CBN Journal of Applied Statistics Vol. 13 No. 2 (December 2022) *1-40*

Size and Determinants of the Shadow Economy in Nigeria: Evidence from a Monetary Approach

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This study investigates the size and determinants of the shadow economy in Nigeria. It adopts an aggregation approach within the monetary framework and utilises the ARDL estimation technique to analyse quarterly data from 2010 Q1 to 2019 Q4. On average, the results suggest that the quarterly size of the shadow economy is about 55 per cent of the country's GDP. The findings show that government size reduces the size of the shadow economy in the short run but increases it in the long run. The study also finds that interest rate, which is the opportunity cost of holding cash, and development of digital payment system (financial innovation) disincentivise informality. The policy implication is that the continuous development of effective digital payment products and their use could potentially reduce the size of the shadow economy in Nigeria.

Keywords: Aggregation approach, interest rate, government size, monetary framework, shadow economy.
JEL Classification: E26, E41, E43
DOI: 10.33429/Cjas.13222.1/7

1. Introduction

Shadow economy is a concept used to describe economic activities that are undeclared or underdeclared, nonmarket activities, transactions that are non-measured, and under-registered to avoid tax or circumvent regulation, including transactions that are illegal and associated with crime, and corruption. The shadow economy can also be referred to as black, hidden, informal, irregular, parallel, second, subterranean, unrecorded, underground, or unregistered economy (Schneider & Bajada, 2003; Gadea & Serrano-Sanz, 2002; Caridi & Passerini, 2001; Schneider & Enste, 2000; Bagachwa & Naho, 1995; Matthews & Rastogi, 1985; Feige, 1979; Gutmann, 1977).

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In recent years there has been increasing interest among economists in understanding the size and development of the shadow economy and this is well documented in literature (Kelmanson *et al.*, 2019; Medina & Schneider, 2018; Medina*et al.*, 2017; Schneider 2015; Schneider, 2013; Schneider & Buehn, 2012; Schneider, 2004). The rising interest in the shadow economy is not unconnected to its implications for growth, cost to and distortions in the wider economy. From policy perspective large shadow economies could impede growth and subvert policy efforts by reducing policy effectiveness. It could be a distortion to the channels through which policy actions transmit to the wider economy and may lead to lower access to financial services (Kelmanson *et al.*, 2019). The shadow economy could also lead to loss of revenue resulting from under/unreported wages and output. Also, the prevalence of tax avoidance means that the provision of public goods could be suboptimal (Kelmanson *et al.*, 2019).

To mainstream the shadow economy and reduce its associated costs, policy makers seek to know its size and understand its drivers, which has led to a plethora of empirical studies in the literature (Kelmanson *et al.* 2019; Medina & Schneider, 2018; Medina *et al.,* 2017). This study is motivated by the limited studies estimating the size and examining the drivers of the shadow economy in Nigeria. Kelmanson *et al.* (2019), who provides estimates of the size of the shadow economy in Nigeria between 1990 and 2015 did not provide its drivers. The determinants of the shadow economy identified by Medina *et al.* (2017) is based on groups of developed and developing economies, hence the implicit assumption that the determinants and magnitude of their effects are similar in each group of countries. Kelmanson *et al.* (2019) uses the model based multiple indicators multiple cause (MIMIC) approach. As laudable as the MIMIC approach is, it is fraught with unstable estimates of the shadow economy after a minor change to the data (Helberger and Knepel cited in Trebicka, 2014). Moreover, the MIMIC approach only provides relative values of the size of the shadow economy and require other methods like the monetary approach, to calibrate them into absolute values (Scheneider, 2013). It is also important to state that previous studies for Nigeria provided annual estimates of the shadow economy, which masks its fluctuations and limits its usefulness for policy formulation.

Therefore, this study estimates the size of the shadow economy in Nigeria using the aggregation monetary approach and quarterly data spanning the period 2010Q1-2019Q4. In addition, it examines the drivers of the shadow economy in the country using an autoregressive distributed lag (ARDL) model. This study is a departure from Medina *et al.* (2017). Unlike Medina *et al.* (2017) the current study uses the monetary aggregation approach, which gives more stable estimates of the size of the shadow economy compared to the MIMIC approach (Scheneider, 2013). It extends the estimates of the shadow economy in Nigeria to 2019, which is the latest provided by any study for the country. Furthermore, the study uses quarterly data to show the seasonality inherent in the development of the shadow economy, making it more useful for policy.

The traditional monetary approach which was pioneered by Cagan (1958), Gutmann (1977), Feige (1979) and Tanzi (1980 & 1983) has been criticized due mainly to its assumptions that cash is used for all transactions in the hidden economy and that the income-velocity of money in the formal economy equals that obtainable in the shadow economy. However, Ahumada *et al.* (2007) provides the aggregation approach within the monetary framework that resolves this issue. The aggregation approach is a more general approach. Unlike the traditional monetary approach where the income elasticity of money demand (used interchangeably with currency demand in this study) is assumed to be unity, the aggregation framework allows for a more flexible estimate that is greater, less, or equal to unity (Ahumada *et al.,* 2007). To the best of our knowledge, this study is the first to apply the monetary aggregation approach to estimate the size of the shadow economy in Nigeria.

The factors driving the development of the shadow economy in developing economies are not the same as those of the advanced economies (Kelmanson *et al.,* 2019; Medina & Schneider, 2018; Medina *et al.,* 2017). For instance, government is heavily involved in the economy in Nigeria, thus the size of government could be an important driver of the mainstream and shadow economy. Government contractors may outsource their services to the informal sector to increase their profit margins thus fueling the development of the shadow economy. Another characteristic of developing economies is the low wage rate in the formal sector. To earn extra income those

employed in the formal sector may engage in informality during off-work periods thus increasing the size of the shadow economy (Schneider *et al.,* 2010).

Also, since transactions in the shadow economy are mostly carried out using cash, participants may not deem it important to hold bank account and could thus be financially excluded. However, if the opportunity cost for holding money is greater than the incentive, some participants in the shadow economy could be encouraged to withdraw from the shadow to the mainstream economy, thus the monetary approach to the shadow economy is important, since it emphasizes the opportunity cost of holding money as the most important means of disincentivizing participation in the shadow economy.

Furthermore, we include financial innovation as an alternative determinant of the shadow economy to examine the model for sensitivity. Developments in telecommunication and the penetration of same has led to massive development in the payment system architecture globally, opening a new horizon in the analysis of financial development in the form of financial innovation. Theoretically, financial innovation like other financial development indicators is expected to have a negative impact on the shadow economy since it leads to the onboarding of the financially excluded to the formal economy by making financial services more accessible and increase their use. In addition to the formal analysis, this study provides empirical evidence on how financial innovation could impact on the development of the shadow economy in Nigeria.

Finally, to examine the drivers of the shadow economy, the study employs the Pesaran *et al.* (2001) autoregressive distributed lag (ARDL) bounds testing approach to cointegration. The ARDL bounds testing approach is desirable for several reasons. First, the ARDL approach, by allowing for a mixture of I(1) and I(0) variables is more flexible compared to the Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990) procedures which require all the variables to be integrated of order one I(1). Second, the bounds testing procedure unlike the Johansen cointegration accommodates small samples. Third, unlike the Johansen (1988) and Johansen and Juselius (1990) approaches that require all the variables to enter the model at equal lag, the ARDL procedure allows for different optimal lags among the

underlying regressors. Additionally, the Johansen (1988) and Johansen and Juselius (1990) approaches that estimate the long-run model in context of a system of equations, the ARDL procedure involves estimating a single reduced form equation with which conclusion is reached concerning both the short- and long-run behaviour of the model.

The rest of the paper is structured as follows: Section 2 presents the literature review while data and methodology are discussed in Section 3. The results are presented in Section 4, and finally, the conclusion and policy recommendations are provided in Section 5.

2. Literature Review

2.1 Theoretical Literature

There exist several approaches to the measurement of the shadow economy in literature, divided into the direct and indirect approaches (Boitano & Abanto, 2019; Abdih & Medina, 2016; Nchor *et al*., 2016; Schneider & Enste, 2010; Vuletin, 2009; Feige & Urban, 2008; Kaliberda & Kaufmann, 1996; Tanzi, 1999, 1983,1980). The direct approach involves the use of surveys and tax auditing. Surveys carried out on the management of a firm can be employed to capture the level of unreported income and workers position/pay which translates to the size of the shadow economy. Likewise, the level of tax evasion and undeclared taxable income can be used to measure the size of the informal economy. It is believed that neither of these techniques yield accurate and reliable results as individual and organizations intentionally hide their income and activities from regulators and relevant authorities (Isanchen *et al.*, 1982). There are existing studies that have used the indirect approach (multiple indicator multiple cause (MIMIC), electricity consumption, labour force statistics, transaction and currency demand approaches) in estimating the size of the shadow economy (Boitano & Abanto, 2019; Abdih & Medina, 2016; Nchor, Adamec & Kolman, 2016; Schneider & Enste, 2010; Vuletin, 2009; Feige & Urban, 2008; Kaliberda & Kaufmann , 1996; Tanzi, 1999,1983,1980). However, this study employs the currency demand approach otherwise known as monetary method to measure the size of the shadow economy in Nigeria.

The traditional "monetary method" of measuring the shadow economy was pioneered by Cagan (1958), Gutmann (1977), Feige (1979) and Tanzi (1980 & 1983). They postulate that cash is used predominantly to carry out transactions in the shadow economy since economic agents who want to hide their transactions from officials and regulators prefer using cash, which leaves no trace. Hence, the size of the shadow economy can be estimated if the value of cash used in hidden transactions could be estimated. The value obtained is then multiplied by the velocity of money to obtain an estimate of the shadow economy. This implies that an increase in the size of the shadow economy reflects in an increase in the demand for currency. This theoretical assumption as provided by Tanzi (1980 & 1983) forms the basis for which studies estimate the size of the shadow economy using the monetary approach.

From the monetary perspective, increase in currency in circulation reflects development in the shadow economy, since participants in informal activities prefer making payments with cash rather than credit/debit cards, checks or bank transactions (Hassan & Schneider, 2016; Buehn, 2012; Schneider *et al.,* 2010; Alanon & Gomez-Antonio, 2005).

Closely related to currency in circulation is the opportunity cost of holding cash – interest rate. The money market is in equilibrium when money demand and money supply are equal. Money demand is driven by the speculative motive for holding money proxied by interest rate, and the transaction and precautionary motives proxied by income. A rise in interest rate means that returns on bonds have increased. People would want to take advantage of the increased returns on bonds by increasing their investment, thus, the desire to hold money declines. Starting from a point of equilibrium in the money market, a rise in interest rate reduces the desire to hold money, hence money demand declines. With the stock of money remaining constant, a decline in money demand leads to excess money supply and disequilibrium in the money market. To reduce the excess cash balances, people will increase their expenditure as they purchase more bonds thereby increasing its demand. The increased demand for bonds puts a downward pressure on interest rate. The interest will fall until equilibrium is re-established in the money market. The increased demand for interest-paying noncash financial-assets means that cash is transferred from the in-

formal sector to the formal sector, hence, the size of the shadow economy declines due to the rise in interest rate (Bovin *et al.*, 2010; Ireland, 2006; Mishkin, 1995; Bernanke & Gertler, 1995).

Other factors that have theoretical link with the shadow economy are tax evasion, government size, labour force participation rate and the level of development of cashless payment system. It is well documented in literature that tax burden is associated with the development of the shadow economy (Schneider, 2010; Buehn, 2012; Hassan & Schneider, 2016). As the tax burden increases it provides incentives for participation in the informal economy as people seek to avoid the tax burden and evade tax.

Government expenditure is a measure of the size of government when divided by GDP. It includes capital and recurrent expenditure, on road network and electricity infrastructure. Other components include expenditure on education, health, law enforcement, and pensions. The wide array of government expenditure channels, products and services could foster the shadow economy, especially when government contractors, in a bid to increase their profit margins outsource their services to the informal sector (Carillo & Pugno in Goel & Saunoris, 2014). Government expenditure could also reduce the size of the shadow economy especially when significant proportion is devoted to enforcing checks in the shadow economy. Therefore, the impact of government expenditure on the shadow economy is mixed.

On labour force participation, it is largely debated that changes in the labour force participation in the registered economy reflects developments in the shadow economy. First, the informal sector serves to absorb resources from the formal economy as human capital shifts to the shadow economy, hence withdraws human resources from the observed economy (Bajada & Schneider, 2005; Dell'Anno *et al.,* 2007; Schneider et al., 2010). Thus, increased labor force participation rate in the observed economy reduces the size of the shadow economy. Second is the counter argument that a decline in labor force participation rate is not a true reflection of increase in shadow economic activities. This is predicated on the basis that labour force does not entirely withdraw from the formal economy instead participates in informal activities during off-work periods like holidays, after working hours, or on weekends. Thus,

labour force participation rate could have a positive impact on the size of the shadow economy (Dell'Anno, 2007). Therefore, theoretically, the relationship between the shadow economy and labour force participation rate could be positive or negative.

2.2 Empirical Literature

The estimation of the shadow economy is mostly based on the monetary and MIMIC approaches. These methods also provide the determinants of the development of the shadow economy. While there is a huge literature on the size and determinants of the shadow economy globally, little has been done for Nigeria. The review of empirical literature follows from the two popular methods that have been used in literature.

The monetary method of measuring the shadow economy is a commonly used approach and has been applied in many countries with different modifications. In recent times, two strands of the monetary approach have been canvassed, both of which ascribe the development of the shadow economy to currency demand and the opportunity cost of holding money. The first strand are those studies relying on the traditional approach by Cagan (1958) Gutmann (1977) and Feige (1979) and Tanzi (1980 & 1983). This strand argues that the velocity of money in the hidden and observed economy are equal as such implicitly assumes an income elasticity of money demand of unity. Thus, most studies relying on this method may have erroneously assumed that the velocity of money is equal in the observed and shadow economy, even when the income elasticity of money demand may be different from unity; thus, over(under) estimating the size of the shadow economy. Studies using the traditional approach include Bajada (2002) who estimates the shadow economy in Australia between the periods1967 and 2000 under the assumption that people are motivated to request for cash payments to avoid paying taxes and therefore consider money supply fit to mirror the size of the shadow economy. Bajada (2002) shows the size of the shadow economy in Australia to be about 14.5 per cent of GDP. In a similar study, Maria and Jose (2002) estimates the shadow economy in Spain for the period 1964 – 1997 and show its size to be between 11 per cent and 24 per cent of GDP depending on the velocity of money circulation. The study concludes that in the shadow economy, it is the response to tax burden by economic agents that leads to excess de-

mand for currency. Using the same approach, Quiroz (2005) estimates the informal economy in Bolivia to be 51 per cent of GDP as at 2001. Also, in a study of 76 countries consisting of OECD members, transition and developing countries, Schneider and Enste (2000) puts the average size of their shadow economies at 12 per cent, 23 per cent and 39 per cent of GDP, respectively. The study also finds that corruption increases participation in the shadow economy. In a related study, Isachsen *et al.* (1982) estimates Norway's shadow economy to be 8 per cent of GDP for the period 1952 - 1978 with an income elasticity of currency demand of 0.85. The size of the shadow economy of Argentina as estimated by Guisarri (1987) for the period 1930 – 1983 is put at 56 per cent of GDP.

The second strand of the monetary approach, which was championed by Ahumada *et al.* (2007), uses an aggregation framework by relaxing the assumption of equal velocity of money and the unity income elasticity of money demand. This represents a departure from the traditional approach. The study argues that the elasticity of money is not equal in the shadow and observed economies, and thus, the income elasticity of currency demand is not always equal to unity. They further show that studies using the traditional monetary approach with estimated income elasticity of currency demand different from unity but assumed equal velocity of circulation in the shadow and registered economy produce biased estimates. Hence, the aggregation framework within the monetary approach by Ahumada *et al.* (2007) represents an improvement on the traditional approach. Ahumada *et al.* (2007) applies the aggregation framework to the same data set as Guisarri (1987) and estimates the size of the shadow economy in Argentina to be 32 per cent of GDP in 1983. The study also reviews empirical studies which were carried out using the traditional monetary method but estimates the income elasticity of currency demand to be different from unity (Quiroz, 2005; Bajada & Schneider, 2003; Isachsen *et al.*, 1982; Isachsen & Strom, 1985; Bagachwa & Naho, 1995) and shows that, like Guisarri (1987), such studies overestimate the size of the shadow economy. Sharma (2016) employs the currency demand approach to estimate the underground economy in India for the period 1970-2013 and shows that the size of the underground economy was about US$957 billion or 52 per cent of GDP. The study also tests for structural breaks and concluded that the drastic declining trend of the underground economy since the early

1990s can be attributed to a range of fiscal reforms. Canh *et al.* (2021) used panel-corrected standard errors (PCSE) estimator and dynamic fixed effects autoregressive distributed lag (DFE ARDL) estimator to evaluate the impact of institutional quality and economic integration on shadow economy for a sample of 112 economies between 2005 and 2015. Findings indicate that foreign direct investment (FDI), trade openness, institutional quality, and the shadow economy are interdependent. Notably, trade openness has negative short- and long-run effects, whereas FDI inflows have negative short-run effects but positive long-run effect. Intriguingly, the influence of institutional quality varies, as corruption control and the rule of law have a substantial negative impact in the short run, whereas political stability has a significant negative impact in the long run.

Other studies employ the MIMIC approach to estimate the size of the shadow economy and identify its drivers. They mostly find regulatory, and tax burdens to be the main causes of the existence and development of the shadow economy. For example, Hassan and Schneider (2016), using the MIMIC approach on data for 157 developing, eastern European, central Asian and high-income OECD countries during the period 1999-2013 estimates the average size of shadow economy to be 33.77 per cent of GDP. The study finds higher taxes, regulatory burden, unemployment, and self-employment rates as the key determinants of the development in the shadow economy. These factors corroborate the findings from Schneider *et al.* (2010) who use similar approach. Enste (2010) used a similar approach but with a regulation index that covers labour and product markets, and institutional quality for 25 OECD countries. In addition to tax burden, and tax moral, the study finds labour and product market regulations, overall regulations, and poor institutional quality as the causal factors of the existence and development of the shadow economy during the period 1995–2005. Within the MIMIC framework, Buehn and Schneider (2008) develop an error correction model (EMIMIC) and examines the size and causes of the shadow economy in France during the period 1981Q1-2006Q4. The study findings are like those of the traditional MIMIC approach. The study also shows that reducing hours of work incentivizes participation in the informal sector. Goel and Saunoris (2014), within the MIMIC framework showed that countries with larger military expenditure have smaller shadow economies but found non-military government expenditure to

be statistically not significant.

In Nigeria, studies estimating the size of the shadow economy and examining its determinants are few. Additionally, the literature is scanty on the use of monetary approach both in the traditional and aggregation sense. Most studies on Nigeria have focused on comparing the size of the shadow economy between Nigeria and other countries. These studies have also mostly used different variants of the MIMIC model. For example, Ogbuabor and Malaolu (2013) using the EMIMIC approach of Buehn and Schneider (2008) shows the average size of the informal economy in Nigeria for the period 1970-2010 to be 64 per cent of GDP. The study finds inflation, government regulation, tax burden and unemployment are determinants of the size of the informal economy.

Medina and Schneider (2018) estimate the average size of the Nigerian shadow economy for the period 1991 to 2015 to be 41.4 per cent and 56.7 per cent of GDP for predictive mean matching (PMM) and MIMIC methods, respectively. The study finds trade openness, unemployment, size of government, fiscal freedom, rule of law, control of corruption and government stability as the determinants of the shadow economy. Schneider (2007) employed the DYMIMIC (dynamic multiple indicator multiple cause) and currency demand approaches to estimate the shadow economy for 145 economies which also includes Nigeria and shows that the size of the shadow economy in Nigeria in 2005 is 59.5 per cent. However, the study did not address the issue of country specific determinants.

Nchor *et al.* (2016) measured the size of the shadow economy in Ghana, Nigeria and UK employing the MIMIC approach. The study showed that at the end of the 2012 fiscal year, the shadow economy stood at 36.73 per cent, 47.75 per cent and 15.05 per cent in Ghana, Nigeria, and UK, respectively. Additionally, the study shows the average size of the informal sector in the previous three decades was 30.20 per cent of GDP for Ghana, 50.36 per cent for Nigerian, and 14.07 per cent for UK. This study identifies different determinants of the size of the shadow economy in the 3 countries. In Nigeria, the study identified size of government, tax rate, unemployment, quality of public service and government regulation as the drivers of the shadow economy. In UK, it was the size of government, unemployment and self-employment rate that

were identified as the determinants of the size of the shadow economy whereas in Ghana, the size of government, total tax rate, and rate of unemployment fuels the shadow economy. Oduh *et al.* (2008) used both the direct and indirect approaches to estimate the size and determinants of the shadow economy in Nigeria. Beside using the MIMIC approach, the study conducted a survey on 4,455 informal sector enterprises in eleven states in the South-South and South-East regions of the country and estimates the size of the shadow economy at between 44-73 per cent of GDP. The study also reveals high tax burden, high black-market premiums and government regulations as the main drivers of the shadow economy. Medina *et al.* (2017) applies the PMM to estimate the size of the shadow economy for 24 Sub-Saharan African countries. While countries like Mauritius, South Africa and Namibia have an informal sector size of 25 per cent of GDP, other countries like Nigeria, Tanzania and Benin have an informal sector size of up to 50 to 65 per cent of GDP. The study identifies fiscal freedom, institutions, unemployment, and trade openness as drivers of the shadow economy in these countries.

Another strand of literature focusing on the role of financial development in determining the size of the shadow economy has emanated in recent years (Bashlakov & bashlakov, 2021; Gharleghi & Jahanshahi 2020; Jahanshahi *et al.*, 2020; Afshar *et al.*, 2019; Berdiev & Saunoris, 2016; Caurkubule & Rubanovskis, 2014). These studies present evidence regarding the relationship between the shadow economy and financial development and show that the shadow economy impedes sustainable development.

The literature reviewed indicate that previous studies estimating the size of the shadow economy in Nigeria did not identify factors triggering the growth of the shadow economy in Nigeria. Every country is unique in terms of economic challenges confronting it and approaches to solving its macroeconomic problems. Identifying driving factors could fast-track the process of mainstreaming the shadow economy and reducing its size. Additionally, despite government efforts geared towards financial inclusion and financial development, the role of financial development in the activities of the shadow economy has been understudied in Nigeria. Furthermore, Nigerian studies have mainly used annual data in estimating the size of the shadow economy in the

country. This limits their usefulness for policy formulation. To fill these gaps, this study estimates the size of the shadow economy in Nigeria and identify the factors driving its development using quarterly data.

3. Data and Methodology

3.1 Data

The variables used for this study include currency in circulation, real gross domestic product, prime lending rate, and government expenditure. Data on these variables were obtained from the Central Bank of Nigeria Statistics database[3]. Annual data on labour force participation were obtained from the world development indicators database[4] and transformed to quarterly data using moving average[5]. Data spanning 2010Q1 to 2019Q4 was used in the study[6]. Table 1 presents the variable measurement and the form they entered the model. The choice of the study period is based on availability of data.

[3] $http://statistics.cbn.gov.ng/cbn-onlinestats/DataBrowser.aspx$

[4] $https://databank.worldbank.org/source/world-development-indicators?l=en$

[5] *We used the linear matching Eviews command for conversion from low to high frequency.*

[6] *We acknowledged that at* 40 *data points, the sample size for the estimation is small. Given the number of variables included in the estimation, this has implications for the model's degrees of freedom. Future studies could improve on this shortcoming by using more data points.*

Table 1: Variable measurement and a priori expectations

Variable	Measurement	Form in model	A priori expectation
Currency in circulation (CINC)	Billions of Naira	Logarithm (cinc)	Negative
Real GDP (Y)	Billions of Naira	Logarithm (y)	In Equation (11) y is expected to be positive.
Shadow economy (S)	Billions of Naira	Logarithm (s)	Negative
Tax burden (tx)	Tax revenue as percentage of GDP	Percentage of GDP (tx)	In Equation (16) tx is expected to be positive.
Government size (gx)	Government expenditure as a percentage of GDP	Percentage of GDP (gx)	In Equation (16) gx is expected to be positive or negative.
Labour force participation (LFP)	Working population as a percentage of the population between age 15 and 64	Percentage (lfp)	In Equation (16) lfp is expected to be positive or negative.
Interest rate (int)	Prime lending rate measured in percentage	Percentage (int)	In Equation (16) int is expected to be negative.
Financial innovation (Finn)	The sum of the number of transactions in the economy carried out by checque, ATM, POS, web, mobile device, NIBSS, NEFT and electronic bill payments.	Logarithm (fin)	Fin is added to Equation (16) to test for sensitivity to finnacial innovation. Fin is expected to be negative.
Automated teller machine (ATM)	Total number of transactions carried out in the economy using ATM.	Logarithm (atm)	In equation (16) atm is expected to be negative.
Cheque (CH)	Total number of transactions carried out using cheque.	Logarithm (ch)	In equation (16) ch is expected to be negative

3.2 Theoretical Framework

The monetary approach to measuring the shadow economy assumes that cash is used to make transactions that people want to hide from regulations or official records. If one can estimate the amount of money used in making hidden transactions, based

on the traditional monetary approach, multiplying this sum by the velocity of money yields an estimate of the shadow economy (Feige, 1979; Tanzi, 1982 & 1983; Guttman ,1977). The currency demand function following Ahumada *et al.* (2007) is defined as:

$$C_0 = A(1+\emptyset)^{\alpha} Y_R^{\beta} exp(-\gamma i) \tag{1}$$

where: $C_0$is observed cash balances; $\emptyset$ is vector of factors that induce people to make hidden transactions (ratio of taxes or government expenditure to GDP); Y_R is real income often proxied by observed real GDP; i is the opportunity cost of holding cash usually proxied by interest rate or inflation; A is a constant parameter; α measures the responsiveness of currency in circulation to developments in the shadow economy; β is income elasticity of currency in circulation; and γ is the responsiveness of currency in circulation to changes in the opportunity cost of holding cash.

Observed currency in circulation (C_0) equals total currency in circulation (C_T) which includes cash used for registered transactions, C_R and cash used for hidden transactions, C_H thus:

$$C_0 = C_T = C_R + C_H \tag{2}$$

Observed (registered) output, Y_R is the real declared output and does not include the hidden output, Y_H, thus total output, Y_T is:

$$Y_T = Y_R + Y_H \tag{3}$$

Ahumada *et al.* (2007) provides an aggregation framework assuming the demand for C_R and C_H have equal parameters as in Cagan's tradition. Using (1), (2) is aggregated as:

$$C_T = AY_R^{\beta}\exp(-\gamma i) + AY_H^{\beta}\exp(-\gamma i) = AY_R^{\beta}\exp(-\gamma i)\left(1+\left(\frac{Y_H}{Y_R}\right)^{\beta}\right) \tag{4}$$

Equation (4) is the aggregation model. It indicates that total currency in circulation is the sum of currency in circulation in the observed and shadow economy. According

to Ahumada *et al.* (2007), this formulation is not restricted to currency in circulation only. It is also valid for wider aggregates such as M1, M2 or M3 provided the opportunity cost of holding money remains the interest rate or inflation. However, the value of β obtained in (1) would only be equal to that obtained in (4) if the ratio $\frac{Y_H}{Y_R}$ is independent of Y_R.

Therefore, (4) is rewritten as:

$$C_T = AY_R^{\beta} \exp(-\gamma i)(1+\emptyset)^{\alpha} \tag{5}$$

One can estimate (5) as in (1) since $Y_0 = Y_R$, $C_T = C_0$, and noting that C_T and Y_R are observed. The assumption that the currency demand function in the registered economy and the hidden economy have the same functional form with equal parameter, allows for $\emptyset$ to be set to zero to get an estimate of currency demand when there is no incentive to hide transactions, C_R as:

$$C_R = AY_0^{\beta} exp(-\widehat{\gamma} i) \tag{6}$$

Since C_R is known from (6) and C_T is observed currency C_0, C_H can be estimated as

$$C_H = C_T - C_R \tag{7}$$

The ratio of C_R *to* C_H:

$$\frac{C_R}{C_H} = \frac{AY_R^{\beta} \exp(-\gamma i)}{AY_H^{\beta} \exp(-\gamma i)} = \left(\frac{Y_R}{Y_H}\right)^{\beta} \tag{8}$$

provides an expression for Y_H in terms of C_R, C_H , Y_R *and* β without the need for the assumption that the velocity of money is equal in both the observed and shadow economies. Thus,

$$Y_H = Y_R \left(\frac{C_R}{C_H}\right)^{-\frac{1}{\beta}} \tag{9}$$

Equation 9 shows that the size of the shadow economy is the product of the observed output and the ratio of currency demand in the registered and hidden economies raised to the negative inverse of the income elasticity of currency demand (β).

3.3 Model Specification

3.3.1 Size of the Shadow Economy

The key determinants of the development of the shadow economy as outlined by the monetary approach are income and the opportunity cost of holding cash. The study introduced other possible factors that could explain the development of the shadow economy into the model. Such factors are government size and labour force participation rate. Hence, the following currency demand function is specified:

$$CINC_t = f(Y_t, int_t, gx_t, lfp_t) \tag{10}$$

where: CINC is observed currency in circulation; Y is real gross domestic product (proxy for national income); *int* is prime lending rate (proxy for opportunity cost of holding cash); gx is government expenditure as a percentage of GDP (proxy for government size); and *lfp* is labour force participation rate.

In a log-linear form, the ARDL currency demand function is specified as:

$$\begin{aligned}\Delta cinc_t = \; & c_1 + \rho_1[cinc_{t-1} - \{\delta_0 + \delta_1 y_t + \delta_2 int_{t-1} + \delta_3 gx_{t-1} + \delta_4 lfp_{t-1}\}] \\ & + \sum_{j=1}^{p-1} \Psi_j \Delta cinc_{t-j} + \sum_{j=0}^{q-1} \lambda_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \phi_j \Delta int_{t-j} + \sum_{j=0}^{q-1} \zeta_j \Delta gx_{t-j} \\ & + \sum_{j=0}^{q-1} \varphi_j \Delta lfp_{t-j} + \varepsilon_{1t}\end{aligned} \tag{11}$$

Where: cinc is the logarithm of CINC, c_1 is a constant; y is the logarithm of Y; ε_{1t} is the error term assumed to be normally distributed with zero mean and constant variance; the long-run parameters are δ_i for $i(0, 4)$; the short-run parameters are $\sum_{j=1}^{p-1} \Psi_j$, $\sum_{j=0}^{q-1} \lambda_j$, $\sum_{j=0}^{q-1} \phi_j$, $\sum_{j=0}^{q-1} \zeta_j$, and $\sum_{j=0}^{q-1} \varphi_j$; ρ_1 is the speed of adjustment to longrun equilibrium; and other variables remain as earlier defined.

Equation 11 shows how currency demand responds when there is a change in income (y_t), the opportunity cost of holding cash (int_t), government size (gx) and labour force participation rate (lfp), respectively. The value of ρ_1 shows how fast it takes currency demand to revert to equilibrium path following a short run perturbation.

Equation 11 is relevant to obtain the values of parameters δ_1 and δ_2 which are used

to estimate the currency demand in the observed economy as follow:

$$CINC_R = Ay_t^{\delta_1} \exp(-\delta_2 int_t) \tag{12}$$

the currency demand in the shadow economy is then estimated as:

$$CINC_H = CINC - CINC_R \tag{13}$$

and the size of the shadow economy as:

$$Y_H = Y_R \left(\frac{CINC_R}{CINC_H} \right)^{-\frac{1}{\delta_1}} \tag{14}$$

3.3.2 Determinants of the shadow economy

To examine the determinants of the shadow economy, this study specifies the following model:

$$s_t = f(\, gx_t,\, tx_t,\, lfp_t,\, int_t\,) \tag{15}$$

where: s is the log of the shadow GDP; tx is tax burden (proxy by tax revenue as ratio of GDP), gx, lfp, and int are as previously defined. The ARDL model is specified as:

$$\begin{aligned} \Delta s_t = {} & c_2 + \rho_2 [s_{t-1} - \{\alpha_0 + \alpha_1 gx_{t-1} + \alpha_2 tx_{t-1} + \alpha_3 lfp_{t-1} + \alpha_4 int_{t-1}\}] \\ & + \sum_{j=0}^{q-1} \lambda_j \Delta gx_{t-j} + \sum_{j=0}^{q-1} \phi_j \Delta tx_{t-j} + \sum_{j=0}^{q-1} \zeta_j \Delta lfp_{t-j} + \sum_{j=0}^{q-1} \varphi_j \Delta int_{t-j} + \varepsilon_{2t} \end{aligned} \tag{16}$$

Where: ε_{2t} is a white noise disturbance term; s is the log-transformed shadow GDP; c_2 is a constant; the long-run parameters are $\alpha_i s \; for \; \forall i \in (0,4)$; $\sum_{j=0}^{q-1} \lambda_j$, $\sum_{j=0}^{q-1} \phi_j$, $\sum_{j=0}^{q-1} \zeta_j$, and $\sum_{j=0}^{q-1} \varphi_j$ are short run parameters; and ρ_2 is the speed of adjustment to long run equilibrium after a permanent short run shock that causes the model to deviate from the its long run path.

3.4 Estimation Procedure

The study tests the variables for unit root to ensure that no variable that is integrated of an order higher than 1 enters the model. Then the size of the shadow economy is estimated using equation 14 and finally the study estimates equation 16 to examine the drivers of the shadow economy.

4. Results and Discussion

4.1 Descriptive Statistics

The descriptive statistics for the study data are presented in Table 2. The mean currency in circulation, and real GDP are N1.692 billion, and N16.413 billion, respectively. The average interest rate for the period is 26.6 per cent while the average labor force participation rate, tax burden and government size are 63.10 percent, 1.14 per cent, and 35. 89 percent, respectively.

Table 2: Descriptive Statistics

Stats	CINC (B'N)	RGDP (B'N)	int (%)	lfp (%)	tx (%)	gx (%)	FINN (Ms)	ATM (Ms)	CH (Ms)
mean	1.692	16.413	26.600	63.100	1.14	35.89	85.755	43.218	14.376
min	1.064	12.790	21.860	53.910	0.76	26.54	6.800	3.100	0.592
max	2.443	19.751	31.550	73.000	1.62	58.63	320.000	80.000	3.500
Std. deviation	3.329	1.746	0.810	1.831	0.22	7.620	76.946	21.805	0.961
kurtosis	2.480	2.300	1.660	1.320	2.520	3.460	4.070	2.090	3.140
skewness	0.170	-0.100	0.140	-0.030	0.190	1.110	1.350	0.100	1.360
Jarque-Bera	0.850	0.900	1.190	4.730	0.640	8.490	13.880	1.450	12.390
Prob (Jarque-Bera)	0.650	0.640	0.550	0.090	0.730	0.010	0.000	0.480	0.000

Note: *CINC* is currency in circulation; *RGDP* is real gross domestic product; *int* is interest rate; *lfp*, *tx* and *gx* are labourforce participation rate, tax burden; and government size, respectively; *FINN* is the sum of the number of transactions in the economy carried out using cheque (CH), automated teller machine (ATM), point of sales service machine (POS), web, mobile devices, NIBSS, NEFT and electronic bill payments.

The average number of financial transactions carried out per quarter is 85.76 million with ATM and Cheques accounting for 43.22 million and 14.38 million, respectively. Except financial innovation and number of transactions carried out using cheque, the Jarque-Bera statistics indicate that the other variables are all normally distributed. The nonnormality of financial innovation and cheques is due to excess Kurtosis.

4.2 Unit Root Test

The unit root test results are reported in Table 3. Both the augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests show that, with the exception of tax burden (tx) and atm that are stationary at level [I(0)], the other variables became stationary at first difference (1). This indicates that the series are a mixture of I(0) and I(1), hence the applicability of the ARDL approach.

Table 3: Unit root test results

	Augmented Dickey-Fuller test			Philips-Perron test		
Variable	level	First Diff.	Order of integration	Level	First Diff.	Order of integration
cinc	-1.844	-6.808***	I(1)	-1.281	-9.793***	I(1)
y	-2.779	-6.477***	I(1)	-2.372	-11.925***	I(1)
int	-2.886	-5.591***	I(1)	-0.377	-7.210***	I(1)
lfp	-1.397	-6.875***	I(1)	-1.406	-6.852***	I(1)
tx	-4.391***	-	I(0)	-4.301***	-	I(0)
gx	-1.312	-6.69***	I(1)	-0.998	-7.207***	I(1)
s	-2.913	-5.639***	I(1)	-2.004	-11.116***	I(1)
finn	-1.463	-5.837***	I(1)	-1.463	-5.836***	I(1)
atm	-3.988**	-	I(0)	-4.164***	-	I(0)
ch	-1.676	-5.626***	I(1)	-1.664	-5.601***	I(1)

4.3 Size of the Shadow Economy

4.3.1 Currency Demand Function

The currency demand function was estimated using the ARDL approach. Having estimated the ARDL model, the study tested for cointegration using bounds test approach and the results are presented in Table 4. The F-statistic (12.64) and the t-statistic (-5.357) in absolute terms, are all greater than the upper bound 5 per cent critical values, respectively thus, indicating the existence of cointegration. The results suggest that the long-run currency demand in Nigeria is jointly explained by the level of income, the opportunity cost of holding cash, government size and labour force participation rate. The study, therefore, estimates the long run coefficients of currency demand and the results are presented in Table 5.

Table 4: ARDL bounds' test results

level of	F- Critical Values		t- Critical Values	
significance	I(0)	I(1)	I(0)	I(1)
10%	2.648	4.016	-2.490	-3.610
5%	3.249	4.826	-2.865	-4.053
1%	4.729	6.803	-3.641	-4.965
	F-stat = 12.640		t-stat = -5.357	

Table 5: Long-run model

cinc	Coefficient	Std. Error	t-statistic	p-value
y_t	1.182	0.126	9.400	0.000
int_t	-0.009	0.117	-0.810	0.426
lfp_t	0.011	0.003	3.93	0.001
gx_t	0.003	0.002	1.68	0.107

The results show that y_t, lfp_t and gx_t have positive sign and int_t a negative sign as expected. Specifically, the income elasticity of currency demand is 1.18 and it is statistically significant, meaning that a percentage change in income leads to more than proportionate change in currency demand, hence the assumption of equal velocity of circulation in the shadow and observed economies breaks down and the traditional approach would be bias in estimating the size of the shadow economy. This gives further motivation and justification for the use of the aggregation framework (Ahumada *et al.,* 2007). The negative sign of interest rate indicates that a percentage change in the interest rate leads to a decline in currency demand, this is, however, statistically not significant. Therefore, the opportunity cost of holding cash proxied by interest rate is not a significant driver of currency demand in Nigeria. The result on labour force participation rate indicates that a change in the labour force participation increases currency demand, which is not surprising as new entrants into the active labour force earn income, the number of people desirous to hold cash increases, hence the demand for currency rises. It turns out that the coefficient is statistically significant indicating that labour force participation is a significant driver of currency demand in Nigeria. Government size, though, positive is statistically not significant, indicating that government size is not an important driver of currency demand. The short-run results and the adjustment coefficient are reported in Table 6.

The results show that in the short run it is income and labour force participation that drives currency demand.

Table 6: Short-run model

$\Delta cinc$	Coefficient	Std. Error	t-statistic	p-value
Δy_t	1. 88	0.510	3.686	0.002
Δlfp_t	-0.022	0.008	-2.75	0.018
ECM	-0.736	0.137	-5.360	0.000
Constant	1.626	0.890	1.830	0.081

In the short run, an increase in income leads to a rise in currency in circulation and this is statistically significant. The impact of a shock that increases the labour force participation rate causes currency demand to decline and is also statistically significant. These results imply that to reduce the demand for cash in the economy, more people should be employed, especially in the formal sector. The ECM term indicates that when there is a perturbation that causes currency demand to deviate from equilibrium, it reverts at a rate of about 73 per cent per quarter, implying that equilibrium is restored in less than two quarters.

4.3.2 Size and Trend of the Shadow Economy

Having estimated the currency demand function, the income elasticity of currency demand was retrieved and used to estimate the shadow economy. Table A1 in the Appendix shows the estimates of the size of the shadow economy. Figure 1 shows the size of the shadow and registered economies in billions of naira. As the size of the observed economy increases the shadow economy also increases however, in recent years the gap between the observed and the shadow economy has become wider. The average worth of the shadow economy between 2010Q1 and 2019Q4 was estimated at **N**8,955.03 billion compared to that of the observed economy of **N**16,412.73 billion. That is, the quarterly average size of the shadow economy during the period of study is 54.54 per cent of GDP (See Table A1 in Appendix). This indicates that Nigeria's GDP is under-reported by about 55 per cent every quarter, suggesting that more than half of the country's GDP (that is about **N**8,955.03 billion of quarterly output) is lying in the informal economy. This is less than the annual average of 64.6 per cent estimated by Ogbuabor and Malaolu (2013) for the period

1970-2010 using EMIMIC approach and the 56.7 per cent estimate from MIMIC model by Medina and Schneider (2018) for the period 1991-2015 but greater than the 46.4 per cent from EMIMIC model by Dell'Anno and Adu (2020) for the period from 1991 to 2017.

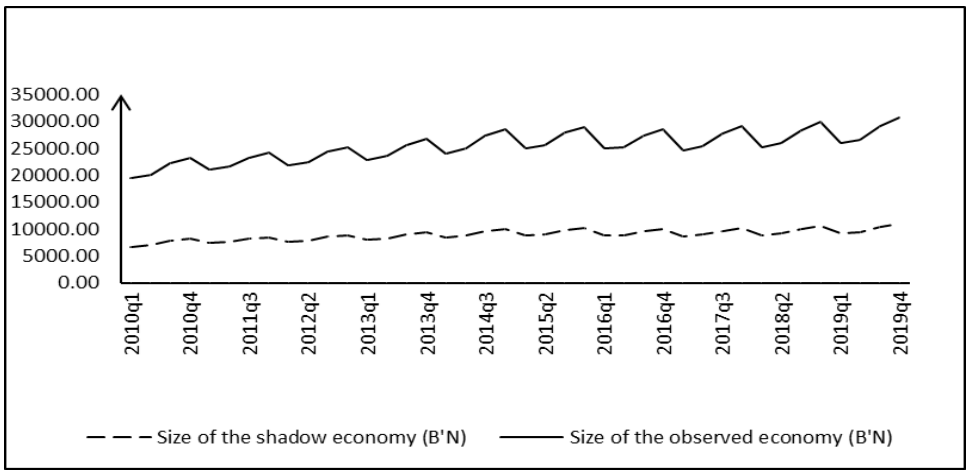

Figure 1: Trend of the shadow and observed economies in Nigeria

In Figure 2, the size of the shadow economy as a percentage of GDP is displayed and it shows how the shadow economy has evolved over time hovering between 53 per cent and 56 per cent of GDP between 2010Q1 and 2019Q4 and has, become larger in recent years.

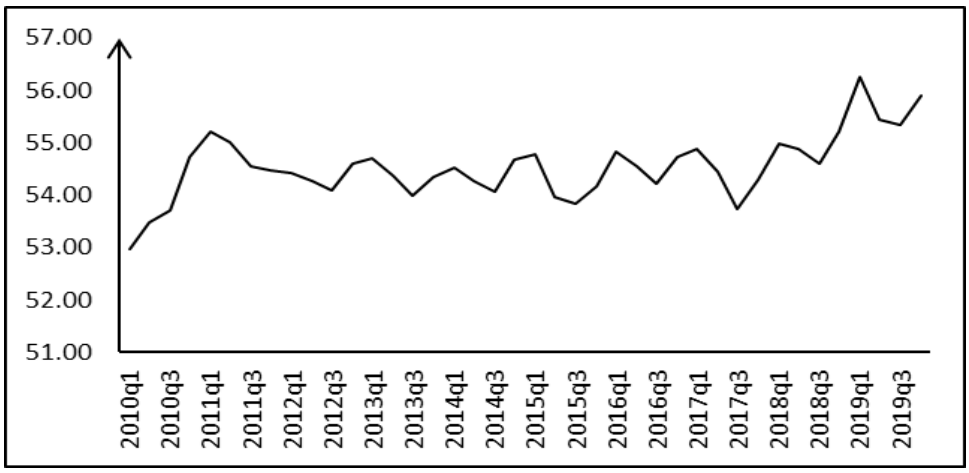

Figure 2: Nigeria's Shadow economy as percentage of GDP

Figure 3 displays the plots of GDP growth and the growth of the Shadow economy in Nigeria. The shadow economy mimics the growth in the observed economy but with time lags. The shadow economy grew at an average rate of 3.41 per cent compared to that of the observed economy of 2.98 per cent (see Table A1 in Appendix).

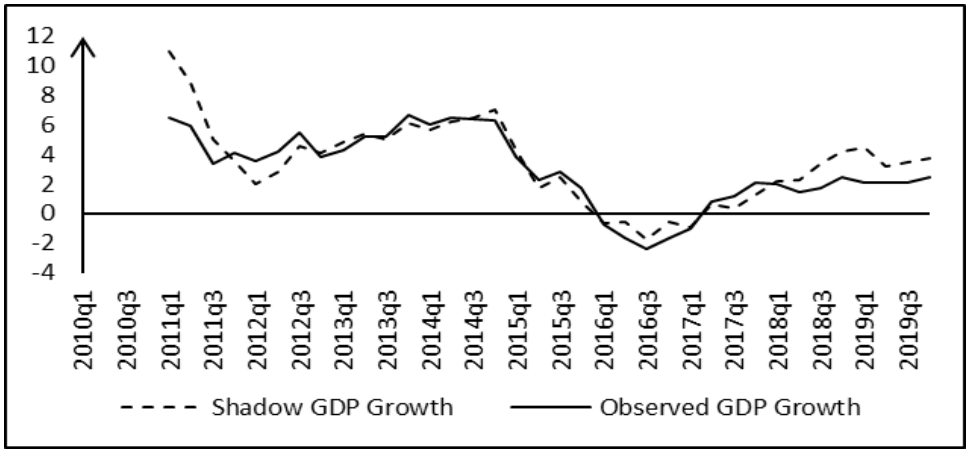

Figure 3: Growth of Nigeria's shadow and observed economies

In the first quarter of 2011, the shadow economy's growth was higher than that of the observed economy and remained so until 2011Q4 when they became equal. Between 2012Q1 and 2012Q4 the observed economy grew faster than the shadow economy. Both the observed and shadow economies' growth moved closely together between 2014Q4 and 2016Q1 when both economies plunged into recession and exited in 2017Q1. Immediately after the recession, the observed economy grew faster until 2018Q1, when the shadow economy gained momentum and grew faster than the observed economy, thus becoming more worrisome for policymakers.

4.4 Determinants of the Shadow Economy

4.4.1 Main results

Having estimated the size of the shadow economy, the study examines its determinants using the ARDL bounds test approach. The bounds test results are presented in Table 7. The results indicate the existence of a long-run relationship between the shadow economy government size, tax burden, labour force participation, and interest rate since in absolute terms the bounds F-statistic (17) and t-statistic (-6.904) are greater than the upper bounds critical values even at 1 per cent.

Table 7: ARDL bounds' test results

level of	F- Critical Values		t- Critical Values	
significance	I(0)	I(1)	I(0)	I(1)
10%	2.605	4.099	-2.430	-3.561
5%	3.223	4.965	-2.824	-4.027
1%	4.775	7.120	-3.639	-4.996
	F-stat = 17.147		t-stat = -6.904	

The existence of a long-run relationship provides ground for the estimation of the long- and the short-run relationship within an ARDL framework. The results are presented in Tables 8 and 9, respectively.

Table 8: Short-run determinants of the shadow economy

	Coefficient	Std. Error	t-statistic	p-value
ECM	-0.876	0.127	-6.90	0.000
Δgx_t	-0.082	0.028	-2.93	0.006
Δtx_t	0.93	0.289	3.22	0.000
Δlfp_t	-0.004	0.009	-0.44	0.562
Δint_t	-0.264	0.053	-5.00	0.000
Constant	50.943	8.005	6.36	0.000

Table 9: Long-run determinants of the shadow economy

s	Coefficient	Std. Error	t-statistic	p-value
gx	0.030	0.005	6.17	0.000
tx	0.380	0.321	1.18	0.252
lfp	0.022	0.006	3.38	0.003
int	-0.414	0.059	-6.96	0.000

The coefficient for government size is negative and statistically significant in the short run (Table 8), suggesting that government size reduces the size of the shadow economy in the short run. As government size increases, it absorbs participants from the informal sector, thus reducing the size of the shadow economy. However, in the long run when the shadow economy is operating at its equilibrium level increase in government size tends to increase the size of the shadow economy (Table 9). This is intuitively plausible as the wide array of government expenditure channels allow for leakages into the informal sector, therefore, provide incentive for participation in the

shadow economy. This result supports Goel and Saunoris (2014) who showed that government expenditure increases the size of the shadow economy, but their result was statistically not significant.

The effect of tax burden is positive and statistically significant in the short run (Table 8), suggesting that an increase in tax burden increases the size of the shadow economy. This is expected since increased tax burden stifles the investment environment and encourages business to operate underground to evade tax. This finding supports Bajada (2002), and Maria and Jose (2002). In the long run tax burden is positive, though, it is statistically not significant (Table 9).

Labour force participation rate is negative and statistically not significant in the short run (Table 8) suggesting that labour force participation is not an import factor contributing to the development of the shadow economy in the short run. However, in the long run as people come to the realization that their income from formal employment is not enough to meet their basic needs and its value is being eroded by inflationary pressure they turn to the informal economy for supplementary incomes. Thus, Labour force participation rate is positive and statistically significant in the long run (Table 9) suggesting that a rise in labour force participation in the formal economy in the long-run increases the size of the shadow economy. This finding suggests that in the long run labour does not totally withdraw from the formal economy in Nigeria, but engage in informal activities during holidays, after working hours, or on weekends to complement earnings from the formal economy corroborating findings from Dell'Anno (2007) for Portugal but differs from Bajada and Schneider (2005), Dell'Anno *et al.* (2007) and Schneider *et al.* (2010).

Interest rate is negative and statistically significant in both the short- and long-run (Tables 8 and 9). A rise in interest rate creates an incipient excess money supply by reducing the demand for money. The rise in interest rate also suggests that non-cash financial assets would yield higher returns, thus increasing the opportunity cost of holding cash leading to changes in peoples spending behaviour as the desire to keep cash balances reduces. Economic agents would shift money from holding cash balances to investing in non-cash financial assets and/or lend their excess cash balances to take advantage of the higher yields resulting from the rise in interest rate. There-

fore, there is withdrawal from the shadow economy to the formal economy hence, the interest rate has a negative impact on the size of the shadow economy both in the short- and long-run.

Finally, The ECM term is negative as expected and statistically significant (Table 8). It specifically indicates that when there are short-run fluctuations that cause the shadow economy to drift from equilibrium path, it has the tendency to revert at a speed of about 88 per cent per quarter, that is, the shadow economy returns to equilibrium after short-run disturbances in less than two quarters.

The variance inflation factors (VIFs) indicate no evidence of multicollinearity since all the VIFs are less than 10 (See Table A2 of Appendix). The model is also stable as the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) plots of the residuals are within the 95 per cent confidence bounds (Figure A1). The results are therefore, adequate for policy directions.

4.4.2 Additional results

For robustness, financial innovation was introduced into the model. The bounds test results presented in Table 10 indicate the existence of a long run relationship, thus corroborating the main results. However, the short run results indicate that financial innovation (finn) has no impact on the development of the shadow economy (Table 11). To probe further we estimate another model using two of the major components of financial innovation (number of atm, and cheque transactions). It turns out that number of atm transactions is positive and the number of cheque transactions negative. Both coefficients are statistically significant suggesting that as the number of atm (cheque) transactions rises, the size of the shadow economy increases (decreases).

Table 10: Bounds test results for robustness check

Level of significance	F-critical values	
	I(0)	I(1)
10%	2.12	3.23
5%	2.45	3.61
1%	3.15	4.43
F-stat	Model 1	Model 2
	14.85	20.168

These results are expected since in Nigeria atm transactions are mainly withdrawal from bank accounts into cash, which are used for payment in the informal economy, thus the shadow economy thrives with increase in the number of atm transactions. For cheques, the transactions appear to be mainly transfers from one bank account to another (usually, from the payer to the payee's bank account), thus the amount involves does not leave the formal sector hence the shadow economy retards with increasing number of transactions carried out using cheques.

In the long run, the results are similar to the main results as tax burden, government size and labour force participation rate turn out positive, but tax burden remains statistically not significant (Table 12 column 1). Interest rate is negative as before and remains statistically significant. Financial innovation is negative but statistically not significant. Replacing financial innovation by its two most prominent components (number of transactions using atm, and cheques) proved useful as the number of atm and cheque transactions each becomes statistically significant with atm being positive and cheques negative (Table 12 column 2). However, the sign on tax burden and government size became negative but statistically not significant. Thus, in the presence of financial innovation strategy such as functional ATM and Cheque payment system, government size and tax burden have the potentials of reducing the shadow economy. This is critical for policy design. If government raises cheque to pay contractors and the contractors pay the cheque into their accounts government size could be useful in reducing the size of the shadow economy. But if the cheques are cashed government size will serve to increase the shadow economy.

These models do not show evidence of multicollinearity as all the VIFs are less than the threshold of 10 (see Table A3 in the Appendix) and are stable as well (Figures

Table 11: Short run robustness check results

s	Model 1	Model 2
constant	51.533***	56.185***
	(4.792)	(3.931)
Δtx	1.590***	-1.283***
	(0.363)	(0.071)
Δgx	-0.078***	0.00
	(0.017)	
Δlfp	-0.024*	-0.054**
	(0.014)	(0.019)
Δint	-0.531**	-0.967***
	(0.148)	(0.180)
$\Delta infl$	-	-
$\Delta finn$	0.000	-
Δatm	-	0.173**
		(0.064)
Δch	-	-0.953**
		(0.324)
ECM	-0.847	-0.985***
	(0.079)	(0.069)

Table 12: Long run robustness check results

s	Model 1	Model 2
TAX	0.173	-0.288
	(0.378)	(0.281)
GEX	0.040***	-0.005
	(0.010)	(0.009)
LFP	0.029**	0.003
	(0.011)	(0.005)
int	-0.401***	-0.348***
	(0.065)	(0.045)
finn	-0.165	-
	(0.164)	
atm	-	0.409**
		(0.139)
ch	-	-0.257**
		(0.090)

A2 & A3 in the Appendix) since both CUSUM and CUSUMSQ are within the 95 per cent confidence bounds.

5. Conclusion and Policy Recommendations

This study estimates the size of the shadow economy in Nigeria using the monetary approach within the aggregation framework and examines its determinants for the period 2010-2019 using quarterly data. The quarterly average of the shadow economy in Nigeria was estimated to be 54.54 per cent of GDP with a monetary value of **N**8, 955.03 billion. The study finds that the size of the shadow economy is determined by government size, labour force participation, and the opportunity cost of holding cash (interest rate). Whereas government size and labour force participation provide incentives for participating in the shadow economy in the long run, the opportunity cost of holding cash disincentivizes participation. The introduction of financial innovation did not affect these findings but using the number of transactions carried out using ATM and cheques changed the signs of tax burden and government size.

The policy implication is that having a deep, wide, and well-developed financial market could serve to reduce the size of the shadow economy in Nigeria since the opportunity cost of holding cash disincentivizes participation in the informal sector. Reducing tax burdens can also be useful in that regard.

Given that the number of transactions carried out using cheque (ATM) is negatively related to the size of the shadow economy, the government could reduce informal sector activities by improving the payment system and encouraging the use of channels that recycle money within the banking system while discouraging those channels that converts money into cash.

The study recognizes the importance of institutional quality as a driver of the shadow economy. This was not included in the study since available data are only in annual frequency, making it difficult to incorporate in the study. This could be a subject for future research.

References

Abdih, Y., & Medina, L. (2016). The informal economy in the Caucasus and Central Asia: Size and determinants. In *Entrepreneurship and the Shadow Economy*. Edward Elgar Publishing.

Afshar J. A. (2019). In a corrupt emerging economy, who would bribe less and then innovate more? Academy of Management Proceedings, 2019 (1), 16892. https://doi.org/10.5465/AMBPP.2019.16892abstract.

Afshar J. A., Al-Gamrh, B., & Gharleghi, B. (2019). Sustainable development in Iran post-sanction: Embracing green innovation by small and medium-sized enterprises. *Sustainable Development*. https://doi.org/10.1002/sd.2028

Ahumada, H., Alvaredo, F. & Canavese, A. (2007). The monetary method and the size of the shadow economy: A critical assessment. *Review of Income and Wealth Series,* 53 (2), 363- 371.

Alañón, A., & Gómez-Antonio, M. (2005). Estimating the size of the shadow economy in Spain: A structural model with latent variables. *Applied Economics, 37*(2), 1011–1025.

Bagachwa, M. S. D., & Naho, A. (1995). Estimating the second economy in Tanzania. *World Development*, *8*(23), 1387-1399.

Bajada, C. (2002). Australia's cash economy: A troubling issue for policymakers. Ashgate, UK. Bajada, C. (2002) Australia's Cash Economy: A Troubling Issue for Policymakers, Ashgate, UK.

Banerjee, A., Dolado, J. J., Galbraith, J. W., & Hendry, D. F. (1993). *Co-integration, Error Correction, and Econometric Analysis of Nonstationary Data.* New York, Oxford; University Press.

Bashlakova, V., & Bashlakov, H. (2021). The study of the shadow economy in modern conditions: Theory, methodology, practice. *The Quarterly Review of Economics and Finance*, *81*, 468-480

Berdiev, A. N., & Saunoris, J. W. (2016). Financial development and the shadow economy: A panel VAR analysis. *Economic Modelling, 57,* 197–207. https://doi.org/10.1016/J.ECONMOD.2016.03.028

Bernanke, B. & Gertler, M. (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. Working Paper #5146. NBER Working Paper Series. https://www.nber.org/papers/w5146.pdf

Boitano, G., & Abanto, D. F. (2019). The informal economy and its impact on tax revenues and economic growth. The case of Peru, Latin America and OECD countries (1995–2016). *360: Revista de Ciencias de la Gestión*, (4), 128-157.

Buehn, A. (2012). The shadow economy in German regions: An empirical assessment. *German Economic Review,* 13 (3), 275–290.

Bovin, J., Kiley, M. & Mishkin, F. (2010). How has the monetary transmission evolved over time. NBER Working Paper #15879.
https://www.nber.org/papers/w15879.pdf

Buehn, A., & Schneider, F. (2012). Size and development of tax evasion in 38 OECD countries: What do we (not) know? CESifo Working Paper Series No. 4004, Available at SSRN: https://ssrn.com/abstract=2181359

Buehn, A., & Schneider, F. (2008). MIMIC models, cointegration and error correction: An application to the French shadow economy. *Available at SSRN 1135882*.

Cagan, P. (1958). The demand for currency relative to the total money supply. *Journal of Political Economy*, 66(4), 303–28.

Canh, P. N., Schinckus, C., & Thanh, S. D. (2021). What are the drivers of shadow economy? A further evidence of economic integration and institutional quality. *The Journal of International Trade & Economic Development*, *30*1, 47-67.

Caridi, P., & Passerini, P. (2001). The underground economy, the demand for currency approach and the analysis of discrepancies: Some recent European experience. *Review of Income and Wealth,* 47(2), 239-250.

Carillo, M. R., & Pugno, M. (2004). The underground economy and underdevelopment. *Economic Systems, 28*(3), 257-279.

Caurkubule, Ž., & Rubanovskis, A. (2014). Shadow economy as an obstacle to sustainable economic development. *Journal of Security & Sustainability Issues, 4*(2), 175–186.

Cordelia, O. (2019). The financial and economic implications of underground economy: The Nigerian perspective. *Academic Journal of Interdisciplinary Studies,* 8(2), 155-167.

Dell'Anno, R. (2007). The shadow economy in Portugal: An analysis with the MIMIC approach. *Journal of Applied Economics,* 10(2), 253-277.

Dell'Anno, R, & Adu, O. (2020). The Size of the informal economy in Nigeria: A structural equation approach. *International Journal of Social Economics* 47(8), 1063-1078. DOI 10.1108/IJSE-12-2019-0747

Engle, R. F. & Granger, C. W. J. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica* 55: 251–76.

Enste, D. H. (2010). Regulation and shadow economy: Empirical evidence for 25 OECD-countries. *Constitutional Political Economy*, *21*(3), 231-248.

Feige, E. (1979). How big is the irregular economy? *Challenge*, 22(1), 5-13.

Feige, E. L., & Urban, I. (2008). Measuring underground (unobserved, non-observed, unrecorded) economies in transition countries: can we trust GDP? *Journal of Comparative Economics*, *36*(2), 287-306.

Feld, L. P., & Schneider, F. (2010). Survey on the shadow economy and undeclared earnings in OECD countries. *German economic review*, *11*(2), 109-149.

Frey, B. S., & Weck-Hanneman, H. (1984). The hidden economy as an 'unobserved variable. *European economic review,* 26(1-2), 33-53.

Gadea, M., & Serrano-Sanz, J. (2002). The hidden economy in Spain: A monetary estimation 1964-1998. *Empirical Economics,* 27, 499-527.

Gharleghi, B., Jahanshahi, A. A., & Thoene, T. (2020). Locational factors and the reindustrialisation process in the USA; reshoring from China. *International Journal of Business and Globalisation*, 24(2), 275–292.

Goel, R. K. & Saunoris, J. W. (2014). Military versus non-military government spending and the shadow economy. *Economic Systems*, 38, 350-359.

Guissarri, A. C. (1987). La Demanda de Circulante y la Informalidad en la Argentina: 1930-1983. *Cuadernos de Economia,* 24(72), 197-224.

Gutmann, P. (1977). The subterranean economy. *Financial Analysts Journal,* 34(1), 24–7.

Hassan, M., & Schneider, F. (2016). Size and development of the shadow economies of 157 countries worldwide: Updated and new measures from 1999 to 2013, 10281, IZA Discussion Papers.

Ireland, P. (2006). The monetary transmission mechanism. Research Department Working Papers Series Number 06-1. *Federal Reserve Bank of Boston.* https://www.bostonfed.org/-/media/Documents/Workingpapers/PDF/wp0601.pdf

Isachsen, A. J., Klovland, J. T., & Strøm, S. (1982). The hidden economy in Norway. University of Oslo, Institute of Economics.

Isachsen, A. & Strom, S. (1985). The size and growth of the hidden economy in Norway. *Review of Income and Wealth,* 31, 21–38.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control*, *12*(2-3), 231-254.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with appucations to the demand for money. *Oxford Bulletin of Economics and statistics*, *52*(2), 169-210.

Johnson, S., Kaufmann, D., Shleifer, A., Goldman, M. I., & Weitzman, M. L. (1997). The unofficial economy in transition. *Brookings papers on economic activity*, *1997*(2), 159-239.

Johnson, S., Kaufmann, D., & Zoido-Lobaton, P. (1998). Regulatory discretion and the unofficial economy. *The American economic review*, *88*(2), 387-392.

Kelmanson, M. B., Kirabaeva, K., Medina, L., Mircheva, B., & Weiss, J. (2019). Explaining the Shadow Economy in Europe: Size, Causes and Policy Options. International Monetary Fund Working Paper No. 2019/278.

Kaliberda, A., & Kaufmann, D. (1996). *Integrating the unofficial economy into the dynamics of post-socialist economies: A framework of analysis and evidence*. The World Bank.

Kripfganz, S., & Schneider, D. C. (2018). Response surface regressions for critical value bounds and approximate p-values in equilibrium correction models. Manuscript, University of Exeter and Max Planck Institute for Demographic Research, www.kripfganz.de.

Loayza, N., Oviedo, A. M., & Serven, L. (2006). The impact of regulation on growth and informality cross-country evidence. In B. Guha-Khasnobis, R. Kanbur, & E. Ostrom (Eds.), *Linking the formal and informal economy, concepts and policies*. Oxford: Oxford University Press.

Mansour, A. M. A. E. A., & Zaki, I. M. (2019). Estimating the size of the shadow economy in nine MENA countries during the period 2000 to 2017 using the MIMIC model. *Open Access Library Journal*, *6*(07), 1.

Maria, D. G. & Jose, M.S. (2002). The hidden economy in Spain – A monetary estimation, 1964 – 1998. *Empirical Economics,* 27, 499 – 527.

Matthews, K., & Rastogi, A. (1985). Little Mo and the moonlighters: another look at the black economy. *Quarterly Economic Bulletin*, *6*(1), 21-24.

Medina, L., Jonelis, A. W., Cangul, M., & Mansoor, A. M. (2017). The informal economy in sub-Saharan Africa: Size and determinants. *International Monetary Fund Working Papers* No. 2017/156.

Medina, L. & Schneider, F. (2018). Shadow economies around the world: What did we learn over the last 20 years? International Monetary Fund (IMF) Working paper WP/18/17.

Mishkin, F. (1995). Symposium on the monetary policy transmission mechanism. *Journal of economic Perspectives. 9(*4), 3-10.
https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.9.4.3

Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics*, 37(17),1979–90.

Nchor, D., Adamec, V., & Kolman, P. (2016). Comparison of shadow economies: The case of Ghana, Nigeria and UK. *Mediterranean Journal of Social Sciences*, *7*(1), 248-248.

Oduh, M., Eric, E., Hycinth, E., & Oliver, U. (2008). Measurement and Explanation of Informal Sector of the Nigerian Economy. AIAE Research Paper 3. African Institute for Applied Economics, Enugu.

Ogbuabor, J. E., & Malaolu, V. (2013). Size and causes of the informal sector of the Nigerian economy: Evidence from error correction mimic model. *Journal of Economics and Sustainable Development*, 4(1)85-103.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of o level relationships. *Journal of Applied Econometrics***,** 16, 289-326.

Schneider, F. (2007). Reducing the shadow economy in Germany: A blessing or a curse? Department of Economics Discussion Paper, University of Linz, Linz.

Schneider, F. (2015). Size and development of the shadow economy of 31 European and 5 other OECD countries from 2003 to 2014: different developments?. *Journal of Self-Governance and Management Economics, 3(4), 7-29.*

Schneider, F. (2013). Size and development of the shadow economy of 31 European and 5 other OECD countries from 2003 to 2013: a further decline. Obtained from ShadEcEurope31_Jan2013 (politeia.org.ro)

Schneider, F. (2012). The shadow economy and work in the shadow: what do we (not) know? IZA Discussion Paper No. 6423

Schneider, F., & Bajada, C. (2003). The size and development of the shadow economies in the Asia-Pacific (No. 0301). Working Paper.

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. & Enste, D. (2000). Shadow economies: Size, causes, and consequences. *Journal of Economic Literature,* 38(1), 77–114.

Schneider, F., & Enste, D. H. (2002). The shadow economy: Theoretical approaches, empirical studies, and policy implications. Cambridge University Press, Cambridge (UK).

Sharma, C. (2016). *Estimating the size of black economy in India.* University Library of Munich, Germany.

Tanzi, V. (1999). Uses and abuses of estimates of the underground economy. *Economic Journal,* 109(3), 338–347

Tanzi, V. (1983). The underground economy in the United States: annual estimates, 1930–1980. *IMF Staff Papers,* 30, 283–305.

Tanzi, V. (1980). The underground economy in the United States: estimates and implications. *Banca Nazionale del Lavoro,* 135, 427–453.

Trebicka, B. (2014). MIMIC model: A tool to estimate the shadow economy. *Academic Journal of Interdisciplinary Studies*, *3*(6), 295-300

Vuletin, G. (2009). What is the size of the Pie? Measuring the informal economy in Latin America and the Caribbean. *Money Affairs,* 21, 161-191.

Williams, C. C., & Schneider, F. (2016). Measuring the global shadow economy: the prevalence of informal work and labour. Edward Elgar Publishing.

Yelwa, M., & Adam, A. J. (2017). Informality and economic growth in Nigeria: 1980-2014. *Journal of Economics and Public Finance*, *3*(3), 405-417.

Appendix

Table A1: The Nigerian economy and estimates of the shadow economy, 2010Q1-2019Q4

Period	Size of the formal economy (B'N)	Size of the shadow economy (B'N)	Shadow economy as percentage of GDP (%)	Shadow GDP Growth (%)	Observed GDP Growth (%)
2010q1	12790.38	6775.91	52.98		
2010q2	13141.50	7029.82	53.49		
2010q3	14516.59	7797.73	53.72		
2010q4	15020.88	8221.20	54.73		
2011q1	13621.79	7522.29	55.22	11.02	6.50
2011q2	13917.31	7656.28	55.01	8.91	5.90
2011q3	15007.59	8188.29	54.56	5.01	3.38
2011q4	15633.66	8515.51	54.47	3.58	4.08
2012q1	14105.66	7676.58	54.42	2.05	3.55
2012q2	14504.45	7873.14	54.28	2.83	4.22
2012q3	15826.00	8560.47	54.09	4.55	5.45
2012q4	16233.94	8866.18	54.62	4.12	3.84
2013q1	14715.33	8049.74	54.70	4.86	4.32
2013q2	15262.31	8300.03	54.38	5.42	5.23
2013q3	16646.80	8987.81	53.99	4.99	5.19
2013q4	17318.41	9412.22	54.35	6.16	6.68
2014q1	15601.05	8507.88	54.53	5.69	6.02
2014q2	16249.37	8819.66	54.28	6.26	6.47
2014q3	17707.53	9572.87	54.06	6.51	6.37
2014q4	18419.51	10072.26	54.68	7.01	6.36
2015q1	16203.80	8877.24	54.78	4.34	3.86
2015q2	16623.05	8969.92	53.96	1.70	2.30
2015q3	18208.48	9805.33	53.85	2.43	2.83
2015q4	18745.36	10152.55	54.16	0.80	1.77
2016q1	16087.23	8819.84	54.83	-0.65	-0.72
2016q2	16349.29	8919.39	54.56	-0.56	-1.65
2016q3	17775.97	9636.52	54.21	-1.72	-2.38
2016q4	18439.94	10093.00	54.73	-0.59	-1.63
2017q1	15919.66	8736.65	54.88	-0.94	-1.04
2017q2	16477.42	8972.66	54.45	0.60	0.78
2017q3	17988.95	9667.76	53.74	0.32	1.20
2017q4	18819.66	10219.40	54.30	1.25	2.06
2018q1	16234.95	8925.97	54.98	2.17	1.98
2018q2	16718.63	9176.07	54.89	2.27	1.46
2018q3	18305.13	9997.12	54.61	3.41	1.76
2018q4	19277.64	10644.65	55.22	4.16	2.43
2019q1	16569.73	9322.11	56.26	4.44	2.06
2019q2	17076.10	9469.79	55.46	3.20	2.14
2019q3	18697.32	10347.99	55.34	3.51	2.14
2019q4	19750.93	11041.40	55.90	3.73	2.46
Average	**16412.73**	**8955.03**	**54.54**	**3.41**	**2.98**

Table A2: Variance inflation factors (VIFs)

Variable	R-squared	Tolerance factor	VIF
Shadow economy model			
tx	0.265	0.735	1.361
gx	0.471	0.529	1.889
lfp	0.473	0.527	1.897
int	0.204	0.796	1.257
Money demand model			
y	0.326	0.674	1.485
gx	0.442	0.558	1.791
int	0.332	0.668	1.497
lfp	0.559	0.441	2.266

Note: tx is tax burden, gx is government size, lfp is labour force participation rate, int is interest rate, y is the log of real GDP

Table A3: Variance inflation factors (Additional Results)

Variable	R-squared	Tolerance factor	VIF
Model 1			
tx	0.781	0.219	4.566
gx	0.848	0.152	6.579
lfp	0.585	0.415	2.410
int	0.337	0.663	1.508
finn	0.829	0.171	5.848
Model 2			
tx	0.073	0.921	1.086
gx	0.782	0.218	4.587
lfp	0.611	0.389	2.571
int	0.401	0.599	1.669
atm	0.696	0.304	3.289
ch	0.711	0.289	3.460

Note: tx is tax burden, gx is government size, lfp is labour force participation rate, int is interest rate, y is the log of real GDP, atm and ch are log of number of atm and cheque transactions, respectively.

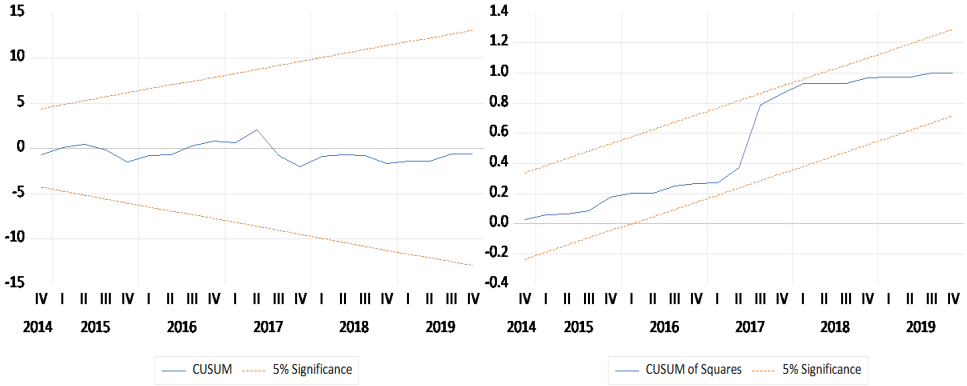

Figure A1: Determinants of the Shadow economy stability test (Main results)

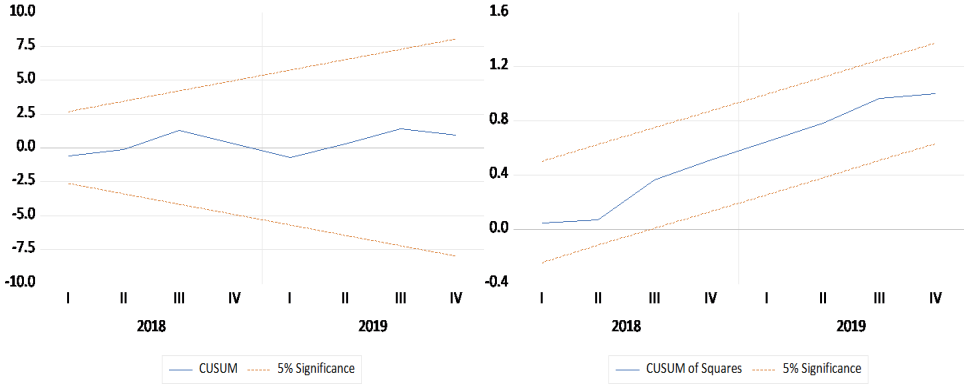

Figure A2: Determinants of the Shadow economy stability test (Additional results Model 1)

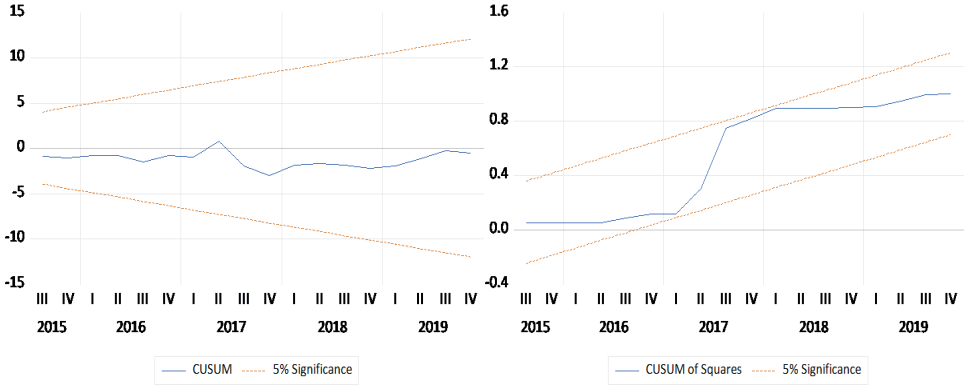

Figure A3: Determinants of the Shadow economy stability test (Additional results Model 2)