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A statistical approach to modeling the underground economy in South Africa

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Abstract

Aim/purpose – The underground economy is a major challenge across the world affecting both developed and developing economies. South Africa is no exception to this phenomenon and has lost billions of rands due to the underground economy. The aim of this study is to estimate the size of the underground economy in South Africa.
Design/methodology/approach – The study used quarterly time series data from 2000 to 2020 and employed the Currency Demand Approach (CDA) for modeling the underground economy.
Findings – The model results revealed that the underground economy is positively influenced by unemployment rate, tax burden, and social benefits granted by the government, however it is negatively influenced by Nominal Gross Domestic Product (NGDP), deposit interest rate, and self-employment rate. Furthermore, the study showed that there was a distinct growth of the underground economy, from 23.9% of GDP in 2003 to 34.5% of GDP in 2019. On average, the underground economy represented 28.8% of GDP for the period 2003 to 2020.
Research implications/limitations – This model can be used in conjunction with other models to observe the trend in the South African underground economic activities. The South African government should take note of the spiraling growth of this economy and come up with measures to curb this growth to protect the formal economy.

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Originality/value/contribution – This study makes a significant contribution to the body of knowledge in this research area and provides much needed insights into the magnitude of the underground economy and the extent of tax evasion in South Africa.

Keywords: underground economy, South Africa, currency demand approach.
JEL Classification: C32, O17, H26, C53.

1. Introduction

Underground economic activities pose a significant challenge to the economy of most countries, but are more prevalent in developing countries than developed ones. The Organisation for Economic Co-operation and Development (OECD) has estimated the size of the underground economy to vary from under 1% of GDP in some countries to over 20% in others (OECD, 2017). Furthermore, Medina and Schneider (2019) suggested that the OECD countries have the lowest estimates with values below 20% and the underground economy is larger in Latin America and Sub-Saharan Africa, averaging 38% and 39% of GDP respectively. The underground economy was estimated to be 30.9% on average for all countries over the period 1991 to 2017(Medina & Schneider, 2019).

Hassan and Schneider (2016) defined the underground economy as all unrecorded economic activities, which, if registered, would contribute to the GDP. In addition, Medina and Schneider (2018) referred to the underground economy as all economic activities that are concealed from officials for regulatory, institutional, and monetary reasons. Regulatory reasons refer to government bureaucracy and regulatory burdens, monetary reasons refer to tax avoidance and social security contributions, and institutional reasons refer to quality of political institutions, corruption and the rule of law. The literature has revealed no agreement on the definition and scope of the underground economy. This lack of agreement has resulted in different names being used for the same construct, namely shadow, underground, irregular, black, illicit, hidden, subterraneous, unofficial, grey, illegal, clandestine, unrecorded, parallel, non-observed, cash or informal economy (Dell'Anno, 2003).The underground economy may refer either to legal activities carried out without the required licenses and payment of taxes or illegal activities. Examples of legal activities in the underground economy include self--employment income which is unreported to the tax authorities. Illegal activities include smuggling, trading in stolen goods, drug dealing, fraud, and illegal gambling (Hall, 2021). This study adopted the definition given by Hassan and Schneider (2016) and focused only on the unreported legal activities that would have if otherwise reported contributed to the national GDP. Therefore, this study did not focus on any illegal activities and legal activities such as do-it-yourself activities.

Tax authorities all over the world are particularly concerned about the underground economy due to its devastating effect on tax revenue and the economy of a country in general. South Africa has been no exception to this phenomenon. Similar to most developing countries, the South African economy has not been spared from the consequences of the underground economy. The country has been losing approximately R250 M daily in tax revenue due to illicit trade. Tax revenue loss due to illegal trade was estimated to be R36.5 B in 2019, with smuggling, counterfeit and artisanal products contributing 39.5%, 38% and 17.7%, respectively (Liedtke, 2020). Most artisanal enterprises in South Africa have been small and unregulated. In fact, the Small Business Institute (2021) stated that there were no reliable, comprehensive and consistent data on Small, Medium and Micro Enterprises (SMME) in South Africa which led to differing estimates on their number, employment figures, the sectors they dominate and their contribution to the country's GDP. The likelihood of tax evasion is higher with the existence of unregistered and unknown SMME's.

Cigarettes and tobacco make up a major ratio of the revenue loss. According to Luckhoff (2021), South Africa has been losing billions in taxes as three out of four retail outlets have been selling illegal cigarettes. The South African tax authority has been struggling to curb the growth in illegal cigarettes for a while now, but the outbreak of COVID-19 in 2020 with the resultant lock down and ban on the sale of tobacco and alcohol products further worsened the problem (Neves, 2021). The South African Revenue Services (SARS) estimated the loss in revenue due to illegal cigarettes to be around R6 billion for the 2015/16 financial year (Chelin & Nyoni, 2020). Clothing and textiles sector has also posed a major challenge for SARS, with under declaration having increased from R5.2 billion in 2014 to R8.5 B in 2018. Consequently, thousands of jobs have been lost in this industry (Liedtke, 2020).

South Africa's economy has been growing at subdued rates in recent years, recording annual GDP growth rates of 0.79% and 0.15% in 2018 and 2019, respectively. The global COVID-19 pandemic worsened the situation and resulted in the GDP contracting by a significant 6.96% in 2020 (World Bank, 2021a). The slowdown in economic activities has resulted in thousands of job losses and perceived increase of activities in the underground economy. The current South African landscape serves as a fertile ground for underground economic activities. It has become imperative for government officials to understand these activities and derive measures to reduce the growth of this economy to protect the formal economy which enables the government to provide essential services to its people. The aim of this paper is to estimate the size of the underground economy using the Currency Demand Approach.

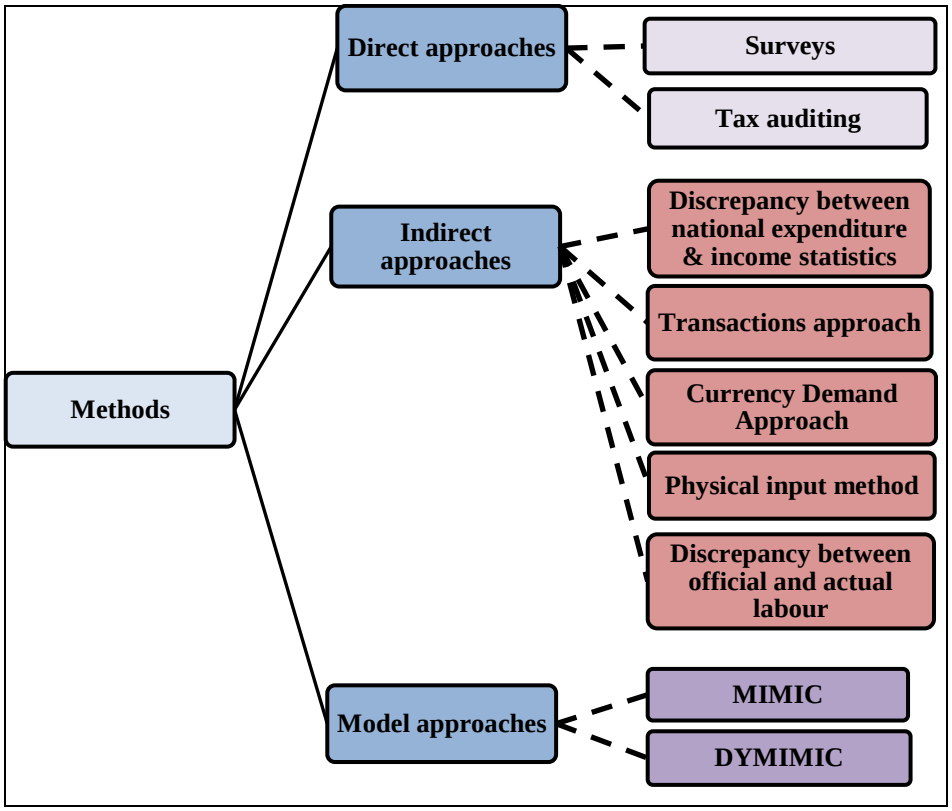
The remainder of this paper proceeds as follows: Section 2 presents the literature review relevant to the underground economy, Section 3 describes the research methodology applied, while Section 4 presents the research findings and results. Section 5 discusses the model results and the implication to the South African economy and Section 6 concludes the paper.

2. Literature review

2.1. Methods used to estimate the size of the underground economy

Due to its latent nature, it is difficult to estimate the size of the underground economy. Schneider and Buehn (2016) provided a comprehensive description of the various methodologies and approaches used in estimating the underground economy. The three different approaches are outlined in Figure 1 below.

Figure 1. Different approaches to estimating the underground economy



Source: Schneider and Buehn (2016).

2.1.1. Direct approaches

Surveys and tax audits are the two direct approaches used to model the underground economy. Surveys are based on voluntary responses and thus are highly dependent on the willingness and cooperation of the respondents. Most respondents would not ordinarily disclose their past fraudulent behavior and it is not easy to determine the quantity of undeclared work from a survey as responses are sometimes not reliable. Tax audits, on the other hand, offer a biased sample of the population as the selection of taxpayers for audits is solely based on the risk of tax fraud. Estimating the underground economy from a biased sample may be inaccurate. Therefore, the main disadvantage of these methods is that not all underground economic activities can be exposed using these approaches (Schneider & Buehn, 2016).

2.1.2. Indirect approaches

The five indirect approaches used to measure the size of the underground economy are briefly discussed below.

1. **The discrepancy between national expenditure and income statistics.**
   According to this approach, the income and expenditure measure of the Gross National Product (GNP) should be equal. The variance between the expenditure and the income measures can be used as an indicator of the size of the underground economy (Schneider & Buehn, 2016). The main disadvantage of this approach is that there are sometimes errors when disclosing expenditure. Therefore, estimates derived this way may be unreliable as they will not only reflect underground economic activities, but also all errors and omissions in the national accounts statistics (Schneider & Enste, 2002).
2. **The discrepancy between official and actual labor force.**
   A decrease in the labor force participation rate can indicate an increase in the underground economy. However, estimates derived this way are considered unreliable as individuals can simultaneously participate in both formal and informal economies (Schneider, 2005).
3. **The transaction approach.**
   The basis of this approach is on the assumption that there is a constant relationship between the volume of transactions and the official GNP over time, as summarized by Fisher's quantity equation 1.

$$MV = pT \tag{1}$$

where:
M = money,
V = velocity,
p = prices,
and T = total transactions.

Accurate data on the volume of transactions should be accessible to enable reliable estimation of the underground economy, which can be challenging for cash transactions, which depend among other factors, on the durability of bank notes (Schneider, 2005).

4. **The physical input method (electricity consumption).**
This approach consists of two methods, namely, the Kaufmann–Kaliberda method and the Lackó method. Kaufmann and Kaliberda (1996) postulated that the single best physical indicator of overall economic activity (official and unofficial) is electricity consumption. The increase in electricity consumption is an indicator of the growth in the overall GDP. Kaufmann and Kaliberda (1996) derived an estimate of unofficial GDP by deducting the estimates of official GDP from this overall measure. Schneider (2005) highlighted the following shortcomings of this method:
   – electricity production and usage has become more efficient over the years,
   – some underground economic activities do not require a substantial amount of electricity as other energy sources can be used; therefore, only a portion of the underground economy will be shown,
   – there have been substantial variations in the elasticity of electricity/GDP over time and among countries.

   Lackó (2000) assumed that household consumption of electricity contributes a certain percentage to the underground economy. It consists of activities such as do-it-yourself activities and household production and services. In countries where the part of the underground economy linked to household consumption is high, the rest of the underground economy will be high. The major disadvantages of this method are:
   – some underground economic activities do not require a substantial amount of electricity as other energy sources can be used; therefore, only a portion of the underground economy will be shown,
   – underground economic activities can take part in other sectors other than the household sector.

5. **The Currency Demand Approach (CDA).**
   The CDA is based on the assumption that illegal or underground transactions are normally conducted in cash so as to leave no obvious traces for the tax authorities. Increased activities in the underground economy will therefore give rise to increased demand for currency. This approach assumes that the major reason people participate in the underground economy is to avoid tax. It is considered the most important determinant of the underground economy. Therefore, if the tax base is given, increasing (or decreasing) tax rates may encourage more (or less) underground economy activities which in turn may increase (or decrease) the demand for currency (Pickhardt & Pons, 2006).

Although this approach is widely used around the world, it has the following shortcomings:

- All the causes of the underground economy are normally not included in the time series model. Important factors such as tax morality, tax complexity, and regulation impact are most often excluded due to the unavailability of reliable data (Dybka, Kowalczuk, Olesiński, Torój, & Rozkrut, 2018).
- Some transactions in the underground economy are not conducted in cash, therefore the CDA may underestimate the size of the underground economy.
- This approach assumes that the velocity of currency is the same for both formal and informal economies, which is not always the case. There is still a lot of uncertainty regarding the velocity of currency in the official economy and it is even more difficult to estimate in the underground economy (Hill & Kabir, 1996). A correction method developed by Ahumada, Alvaredo, & Canavese (2007) is proposed.
- The CDA often estimates the underground economy using a scenario of an economy with zero tax which does not exist. Dybka et al. (2018) suggested calibration of the lowest possible level of the underground economy by using the lowest recorded tax and social security contributions inflows.

2.1.3. Model approaches

The Multiple Indicators Multiple Causes (MIMIC) model and the Dynamic Multiple Indicator Multiple Cause (DYMIMIC) models

The MIMIC model, in which the underground economy is linked to a set of indicators and causal variables through a system of linear equations, was proposed by Frey and Weck-Hannemann (1984) and Giles (1999). The MIMIC

model consist of the measurement model and the structural equation model. The structural equation model regresses the underground economy against identified causal variables and the measurement model assesses the effect of the underground economy on the specified indicator variables. The measurement model is mathematically represented by equation 2.

$$\boldsymbol{y_t} = \boldsymbol{\lambda}\eta_t + \boldsymbol{\varepsilon_t} \tag{2}$$

where $\boldsymbol{\lambda}$ is a (px1) vector of unknown coefficients, $\boldsymbol{\varepsilon_t}$ is a (px1) vector of disturbances where every ε_{jt} , j = 1, …, p is a white noise error term. The latent variable, η_t, determines linearly a set of observable endogenous indicators $y_{1t}, y_{2t}, \dots, y_{pt}$ subject to disturbances $\boldsymbol{\varepsilon_t}$.

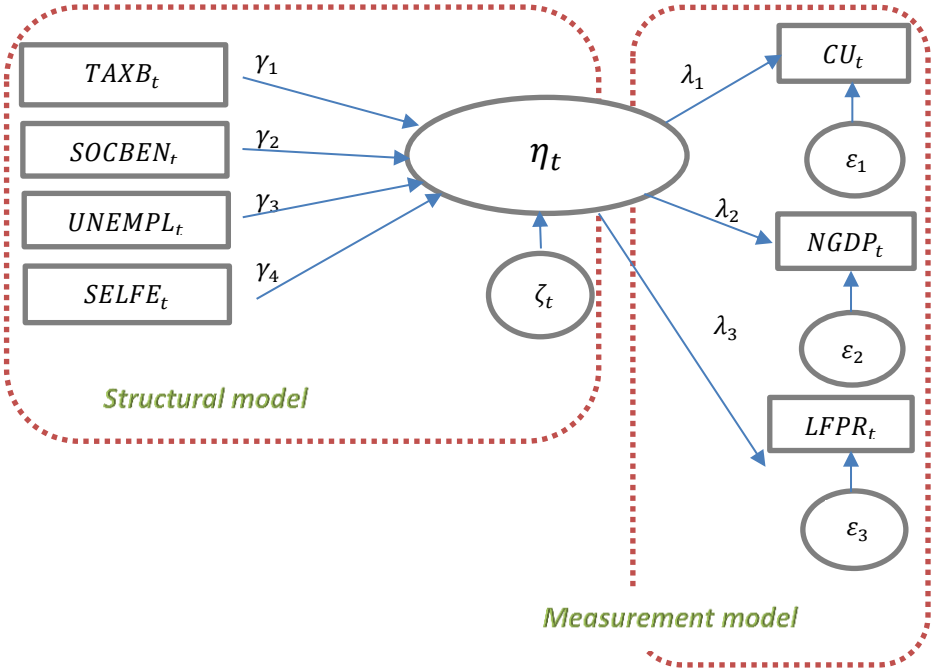
The structural equation model is mathematically represented by equation 3.

$$\eta_t = \boldsymbol{\gamma}'\boldsymbol{x_t} + \zeta_t \tag{3}$$

where $\boldsymbol{\gamma}' = (\gamma_1, \gamma_2, \dots, \gamma_q)$, a (1xq) vector of unknown coefficients, η_t is the latent variable (underground economy) and ζ_t is the error term representing the unexplained component. The latent variable η_t is linearly determined by a set of observable exogenous causes x_{1t}, x_{2t}, …, x_{qt} subject to disturbances ζ_t.

The relationship between the latent, causal and indicator variables is demonstrated by Figure 2 below. The latent variable, the underground economy (η_t), is defined by currency in circulation outside the banks (CU_t), NGDP ($NGDP_t$) and labor force participation rate ($LFPR_t$) with separate measurement error terms, ε_i and coefficients, λ_i for each. This is the measurement part of the MIMIC model that defines the latent variable with respect to indicator variables. The underground economy is predicted by the observed variables, tax burden ($TAXB_t$), social benefits granted by the government ($SOCBEN_t$), unemployment rate ($UNEMPL_t$), and self-employment rate ($SELFE_t$). The coefficients are shown by γ_i and the error term related to η_t is shown by ζ_t, This is the structural part of the MIMIC model that uses observed causal variables to predict a latent variable.

Figure 2. A typical MIMIC model



Source: Author's own computation.

One of the main disadvantages of the MIMIC model is that it requires an exogenous estimate of the size of the underground economy for a base year using another model. In most cases, the CDA is used for this purpose. The model is also too dependent on the causal and indicators variables chosen and the benchmarking procedure utilized is still subject to academic debate (Pickhardt & Pons, 2006)

2.2. Empirical studies conducted using the CDA model

The literature review revealed limited studies conducted to estimate the underground economy in South Africa. Makananisa, Koloane, & Schneider (2020) estimated the South African underground economy using both the CDA and the MIMIC models for the period 2004 to 2018. The study used time series data from 2000 to 2019, mostly sourced from Statistics South Africa (Stats SA). The CDA model indicated positive coefficients for the tax burden, government employment rate, self-employment rate, and deposit interest rate. A negative

coefficient was observed for NGDP, similar to the results from the MIMIC model. The model showed a marginally decreasing trend in the underground economic activities from 2012, with an average value of 22.47% for the period 2004 to 2018, a minimum value of 18.90% in 2004 and a maximum value of 25.20% in 2011. Similar to the CDA model, a positive significant coefficient was observed for the tax burden when using the MIMIC model. In addition, household income, household consumption and the interaction of unemployment with household debt were found to be positively related to underground economic activities. The indicators such as NGDP, currency in circulation outside the banks and labor force participation rate were found to be highly significant, with labor force participation rate and currency both showing positive relationships while NGDP showed an opposite relationship with the underground economy. In contrast to the CDA model, the MIMIC model showed a marginally increasing trend from 2011, with an average value of 25.45% for the period 2004 to 2018, a minimum value of 23.55% in 2011 and a maximum value of 27.48% in 2005.

Medina and Schneider (2019) conducted a study to estimate the size of the shadow economy for 157 countries over the period 1991 to 2017 using the MIMIC approach. Aggregated MIMIC model results were provided for all the developing countries. Trade openness, GDP per capita, unemployment rate, size of government, fiscal freedom, rule of law, control of corruption and government stability were included as causal variables in the model while currency in circulation, labor force participation rate and GDP per capita growth were included as indicators. The shadow economy in South Africa was estimated to be on average 26.8% with a minimum value of 21.9% and a maximum value of 30.4%.

Abela, Gauci, & Rapa (2021) conducted a study to estimate the shadow economy in Malta using both the CDA and MIMIC models. Quarterly data were collected for the period 2000 to 2019. The CDA model showed a cointegrating relationship between currency in circulation outside the banks and GDP, financial wealth, the tax burden, and financial innovation. The results showed that an increase in economic activity raises the demand for currency both in the long and short run. The positive and significant coefficient of financial wealth confirms the hypothesis that Maltese households prefer to hold part of their financial portfolio in cash. The Maltese shadow economy increased from 9.6% of GDP in 2000 to 20.4% of GDP in 2019. However, it has remained relatively stable, averaging just below 21% over the last decade. The MIMIC model, on the other hand, has indicated a downward trend in the underground economy over the last decade, with the index falling by approximately 6% over the period.

Bouriche and Bennihi (2020) conducted a study to estimate the informal economy in Algeria from 1980 to 2019 using yearly data which were obtained from the Official National Statistics and the World Bank database. The VEC model was built using the following variables: inflation rate, currency, nominal deposit interest rate, money supply, total tax outside oil tax revenues, and real non-oil GDP. The real non-oil GDP was used as a replacement for GDP to highlight the development of the official economy by taking out the repeated oil shocks which may be misleading. The study showed that the average Algerian informal economy is approximately 21% of the official GDP over the estimation period and that the informal economy is mostly influenced by the tax burden.

Similarly, Awad and Alazzeh (2020) estimated the Palestinian underground economy for the period 2008-2017 using data collected from the Palestine Monetary Authority (PMA) and the Palestinian Central Bureau of Statistics (PCBS). A CDA model was constructed using the following variables: cash outside the bank system, GDP, supply of money, tax, wages and government salaries, the price of revenue on saving deposits in commercial banks, the rate of workers in their private business to the real ratio of workers in Palestine, and GDP per capita. The study showed that the underground economy of Palestine was gradually decreasing from 28.6% in 2010 to 13.80% in 2016. The underground economy marginally increased to 18.37% in 2017.

Nchor and Konderla (2016) examined the underground economy of the Czech Republic using the following variables: currency in circulation outside the banks, GDP deflator, the total number of automatic teller machines, NGDP, the deposit interest rate, average tax, velocity of money, and nominal money supply. Annual data for the period ranging from 1993 to 2013 were collected from the World Bank country indicators and the International Financial Statistics. Extrapolation method was used to derive the data for 1991 and 1992 to ensure that the analysis period covered the period 1991-2013. The study revealed that on average the underground economy of the Czech Republic was 20.9% of GDP.

Raut, Chalise, and Thapa (2014) estimated the size of the underground economy in Nepal by applying the CDA model. The data for the period 1985-2011 were sourced from the economic bulletin of Nepal Rastra Bank, economic survey of ministry of finance, the government of Nepal, and the World Bank database. The VEC model was built using the following variables: the ratio of cash holdings to current and deposit accounts, total tax revenue of the government per GDP, per capita income, proportion of private consumption in national income, interest paid on savings deposits, and the inflation rate. The study

revealed a significant 31.7% rise in the underground economy between 2011 and 2012. The growth rate for prior years was much lower at 19.21% and 16.68% for the period 1991-2000 and 2001-2010, respectively.

Manzoor, Shabbir, and Syed (2018) developed a modified CDA model to estimate Pakistan's underground economy. An Auto Regressive Distributed Lag (ARDL) bound test was applied to estimate the dynamic monetary model and estimate the size of the underground economy. The model investigated the relationship between the tax burden and currency ratio by controlling for the impact of financial development, interest rate, education and strength of government regimes. Annual data for the period 1972-2015 were sourced from World Development Indicators, Pakistan's handbook of statistics, International Financial Statistics and Polity IV. The study showed a positive and significant long-run equilibrium relationship between the tax burden and currency ratio. Interest rate, financial development, education and regime strength had opposite relationship with money demand. The size of the underground economy was estimated to be 49.38% of GDP in 1998 and decreased to 27.16% of GDP in 2015.

Dahalan and Al-Gamal (2017) conducted a study to estimate the underground economy of Qatar for the period 1980-2010 using the Gregory and Hansen cointegration test based CDA. The results showed that the underground economy of Qatar has been growing at an average of 17.03% of the official GDP. It was 16.90% of the official GDP in 1980 and 15.51% of the official GDP in 2010. The underground economy as a percent of the official GDP was steadily increasing since 1980 to 2010, excluding the year 1998. Furthermore, the study revealed that tax evasion constitutes a major portion of the non-oil tax revenues in the Qatari economy. The growth rate of tax evasion as a percent of total non-oil tax revenues was estimated at 16.90% in 1980 and 15.50% in 2010.

3. Research methodology

This study adopted a time series approach, named the Currency Demand Approach (CDA), which was initially proposed by Cagan (1958) and further modified by Tanzi (1980, 1983). The CDA infers that the size of the underground economy can be estimated by the amount of cash used to conduct informal activities. To model the cash used in the underground economy, a Vector Error Correction Model (VECM) is used.

3.1. The currency demand approach

Cagan (1958) defined a currency demand function as:

$$C_0 = A(1+\theta)^{\alpha} Y_0^{\beta} \exp(-\gamma i) \tag{4}$$

where C_0 is the observed cash, θ is the tax burden, Y_0 is the formal GDP which estimates the level of transactions in the economy, i is the deposit interest rate signifying the opportunity cost of holding cash and A, α, β, γ are the positive parameters.

Data on the following variables were collected for possible inclusion in the CDA model: currency in circulation outside the banks, NGDP, tax burden, deposit interest rate, inflation rate, agricultural employment rate, mining employment rate, money supply (M2), money supply (M1), total tax, employment rate, social benefits granted by the government, unemployment rate, self-employment rate, and government expenditure. Several CDA models were constructed using different combinations of the explanatory variables. The study sought to search for the most parsimonious model by systematically dropping non-significant variables. Furthermore, the models were tested for serial correlation, normal distribution of residuals, stationarity, cointegration and hypothesized signs of the variables before finally settling for the model which provided the best results. In order to capture the long-run relationships of the explanatory variables on currency demand, the following CDA model was then decided upon:

$$\begin{aligned} lnCU_t = {} & \beta_0 + \beta_1 lnNGDP_t + \beta_2 lnTAXB_t + \beta_3 lnSOCBEN_t \\ & + \beta_4 lnSELFE_t + \beta_5 lnINT_t + \beta_6 lnUNEMPL_t + \varepsilon_t \end{aligned} \tag{5}$$

with, $\beta_2 > 0$, $\beta_4 > 0$, $\beta_6 > 0$ and $\beta_1 < 0$, $\beta_5 < 0$. The sign for β_3 can either be negative or positive.

where CU_t represents the currency in circulation outside the banks, $NGDP_t$ represents Nominal GDP, $TAXB_t$ represents the tax burden, $SOCBEN_t$ represents social benefits granted by the government, $SELFE_t$ represents self-employment rate, INT_t represents the deposit interest rate, $UNEMPL_t$ represents unemployment rate and ε_t represents the error term. A natural logarithm transformation was applied to the variables to render the data as normal as possible so that statistical analysis from this data becomes more valid.

Currency demand ($\widehat{CU}$) can be estimated from equation 5 using a VECM. Setting the tax burden to a minimum and leaving all the other variables as they are, yields $\widetilde{CU}$. This is done to analyze currency when the tax burden is not a factor which should result in less currency in circulation. Extra Currency (EC), which is the illegal money used in the underground economy to conduct informal transactions can be represented by equation 6.

$$\text{EC} = \widehat{CU} - \widetilde{CU} \tag{6}$$

As suggested by Tanzi (1983), equal velocity is assumed for both the formal and informal economies, and is calculated as follows:

$$V = \frac{Y}{C} \tag{7}$$

where Y is the formal economy and C is currency. This assumption only holds when the coefficient of Y is equal to one ($\beta_1 = 1$). The size of the underground economy is estimated by equation 8.

$$Y_{informal} = EC * V \tag{8}$$

Inferences about the size of the underground economy as a percentage of GDP can be made using equation 9. If $\beta_1 \neq 1$, a correction method needs to be applied to the results to obtain accurate estimates of the South African underground economy. The following correction method by Ahumada et al. (2007) was applied:

$$\frac{Y_{informal}}{Y_{formal}} = \left[\frac{C_{informal}}{C_{formal}}\right]^{\frac{1}{\beta}} = \left[\frac{\hat{Y}_{informal}}{\hat{Y}_{formal}}\right]^{\frac{1}{\beta}} \tag{9}$$

where Y represents GDP, C represents currency and β represents the income elasticity.

The variables used in the CDA model for this study are discussed in the section that follows.

3.1.1. Currency in circulation outside the banks

Underground transactions are normally conducted in cash rather than with cheques, credit cards or electronic transfers. Thus, the larger the currency in circulation is, the larger is the underground economy (Schneider & Buehn, 2016). In South Africa, there is a thriving township economy which includes spaza shops, salons, and the taxi industry. This economy mostly uses cash for

trading and these transactions are usually unrecorded and remain unnoticed by the tax authorities. Cash is a preferred means of payment for a large sector of the population.

Hypothesis: The larger the currency in circulation is, the larger is the size of the underground economy, ceteris paribus.

3.1.2. Tax burden

The tax burden is the main variable behind all currency models because an increase in the tax burden is expected to have a positive impact on currency demand, whereby individuals will tend to hold more cash for their informal transactions. It is a variable that gives incentives for individuals to engage in underground activities. In South Africa, only three million people carry the tax burden of a population of 59.5 million (IOL, 2021).

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

3.1.3. GDP

On the one hand, a rise in the underground economy leads to a reduction in the official economy because productive resources and factors are being used by the underground economy. On the other, poor people are able to produce and sell cheap products in the underground economy as a way of generating income. The increased demand in the underground economy will have a positive spillover effect on the formal economy. Schneider (2005) contended that in developing countries, the relationship is negative and it is positive in the developed and transition countries. In recent times, South Africa's economy has been stagnant recording annual GDP growth rates of 0.79% and 0.15% in 2018 and 2019 respectively. The COVID-19 pandemic further exacerbated the poor performance resulting in a contraction of 6.96% in 2020 (World Bank, 2021a). Therefore, in this environment one can expect a growth in the underground economic activities.

Hypothesis: The lower the GDP is, the higher is the underground economy, ceteris paribus.

3.1.4. Social benefits granted by the government

Social benefits have an ambiguous effect on the underground economy. Social benefits can encourage individuals not to be formally employed but to enjoy extra revenue from the underground economy, by dedicating all their available working time to the underground economy. However, Dell'Anno, Gómez-Antonio, & Pardo (2007) argued that social benefits can reduce the underground economic activities. Social benefits increase the cost of engaging in the underground economic activities because informal workers do not have access to unemployment allowances and financial aid. The South African government has significantly increased social benefits in the past 18 years. In 2006, they were increased by a massive 800%, and again in 2020 there was a significant increase to mitigate the impact of COVID-19 pandemic.

Hypothesis 1: The higher the social benefits granted by the government are, the lower is the underground economy, ceteris paribus.

Hypothesis 2: The higher the social benefits granted by the government are, the higher is the underground economy, ceteris paribus.

3.1.5. Unemployment rate

Unemployment can encourage individuals to seek employment in the underground economy. According to Gauci and Rapa (2020), an increase in the unemployment rate will most likely result in an increase in the underground economic activities. South Africa recorded an unemployment rate of 34.9% in the third quarter of 2021, the highest in the world.

Hypothesis: The higher the unemployment is, the larger is the size of the underground economy, ceteris paribus.

3.1.6. Deposit interest rate

Increasing interest rates may encourage individuals to deposit money since they can achieve a higher return on it while low interest rates might disincentivize individuals to deposit money. The higher the deposit interest rate is, the less likely individuals will participate in underground economic activities. In South

Africa, the deposit interest rate gradually decreased from a high of 11.61% in 2008 to a low of 4.8% in 2020 (World Bank, 2020).

Hypothesis: The higher the deposit interest rate is, the lower is the size of the underground economy, ceteris paribus.

3.1.7. Self-employment rate

A growth in self-employment increases the number of opportunities to hide revenue from the tax administrators, thus increasing underground economic activities (Dell'Anno et al., 2007). Self-employed workforce have greater probability of tax evasion than large entities as there are generally fewer auditing controls in their businesses and they work very closely with their clients (Gauci & Rapa, 2020). In South Africa, self-employment represents only 10% of all jobs, a relatively low figure compared to 30% in most upper middle-income countries such as Turkey, Mexico, and Brazil (World Bank, 2021b).

Hypothesis: The higher the self-employment rate is, the larger is the size of the underground economy, ceteris paribus.

3.2. Vector Error Correction Model (VECM)

A VECM is a multivariate time series model that relates current observations of a variable with past observations of itself and past observations of other variables in the system. All the variables in a VECM are endogenous and there are no exogenous variables. The model is a special case of the VAR model which does not only require stationarity of variables but also that the variables be cointegrated, hence it is sometimes also called the restricted VAR model. A VAR model with three variables, currency in circulation outside the banks (CU_t), unemployment rate ($UNEMPL_t$) and interest rate ($INTR_t$), for example, shown in natural logarithms, can be represented by equations 10-12, where the dependent variable is a function of its own lag and the lag values of other variables in the model.

$$lnCU_t = \alpha + \sum_{i=1}^{k} \beta_i lnCU_{t-i} + \sum_{j=1}^{k} \phi_j lnUNEMPL_{t-j} + \\ + \sum_{m=1}^{k} \varphi_m lnINTR_{t-m} + \varepsilon_{1t} \quad (10)$$

$$lnUNEMPL_t = c + \sum_{i=1}^{k} \beta_i lnCU_{t-i} + \sum_{j=1}^{k} \phi_j lnUNEMPL_{t-j} + \\ + \sum_{m=1}^{k} \varphi_m lnINTR_{t-m} + \varepsilon_{2t} \quad (11)$$

$$lnINTR_t = d + \sum_{i=1}^{k} \beta_i lnCU_{t-i} + \sum_{j=1}^{k} \phi_j lnUNEMPL_{t-j} + \\ + \sum_{m=1}^{k} \varphi_m lnINTR_{t-m} + \varepsilon_{3t} \quad (12)$$

The VECM model, which is a differenced VAR model, with cointegrated variables will thus be represented by equation 13-15 below.

$$\Delta lnCU_t = \alpha + \sum_{i=1}^{k-1} \beta_i \Delta lnCU_{t-i} + \sum_{j=1}^{k-1} \phi_j \Delta lnUNEMPL_{t-j} \\ + \sum_{m=1}^{k-1} \varphi_m \Delta lnINTR_{t-m} + \lambda_1 ECT_{t-1} + \varepsilon_{1t} \quad (13)$$

$$\Delta lnNGDP_t = c + \sum_{i=1}^{k-1} \beta_i \Delta lnCU_{t-i} + \sum_{j=1}^{k-1} \phi_j \Delta lnUNEMPL_{t-j} \\ + \sum_{m=1}^{k-1} \varphi_m \Delta lnINTR_{t-m} + \lambda_2 ECT_{t-1} + \varepsilon_{2t} \quad (14)$$

$$\Delta lnINTR_t = d + \sum_{i=1}^{k-1} \beta_i \Delta lnCU_{t-i} + \sum_{j=1}^{k-1} \phi_j \Delta lnUNEMPL_{t-j} \\ + \sum_{m=1}^{k-1} \varphi_m \Delta lnINTR_{t-m} + \lambda_3 ECT_{t-1} + \varepsilon_{3t} \quad (15)$$

where $\beta_i, \phi_j, \varphi_m$ represents the short-run dynamic coefficients of the model's adjustment long-run equilibrium, α, c, d represents constants, k represents the lag length and is reduced by one after differencing, λ_i is the speed of adjustment parameter, ECT_{t-1} is the lagged value of the error correction term and ε_{it} are the residuals or stochastic error terms. The error correction term is the lagged value of the residuals obtained from the cointegrating regression of the outcome variable on the predictor variables. It explains previous deviations from the long run equilibrium (CrunchEconometrix, 2018; Hill, Griffiths, & Lim, 2018).

4. Research findings

Time series data for the period 2000 to 2020 (84 quarterly observations) were sourced from Stats SA (2022), the International Monetary Fund (IMF, 2021) and the South African Reserve Bank (SARB, 2021). The STATA statistical software was used for analysis and estimation purposes.

A VECM was used to model the currency demand. In order to use this model, data need to be stationary and cointegrated to indicate long run relationship between the variables. The variables were first log transformed (*ln*) to approximately conform to normality and then tested for the presence of unit root and cointegration.

4.1. Unit root test

The Augmented Dickey Fuller (ADF) test was used to test for the existence of unit roots on the transformed variables. The presence of unit roots indicates that the data are non-stationary. Table 1 shows the test statistic and the respective critical values of the ADF unit root test for the levels and first differences of the variables.

Table 1. ADF unit root test at level and first difference

Unit root at:	Statistic	CU_t	$NGDP_t$	$SOCBEN_t$	$UNEMPL_t$	$TAXB_t$	INT_t	$SELFE_t$
I (0)	Test Statistic	−1.436	1.619	−2.053	−1.309	0.138	−2.851	−3.295
	5% critical value	−3.472	−3.471	−3.469	−3.471	−1.950	−3.469	−3.468
I (1)	Test Statistic	−3.730	−3.997	−6.863	−3.985	−3.888	−4.080	−8.736
	5% critical value	−3.473	−3.472	−3.470	−3.472	−1.950	−3.470	−3.469

Source: Author's own computation.

The variables are not stationary at level (0) but become stationary after first differencing since the calculated t-statistics from the ADF equations are larger in absolute terms than the critical values at 5% level of significance.

4.2. Johansen cointegration test

An optimal lag length of 3 was chosen to perform the Johansen cointegration test. The hypothesis at rank 0 is as follows:

H_0: There is no cointegrating equation.

H_1: There is a cointegrating equation.

Therefore at rank 2 the hypothesis will be as follows:

H_0: There are 2 cointegrating equations.

H_1: There are more than 2 cointegrating equations.

If the trace statistic > 5% critical value, H_0 is rejected. Otherwise H_0 will be accepted.

Table 2 shows the results of the Johansen cointegration test. The test indicates that there are at least 2 cointegrating equations.

Table 2. Johansen cointegration test

Trend: constant — Number of obs = 81
Sample: 2000q4 - 2020q4 — Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	105	948.24417	.	183.5624	124.24
1	118	985.9362	0.60571	108.1783	94.15
2	129	1005.899	0.38915	68.2528*	68.52
3	138	1022.1861	0.33112	35.6786	47.21
4	145	1030.4456	0.18449	19.1594	29.68
5	150	1036.4401	0.13758	7.1705	15.41
6	153	1039.873	0.08127	0.3047	3.76
7	154	1040.0254	0.00375		

Note: * indicates when the trace statistic < 5% critical value, i.e. when H_0 is not rejected.

Source: Author's own computation.

4.3. VECM results

Given the absence of unit roots, the presence of a long run association between the variables and the cointegration of the variables, currency demand can now be estimated using the VECM. This type of model is considered superior to other estimation methods as it caters for both the long and short run effects.

Table 3 shows the short run causality between the variables and the target model, that is, $ln\,CU$. For the short run causality, with the exception of $lnINT$ and $lnSELFE$, all the variables are significant at 1% or 5% level on either lag 1 or 2.

Table 3. Short run causality

Target model with variables		Coefficient	Standard Error	z	P(z)	[95% confidence interval]	
1		*2*	*3*	*4*	*5*	*6*	
D_lnCU							
	ECT						
	L1	−0.029	0.009	−3.290	0.001	−0.046	−0.012
	lnCU						
	LD	−0.609	0.083	−7.300	0.000	−0.773	−0.446
	L2D	−0.200	0.120	−1.670	0.094	−0.434	0.034
	lnNGDP						
	LD	−0.133	0.100	−1.340	0.182	−0.328	0.062
	L2D	0.288	0.108	2.67	0.008	0.076	0.499
	lnINT						

Table 3 cont.

1		*2*	*3*	*4*	*5*	*6*	
	LD	−0.056	0.044	−1.260	0.206	−0.143	0.031
	L2D	0.007	0.041	0.160	0.873	−0.074	0.087
	lnUNEMPL						
	LD	−0.119	0.061	−1.940	0.052	−0.239	0.001
	L2D	−0.227	0.070	−3.250	0.001	−0.365	−0.090
	lnTB						
	LD	−0.268	0.046	−5.830	0.000	−0.358	−0.178
	L2D	−0.300	0.039	−7.600	0.000	−0.373	−0.220
	lnSELFE						
	LD	0.060	0.048	1.240	0.215	−0.035	0.154
	L2D	−0.024	0.049	−0.490	0.625	−0.121	0.072
	lnSOCBEN						
	LD	−0.004	0.010	−0.370	0.712	−0.022	0.015
	L2D	0.018	0.009	2.080	0.038	0.001	0.035
	Constant	0.018	0.007	2.680	0.007	0.005	0.030

Source: Author's own computation.

The speed of adjustment term (−0.029) is statistically significant at 1% level indicating that deviations from long run equilibrium are corrected for within the current year at a convergence speed of 2.9%. In other words, there is a long causal effect in the $ln\,CU$ equation at 1% level.

The estimated VECM model can now be written as equation 16:

$$\Delta\, ln\, CU_t = 0.018 + \sum_{i=1}^{2}(\theta_i \Delta lnCU_{t-i} + \gamma_i \Delta \ln NGDP_{t-i} + \delta_i \Delta lnINT_{t-i} + \vartheta_i \Delta lnUNEMPL_{t-i} + \alpha_i \Delta lnTAXB_{t-i} + \omega_i \Delta \ln SELFE_{t-i} + \varphi_i \Delta \ln SOCBEN_{t-i}) - 0.029 ECT_{t-1} + \varepsilon_t \quad (16)$$

where coefficients are indicated in Table 4 below.

Table 4. Model lagged coefficients

Lag$(t-i)$	θ_i	γ_i	δ_i	ϑ_i	α_i	ω_i	φ_i
1	−0.609	−0.133	−0.056	−0.119	−0.268	0.060	−0.004
2	−0.200	0.288	0.007	−0.227	−0.300	−0.024	0.018

Note: $i = 1,2$.

Table 5 shows the long run equation from which the error correction term (ECT_{t-1}) is generated, often called the Johansen normalization restriction. The error correction term is mathematically represented as equation 17.

$$ECT_{t-1} = 1.000lnCU_{t-1} + 1.094lnNGDP_{t-1} + 1.110lnINT_{t-1} - 2.139ln\ UNEMP_{t-1} - 7.798lnTAX_{t-1} + 1.654lnSELFE_{t-1} - 0.282lnSOCBEN_{t-1} - 1.020 \quad (17)$$

Table 5. Johansen normalization restriction

beta	Coefficients	Standard Error	z	P(z)	[95% confidence interval]	
_ce1						
$lnCU$	1.00	.	.	.	.	.
$lnNGDP$	1.094*	0.263	4.15	0.000	0.578	1.610
$lnINT$	1.110*	0.180	6.18	0.000	0.758	1.462
$lnUNEMP$	−2.139*	0.590	−3.62	0.000	−3.296	−0.982
$lnTAXB$	−7.798*	1.081	−7.21	0.000	−9.918	−5.679
$lnSELFE$	1.654*	0.360	4.59	0.000	0.948	2.360
$lnSOCBEN$	−0.282*	0.093	−3.02	0.003	−0.465	−0.099
Constant	−1.020	.	.			
R^2=0.866						

* Significant at the 1% level.

Note: All variables are in natural logarithm. The models are estimated with one cointegrating equation.

Source: Author's own computation.

The restriction is placed on currency in circulation outside the banks which is shown as the dependent or target variable. *_ce1* indicates the cointegrating equation. For interpretation, the signs of the coefficients are reversed. In the long run, unemployment rate, tax burden and social benefits granted by the government have a positive effect on currency, while NGDP, deposit interest rate and self-employment rate have a negative effect on currency. All the coefficients are statistically significant at 1% level. Tax burden has the highest impact on the underground economy, followed by deposit interest rate, self-employment rate and NGDP. The overall explanatory power of the model is strong, with an R-squared of 0.87 which indicates that these variables considerably explain the variations of currency demand in South Africa.

4.4. Model diagnostics

A Lagrange multiplier test is used to test for serial correlation in the residuals. According to Table 6, there is no serial correlation at lag 2 and lag 4.

Table 6. The Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	71.6671	49	0.01903
2	62.0383	49	0.09999
3	70.9411	49	0.02185
4	36.7831	49	0.90075

Source: Author's own computation.

The Jarque–Bera tests whether the residuals are normally distributed. As shown by Table 7 below, the residuals for the target model, *D_lnCU* are normally distributed.

Table 7. The Jarque–Bera test

Equation	chi2	df	Prob > chi2
D_lnCU	1.285	2	0.52607
D_lnNGDP	2015.875	2	0.00000
D_lnINT	31.455	2	0.00000
D_lnUNEMPL	1.963	2	0.37479
D_lnTB	0.628	2	0.73065
D_lnSELFEMPL	57.444	2	0.00000
D_lnSOCBEN_GOVTEX	3560.964	2	0.00000
ALL	5669.613	14	0.00000

Source: Author's own computation

4.5. Estimating the size of the underground economy

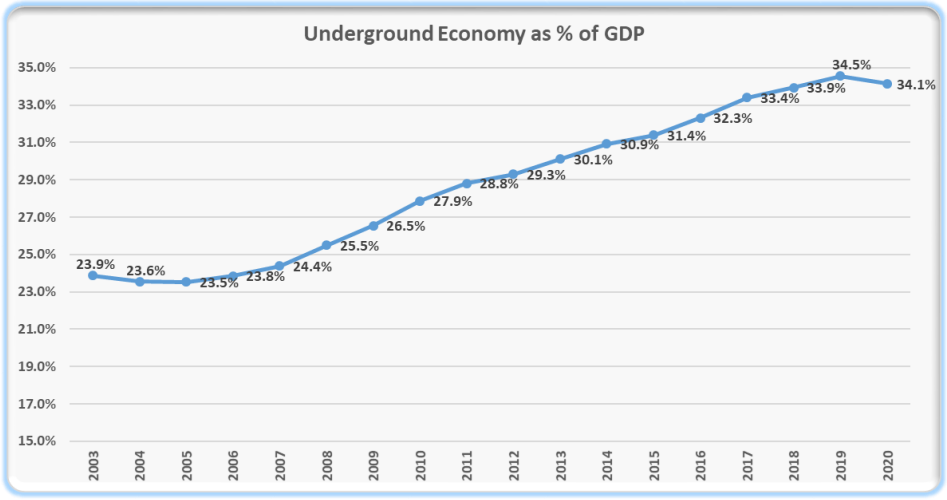
The size of the underground economy in South Africa can now be calculated using the VECM currency demand model shown in equation (4.2). Initially, currency in circulation outside of banks is estimated with the tax burden and thereafter with minimal tax burden to minimize the incentive for individuals to participate in the underground economy. A minimal tax burden was chosen instead of zero tax burden in line with the suggestion by Dybka et al. (2018) citing that there is no country with an average tax burden equal or close to zero.

Currency in circulation outside of banks would be lower when the tax burden is minimized because there is less demand for cash payments of goods and services to evade tax. The difference between the two estimates yields Extra

Currency (EC), which is the illegal money used in the underground economy. The size of the underground economy is the product of EC and velocity of currency. Since the coefficient of NGDP is not equal to 1, the correction method by Ahumada et al. (2007) was applied to obtain correct estimates of the South African underground economy.

Figure 3 shows the historical trend of the underground economy in South Africa from 2003 to 2020. The size of the underground economy is shown as % of GDP.

Figure 3. The size of the underground economy in South Africa



Source: Author's own computation.

The underground economy gradually increased from 23.9% in 2003 to 34.5% in 2019 and slightly declined to 34.1% in 2020. On average, the underground economy in South Africa represented 28.8% of GDP for the period 2003 to 2020.

5. Discussion

Gross Domestic Product is closely related to employment. During the 2008/09 global financial crisis, over one million jobs were lost as South Africa entered into a recession. The recovery from 2010 to 2013 saw approximately 650 000 jobs gained (Stats SA, 2013). Prior to the global financial crisis, the

economic growth rate was much higher (averaging over 5% per year). In recent times, South Africa's economy was stagnant recording annual GDP growth rates of 0.79% and 0.15% in 2018 and 2019, respectively. The COVID-19 pandemic further exacerbated the poor performance resulting in a contraction of 6.96% in 2020 (World Bank, 2021a). This type of environment serves as a fertile ground for underground economic activities.

The underground economy has been steadily increasing in the past 18 years. This increase is due to the declining economic conditions in South Africa. Unemployment is currently the highest in the world and the majority of economic sectors are declining. Youth unemployment is alarming with recent media reports suggesting that the youth do not have the skills required by the industry. There is a general perception of corruption and misuse of state funds which encourages even law abiding citizens to evade tax and get involved in illegal activities. Recent media reports have suggested that high-net-worth and ultra--high-net-worth South Africans are emigrating in large numbers, which leaves a few individuals who are already struggling, to carry the tax burden of South Africa. Some of the reasons cited by these individuals are political instability, safety and security, education, volatile currency or the lack of job opportunities in South Africa (BusinessTech, 2021).

The analysis indicates that the tax burden plays a more significant role in in-creasing the underground economic activities. South Africa's tax rates are reported to be among the top 10 in the world (Gonçalves, 2019). It is recommended that policy makers should implement major tax reforms and introduce educational campaigns in order to improve tax compliance and increase tax morale.

The deposit interest rate in South Africa has been consistently declining for the period under review with 2020 rate only at 4.88% compared to an average of 7.11% for 2016 to 2019. This is rather concerning as with the declining deposit interest rate, one can expect the underground economy to increase, which is what is indicated by the results of the model. In order to revitalize the formal economy, the SARB should review the current monetary policy. The monetary policy's intention is to achieve and maintain price stability in the interest of balanced and sustainable economic growth. If the SARB raises the interest rate, borrowing costs will increase for borrowers with floating interest rate debt (e.g., the interest rate on home loans). However, the increased interest rate will also promote saving and discourage borrowing. This is often called the savings and investment channel (SARB, 2020). This will result in less currency in circulation to conduct underground economic activities.

The increasing trend in the underground economy puts a lot of pressure on the South African government to devise strategies to reduce this economy. A number of additional new strategies such as tamper-proof electronic tills and online tills are being proposed by the OECD (2017). Together with these new measures, the South African government should consider increasing regulatory frameworks in the business sector, particularly the township economy. Tax authorities should collaborate with customers, intermediaries and employees so as to verify information supplied by the taxpayers. Strategies aimed at such groups might assist in increasing reporting. Examples are customer verification of purchases, whistle-blowing schemes, and wider reinforcing of social norms (OECD, 2017).

Furthermore, the South African government needs to resuscitate most of the economic sectors, particularly the agricultural and manufacturing branches. Major structural reforms are required in the education sector in order to equip the youth with appropriate skills to gain formal employment.

6. Conclusions

6.1. Contribution of study to research

This study sought to assess the extent of the underground economic activities in South Africa and to identify the drivers of this economy using the CDA model. The model results indicate an increasing trend in the underground economy with an average of 28.8%, the maximum value of 34.4% and the minimum value of 23.5% for the period 2003 to 2020. In contrast, the CDA results by Makananisa et al. (2020) showed a more stable trend with values ranging between 18.90% and 25.20% for the period 2004 to 2018. The average value for the period was 22.5%, which is 6.3% lower than the average value from this study. However, their MIMIC results are more consistent with the results of this study, where a slightly increasing trend is observed from 2011. The MIMIC model by Makananisa et al. (2020) estimated the South African shadow economy to be 25.5% on average for the period 2004 to 2018, with the minimum value of 23.6% in 2011 and the maximum value of 27.5% in 2005.

Similar to the results obtained by Makananisa et al. (2020), the study identified tax burden, NGDP, self-employment rate and interest rate as the predictors of the underground economy. However, contrary to the findings by Makananisa et al. (2020), this study confirms the negative relationship between deposit inter-

est rate and the underground economy found by various authors such as Abela et al. (2021) and Sharapenko (2009). The increase in deposit interest rate serves as an incentive for individuals not to indulge in underground economic activities but rather to save money and earn interest on it. However, self-employment showed a negative relationship with the underground economy, diverging from the literature and findings by Makananisa et al. (2020). Nominal GDP has a negative, significant coefficient confirming the assertion made by Schneider (2005) that in developing countries, the official economy has a negative relationship with the underground economy.

In addition, this study confirmed the positive relationship between the underground economy and unemployment rate as well as social benefits granted by the government. South Africa is experiencing unprecedented unemployment levels. In fact, the official unemployment rate for the third quarter of 2021, as reported by Stats SA, was 34.9%, with youth unemployment at an alarming 66.5%. In order to alleviate the rising poverty as a result of unemployment, the government has significantly increased social grants, resulting in increased underground economic activities as shown by the increasing trend in Figure 3.

Table 8 shows the hypothesized signs of the explanatory variables in accordance with the literature review and the results obtained from the VEC model.

Table 8. Empirical confirmation of the hypotheses

Explanatory Variable	Hypothesized Sign	Model Result
1. NGDP	Negative (−)	Confirmed
2. Deposit Interest Rate	Negative (−)	Confirmed
3. Unemployment Rate	Positive (+)	Confirmed
4. Tax Burden	Positive (+)	Confirmed
5. Social benefits granted by the government	Ambiguous effect (+) or (−)	Positive
6. Self-Employment Rate	Positive (+)	Not Confirmed

Source: Author's own computation.

This study provides the following essential contributions:

- It serves as an initial step in calculating the tax gap in South Africa and quantifying the extent of tax evasion, resulting in an improved tax base and compliance.
- A confirmation of the upward trend in the growth of the underground economy in South Africa. The MIMIC and CDA results by Makananisa et al. (2020) provided contrasting trend of the underground economy. This study confirms the upward trajectory of this economy.

- Mounting unemployment is South Africa's most pressing challenge at the moment. Unemployment rate and social benefits granted by the government should be considered as predictors of the underground economy as they have a significant positive relationship with the underground economy.
- The CDA provides a reliable exogenous estimate of the underground economy which can be used as an input into the MIMIC model. However, careful consideration should be taken in choosing relevant predictors to capture the economic dynamics of the country under study.

6.2. Limitations of this study and future work

A significant limitation to this study was the unavailability of data for key variables. Employment data such as unemployment rate, labor force participation rate and self-employment rate were not available from Stats SA for periods earlier than 2000 as previous estimates were derived using the October Household Survey and these estimates have not been adjusted to the current methodology. Therefore, quarterly data on the variables of interest were only available for the period 2000 to 2020. Furthermore, limited to no data were available for variables such as the corruption index, tax morale, tax complexity, economic freedom index and immigration. Future work should involve a comprehensive sectoral analysis to identify the proportional contribution of each economic sector to the underground economy in order to enable the South African government to implement focused interventions to restrict the growth in this economy.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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