81***	0.82***	0.82***
	(14.28)	(14.51)	(14.27)	(14.54)
Statistical tests				
Chi2	25.98	14.63	22.93	11.55
Pvalue	(0.0038)	(0.0668)	(0.0035)	(0.0728)
Swain corrected chi2	27.19	16.39	25.59	14.75
Pvalue	(0.0024)	(0.0371)	(0.0012)	(0.0223)

Source: Authors

Table A.6.*Relaxing the reference variable (Real GDP index) and fixing money_growth to +1*

Variables/specifications	MIMIC1 5-1-3	MIMIC2 4-1-3	MIMIC3 4-1-3	MIMIC4 3-1-3
Causes				
Total Tax Burden	0.26***	0.29***	0.28***	0.33***
	(3.99)	(6.38)	(3.76)	(8.54)
Institutional Quality	-0.48***	-0.46***	-0.48***	-0.46***
	(-9.01)	(-9.34)	(-8.94)	(-9.29)
Agriculture Importance	0.26*	0.35***	0.33***	0.46***
	(1.75)	(2.67)	(2.44)	(7.48)
Unemployment Rate	-0.10	-0.13		
	(-0.70)	(-0.94)		
Self-Employment	0.15		0.17	
	(1.07)		(1.17)	
Indicators				
Real GDP Index	-0.97	-0.97	-0.96	-0.97
Money	+1	+1	+1	+1
Total Employment	-0.82***	-0.81***	-0.82***	-0.82***
	(-14.28)	(-14.51)	(-14.27)	(-14.54)
Statistical tests				
Chi2	25.98	14.63	22.93	11.55
Pvalue	(0.0038)	(0.0668)	(0.0035)	(0.0728)
Swain corrected chi2	27.19	16.39	25.59	14.75
Pvalue	(0.0024)	(0.0371)	(0.0012)	(0.0223)

Source: Authors

Table A.7. *Size of the Egyptian shadow economy as % of GDP (1976-2013)*

Year	SE_CDA	SE_MIMIC
1976	59.02	35.00
1977	49.05	34.36
1978	48.41	33.89
1979	47.10	31.49
1980	45.54	32.62
1981	36.31	36.36
1982	38.74	34.71
1983	35.21	34.80
1984	36.34	34.26
1985	31.24	32.16
1986	23.27	32.30
1987	21.63	31.01
1988	21.89	29.81
1989	21.71	29.92
1990	12.07	29.43
1991	13.25	29.86
1992	11.89	28.98
1993	19.04	28.10
1994	13.97	27.93
1995	13.59	27.64
1996	13.92	27.53
1997	15.21	26.97
1998	15.93	28.00
1999	13.30	28.10
2000	12.32	27.33
2001	10.69	26.93
2002	18.96	27.20
2003	11.76	27.13
2004	12.44	26.25
2005	13.77	21.47
2006	12.07	21.17
2007	20.19	21.18
2008	10.46	20.69
2009	9.29	19.91
2010	14.26	19.97
2011	11.69	17.94
2012	11.19	20.05
2013	21.43	21.43

Source: Own calculations

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