

Mining Production and Economic Growth Nexus (Hubungan antara Pengeluaran Perlombongan dan Pertumbuhan Ekonomi)

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ABSTRACT

The production crisis in the mining sector is a great concern to the South African economy. This happens regardless of the policies and implementation of investment strategies that the government has put in the industry, which still has a steady contribution to the gross domestic product. The aim of this study was to investigate the relationship between mining production, government expenditure and economic growth in South Africa. As a resource-endowed country that depends primarily on minerals to enhance growth, the operation in mining production is crucial. The paper employed the vector error correction model to analyze the annual time series data from the South African Reserve Bank covering the period 1983 to 2015. Preliminary results show that all variables were found to be stationary at first difference. Subsequently, the cointegration results indicated that there was at least one cointegrating equation, which confirmed the existence of a long-run relationship in the system. The long-run analysis showed that mining production excluding gold has a significant coefficient compared to all other variables, and has a positive relationship with expenditure on gross domestic product. The mining production of gold showed a negative relationship with expenditure on the gross domestic product, which supports the 'resource curse' theory. Finally, the short-run analysis showed that the system will come back to equilibrium. The study recommends that policymakers should formulate policies that will encourage and attract both local and international investors in this industry, especially in mining production excluding gold.

Keywords: Mining production; expenditure on the gross domestic product; cointegration; South Africa

ABSTRAK

Krisis pengeluaran dalam sektor perlombongan telah mendapat perhatian yang meluas kepada ekonomi Afrika Selatan. Ini berlaku tanpa mengira dasar dan pelaksanaan strategi pelaburan yang telah dilaksanakan oleh kerajaan dalam industri, yang masih mempunyai sumbangan penting kepada keluaran dalam negara kasar. Kajian ini mengkaji hubungan antara pengeluaran perlombongan, perbelanjaan kerajaan dan pertumbuhan ekonomi di Afrika Selatan. Sebagai negara yang mempunyai anugerah sumber yang bergantung kepada mineral untuk meningkatkan pertumbuhan, operasi dalam pengeluaran perlombongan adalah penting. Maka, kajian ini menggunakan model vektor pembetulan ralat (VECM) untuk menganalisis data siri masa tahunan dari Bank Rizab Afrika Selatan yang meliputi tempoh 1983 hingga 2015. Penemuan awal kajian menunjukkan semua pemboleh ubah siri masa mencapai kepegungan pada peringkat pembezaan pertama. Selanjutnya, hasil ujian kointegrasi menunjukkan bahawa terdapat sekurang-kurangnya satu persamaan vektor yang berkointegrasi, yang mengesahkan adanya hubungan jangka panjang dalam siri masa tersebut. Analisis jangka panjang menunjukkan bahawa pengeluaran perlombongan tidak termasuk emas mempunyai pekali yang signifikan berbanding semua pemboleh ubah lain, dan mempunyai hubungan positif dengan perbelanjaan terhadap keluaran dalam negara kasar. Pengeluaran perlombongan emas menunjukkan hubungan negatif dengan perbelanjaan terhadap keluaran dalam negara kasar, yang menyokong teori 'sumpahan sumber alam'. Akhir sekali, analisis jangka pendek menunjukkan bahawa siri masa tersebut akan kembali kepada keseimbangan. Kajian ini mencadangkan agar penggubal dasar harus merangka dasar yang menggalakkan dan menarik pelabur tempatan dan antarabangsa dalam industri ini, terutamanya dalam pengeluaran perlombongan yang tidak termasuk emas.

Kata kunci: Pengeluaran perlombongan; perbelanjaan terhadap keluaran dalam negara kasar; kointegrasi; Afrika Selatan

INTRODUCTION

Natural resources are assets that consist of a portion of total wealth in low-income standards, which is if these resources get an opportunity to increase income level

in resource-dependent countries (Canuto & Cavallari 2012). This income level results from the mentioned assets together with labor. If there is a lack of skills and knowledge about the resources, then this could resort to insufficient input in the economy. Non-renewable



resources do not generate any productive wealth, but consumption; and as soon as they are depleted, there will be no replacement. These natural resources could possibly be wealth generators, but in the international market, prices are not stable, thus making loans difficult to repay and have a disadvantage in terms of trade. The countries' lack of resources knowledge to convert natural resource wealth into income and improved development remains high in a resource-rich economy like South Africa (Kantor 2013). Thus, it is evident that the country has been diagnosed with many of the outlined symptoms in the literature of the resource curse, which include slow growth, gross inequalities, entrenched poverty and the creation of a rentier state.

Minerals are the primary attraction of potential investors and are an abundant resource in South Africa. The South African economy has always relied on these important natural resources to a level where Fedderke and Pirouz (2002) argued that conventional wisdom viewed the mining sector as the country's quintessence. They maintained that the sector is a contributor to aggregate output, a foreign exchange earner for the economy, an employer and a generator of tax revenues. Furthermore, the sector is viewed as the locomotive of the country's economic development. According to Hanusch (2018), mining and related products still account for about 60% of exports. Vegter (2018) posited that South Africa's mineral resources are the lifeblood of the economy. This notion of "the lifeblood of the economy" is underpinned by the fact that South Africa's energy sector is heavily dependent on a thriving mining industry, and will remain so for the foreseeable future. Vegter warned that without urgent policy interventions to revitalize the mining industry, the country's entire economy will wither, like a gold rush town falling into decay. Furthermore, Vegter (2018) contended that even though the industry is struggling, it is far from dead. He argued that South Africa is the world's leading producer of platinum, vanadium, vermiculite, manganese, and chromium. It is the second-largest producer of ilmenite, industrial garnet, palladium, rutile, and zirconium. It is also the world's third-largest coal exporter, and a large producer of iron ore. Other significant minerals include gold, titanium, nickel, antimony, phosphates, rare earth elements, uranium, diamonds, tin, and copper.

The positive contribution of the mining industry to the South African economy was further echoed by Kane-Berman (2018), who maintained that regardless of all its predicaments, the industry is well-positioned for a new lease of life despite all the vicissitudes. Even though the attractiveness of South Africa in mining investment has declined, the country still has the world's richest reserves of precious minerals and base metals. Companies, both large and small would like to exploit these. Some are already doing so in spite of the political threats. Even more, they will do so if the threats can be effectively managed or reduced. In contrast with the

recent global crises, despite the global commodities boom and recovery in fixed investment in the sector, the total mining production, which is described as the overall finished minerals that are saleable, has continued to decline to an extent that the country has not been able to take full advantage of this boom. The impact on the economy has been substantial where export earnings, gross domestic product (GDP) and investment are all likely to be affected by this crisis. Nevertheless, Baxter (2012) indicated that South Africa has also had a combination of factors that were responsible for the decline. They include infrastructure challenges, regulatory red tape and production disruptions due to safety shutdowns.

As if that was not enough, the industry was caught by what seemed to be a type of "prisoners' dilemma", where workers were coerced into striking for lengthy periods, and mining companies' refusal to accede to unaffordable wage demands (Harvey 2014). The South African mining sector, particularly gold and platinum, had a negative impact on GDP and the expected GDP growth. Thus, the mines as businesses had to cover their costs by planning for lower operational costs. Production and most mineshafts were closed. These external factors, such as strikes in the mining industries influence growth negatively. Therefore, this is likely going to result in investors losing confidence in the prospects of the industry, and to affect the economic growth of South Africa since it relies heavily on the production of minerals (Kantor 2013). Furthermore, Best (2015) noted that the industry is faced with a systemic crisis.

Local gold production has declined by 22% from 1994 to 2014. This is despite a 218% boom in the gold price during this time. Meanwhile, South African gold reserves are still ranked number one internationally (by value US\$151bn). Statistics South Africa (2015) also stressed that the total mining production was 1.6% lower in 2018 compared to 2017. The 1.6% decrease in annual production followed an increase of 3.9% in 2017 and a decrease of 3.7% in 2016. Hermanus (2017) attributed most of these challenges to both historical and current contexts. He argued that the South African mining sector is in a predicament as contradictions rooted in its apartheid past have come home to roost: mineral prices remain stubbornly low, and another industrial revolution affecting all industries, including mining, gets underway.

By the same token, the economy has not been doing well for some time. According to Bhorat and Kimani (2018), the South African economy is stuck in a low and sluggish growth trap; an indication that there are significant economic constraints acting as stumbling blocks to the country's economic growth. It has lagged behind other countries since democracy in 1994 and risks falling further behind. Growth per capita averaged 1.1% between 1994 and 2000, 2.9% between 2001 and 2008, and has stagnated since 2009, turning negative in 2015. To this extent, South Africa has been consistently

outperformed by other Sub-Saharan African countries since democracy (Hanusch 2018). Similarly, Wasserman (2019) pointed out that the South African economy contracted by more than 3% in the first quarter of 2019, which could be attributed to challenges such as weak electricity supply, which was signified by persistent load shedding, strikes at gold mines, and a dire lack of investment hitting growth. He argued that because of all these challenges, the mining industry decreased by 10.8%, with sharp falls in coal and iron ore. At the same time, the manufacturing industry contracted by 8.8%, with vehicle manufacturing as one of the worst performers, and the agriculture, forestry and fishing sectors saw a 13.2% fall.

South Africa is also enmeshed in a quandary of infrastructure spending outcomes in all three spheres of government. According to the National Treasury (2019), over the past 10 years, the public sector has spent more than R2.3 trillion on infrastructure. State-owned companies have been the biggest contributors to public-sector expenditure over this period, spending R1 trillion in total. As it stands, the debt-to-GDP ratio is projected at 60.8% of the 2019 fiscal year, and it is projected to rise to about 64.9% in 2020 and to around 68.5% in 2022.

Given all these predicaments and the importance of mining in the South African economy, our literature search has revealed very minimal contributions to the literature in this field. On the one hand, previous studies mainly focused on issues such as contributing mining sectors and mineral resource endowment towards economic growth. Some of these studies include Fedderke and Pirouz (2002), who focused on the contribution of three aggregate mining sectors of the South African economy to output and employment over the 1970-97 period; and Awolusi (2015), who investigated the relationship between mineral resource endowment and economic growth in Southern African economies using a panel dataset of 14 countries in the Southern African Development Community. Therefore, this paper is envisaged to contribute to the body of knowledge and policy formulation by investigating the relationship between mining production, government expenditure, and economic growth. The choice of these indicators was inspired by Hlavová (2015), who studied the relationship between the share of mineral resources in total export and economic growth in the economies of Sub-Saharan Africa. He proclaimed that the problem of lower growth rates in the region cannot be completely ascribed to their one-sided focus on raw materials. Hence the focus of this study is mainly on mining production rather than purely on resources.

The rest of the paper is structured as follows: Section 2 covers the literature review and focuses on both the theoretical and empirical literature. Section 3 focuses on the methodology and presents all the econometric tests undertaken by the study. Section four presents the results and discussion, and section five concludes the study.

LITERATURE REVIEW

This study is underpinned by two theories, namely the 'natural resource curse' and the endogenous growth theories. Auty (1993) realized that small economies with natural resources are underperforming when weighed against other economies because structural volatility causes the export sector to compress in an unsustainable way. He argues that this leads production to shut the economy and to follow policies that will mislead the allocation of resources. Such policies will then lead growth to crumble using more resources that would have been sustained for the following generations to regain rapid growth. This led Auty (2001) to create the term 'natural resource curse', which describes how countries rich in natural resources were not able to use their wealth to improve their economies, and how they experienced lower economic growth (Mahonye & Mandishara 2015).

On the other hand, the endogenous growth theory illustrates the relationship between human capital, physical capital, technological innovation, economic governance and growth (Di Boscio 2010). The links between the outlined variables are key to understanding challenges and potential abilities in mining economies. The theory focuses on the long-run growth that comes from economic activities but does not differentiate between capital accumulation and technological progress. Arrow (1962) stated that technological escalation is only fulfilled by factors that are not influenced by economic forces. However, the neoclassical era has challenged this, seeing great significance in these economic forces. Frankel (1962) came up with the first version of this theory, which is known as the AK theory (where A = factors affecting technical capacity, and K = human and physical capital stocks). This theory assists in the functioning of production in mining where workers and equipment available are important in the operation of the industry. As far as the empirical literature is concerned, several studies such as Mavrotas et al. (2011), Mahonye and Mandishara (2015) and Saadat (2016) focused on the analysis of countries or regions with an abundance of resources. In most cases, the results show that the natural resource curse exists on economies that are endowed with resources. Another finding is that such economies base their growth on these resources, which lead to negative impulses in most of the periods analyzed. Mahonye and Mandishara (2015) employed the Ordinary Least Squares to investigate the role of mineral resources in economic development in Zimbabwe. Their empirical results showed that real manufacturing growth, real mining growth, the share of mineral exports to total exports, property rights and political rights are important determinants of economic growth. Similarly, Saadat (2016) noted that Pakistan is known to have abundant mineral resources, but its contribution to the economy has not been explored significantly. Based on this argument, he studied the relationship between mineral

resource production and economic growth in Pakistan using time series from 1975 to 2009. The results showed a statistically negative and significant relationship between natural resources and economic growth during the sample period.

It has also been discovered that in most resource-abundant countries, there are high possibilities of low and steady growth. James (2014) supported this statement by stating that natural resource production hinders growth due to a lack of success in international markets. The study provides another approach to steady growth in resource-abundant countries by looking at the data of most developing countries. When comparing endowed countries with those that are not gifted with natural resources, the results show that the latter seems to be more developed. Such discoveries have therefore led to the notion that there is an inverse relationship between economic growth and resource-based countries, but occurs fast in those that are not gifted with minerals. This shows that the abundance of resources is not an indication of growth in most gifted countries. Roy et al. (2013) state that the natural resource curse is inevitable or manmade in different countries. This is based on empirical evidence which revealed that resource-abundant countries tend to perform less than countries that do not have natural resources. This notion further indicates that GDP per capita and the type of leadership of such countries also affect development significantly. This goes to show that the natural resource curse is not inevitable, but it is rather based on the level of institutional quality of the countries. The same sentiment is shared by Mobarak and Karshenasan (2012). Therefore, the regulations and policies of these resource-endowed countries seem to be causing a negative relationship between mineral production and economic growth.

Alpha and Ding (2016) employed the Error Correction Model (ECM) regression technique to study the impact of natural resources endowment on economic growth in Mali. They discovered that the export of natural resources has a positive impact on growth. However, the interaction between natural resources export and corruption impacts negatively on economic growth. A similar study was undertaken by Hlavová (2015), who studied the relationship between the share of mineral resources in total export and economic growth in the economies of Sub-Saharan Africa. Contrary to most empirical findings and to the natural resource curse, Hlavová (2015) argued that the problem of lower growth rates in this region cannot be ascribed to the one-sided focus on raw materials. The results of this study indicate that it cannot be easily argued that dependence on mineral resources in the economy is not a factor leading to the underdevelopment of this region of the world without further analysis. It is necessary to further investigate the impact of mineral resources on new alternative indicators of development and quality of life to see how they are affected by mineral resources. Given all these

controversies around natural resources, and the fact that since South Africa is also a mineral resource-endowed country, it makes sense to conduct a similar study in order to compare it against these findings.

METHODOLOGY

The study employed the vector error correction model (VECM) approach to investigate the relationship between mining production, government expenditure and economic growth in South Africa. The approach involves estimation techniques such as the unit root and the cointegration analyses, which were followed by the VECM analysis. Other additional tests include diagnostic and stability tests, generalized impulse response function, and the variance decomposition.

DATA AND MODEL SPECIFICATION

The study uses annual time-series data from the South African Reserve Bank (SARB) for the period 1983 to 2015 to examine the relationship between mining production and economic growth in South Africa. The mining production is proxied by two variables which represent indicators of real economic activity in mining production, namely, mining production including gold, and mining production excluding gold. The third variable is the total general government expenditure (Total expenditure: consolidated general government: Economic affairs of which: Mining, manufacturing, and construction), which was added in the model because it has a controlling effect on economic growth.

The model of the study was grounded on the traditional neoclassical growth models for estimating economic growth, and followed the linear model of Hussain et al. (2009), Saadat (2016) and Mahonye and Mandishara (2015), who used GDP as their dependent variable and different types of dependent variables. In terms of the selection of independent variables, this study is closely related to Saadat (2016), who used production related to the mineral as a percentage of GDP. However, in terms of innovation, this study focuses on mining production (gold and excluding gold) in South Africa. The interest in gold production is based on the fact that South African gold reserves are still ranked number one internationally, and the fact that the mining sector is one of the country's major employers. The estimated model is presented as follows:

$$LGDP_t = \beta_0 + \beta_1 LTGGEXP_t + \beta_2 LMINPRG_t + \beta_3 LMINPREG_t + \varepsilon_t \quad (1)$$

Where L in front of each variable means conversion into logarithm; TGGEXP is the total general government expenditure; MINPRG is the mining production: Gold; MINPREG refers to mining production excluding gold; β_0 is the intercept and β_1 to β_3 are the parameters and the

slope of the coefficients in the model. The error term is represented by ε and takes care of variables not included in the model, which is likely to influence the dependent variable. Based on the 'natural resource curse' theory, and on Kantor (2013), mining production is expected to have a negative relationship with GDP whereas the total expenditure (consolidated general government) is expected to have a positive relationship with economic growth.

There are other types of explanatory variables used to determine the effects of natural resources on economic growth. Hussain et al. (2009) noted that exports related to agriculture, fuel, and minerals as a percentage of GDP have been taken as a proxy for natural resource abundance. The other types of explanatory variables used are related to investment in human capital. They include expenditures on education as a percentage of GDP and expenditures on health as a percentage of GDP. The third type consists of the set of macroeconomic variables having a controlling effect on economic growth. They include variables such as rate of inflation, trade openness and investment as a percentage of GDP, which shows the efficiency of government. Finally, Sachs and Warner (1995) used resource dependence measures (e.g. share of resource exports in GDP) as proxies for resource abundance.

ESTIMATION TECHNIQUES

The section discusses all the econometric techniques mentioned under the methodology section.

UNIT ROOT/STATIONARITY

The unit root test operates on two bases, namely, the deterministic functions of time and recurrence equations. According to Shumway and Stoffer (2017), the objective of the series is to build a statistical or mathematical model that gives a clear picture of sample data. In addition, Pelagatti (2013) indicated that some variables seem to develop smoothly, rather than frequent, changes, and thus using time homogeneity is proper for a finite period known as stationary. These variables should be analyzed to make sure that the unit root problem is realized without spurious effects as according to Amountzias, et al. 2019 non-stationary series would results in incorrect estimates of the standard errors.

The unit root will be tested by the Augmented Dickey-Fuller (ADF) test by Dickey and Fuller (1979), and the Phillip-Peron (PP) test (Phillips & Perron 1988). The two tests are used to determine whether or not each variable has a unit root. Their null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. According to Arltova and Fedorová (2016), the ADF test is and will be one of the most commonly used unit root tests since its crucial advantage lies in its simple construction and feasibility. But its practical problem is the choice of lags.

As a way of dealing with the weakness of the ADF test, instead of describing the autocorrelation structure of the generating process by corresponding autocorrelation models, Phillips and Perron (1988) used standard Dickey-Fuller test with non-parametrically modified test statistics. Furthermore, the PP test uses the Newey and West (1987) standard errors to account for serial correlation, whereas the ADF test uses additional lags of the first-differenced variable. The two tests differ mainly on how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric autoregression to approximate the autoregressive moving average structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression (Zivot et al. 1992). Compared with the ADF tests, the PP tests are said to be robust to general forms of heteroskedasticity in the error term. Another advantage is that the user does not have to specify a lag length for the test regression. In addition, Davidson and MacKinnon (1993) argued that the PP test was constructed to eliminate asymptotic bias appearing in the original ADF test when serial correlation exists in the residuals.

The time series stationary can be expressed as follows:

$$X_{C_t}^R = \beta_0 + \beta_1 X_{t-1}^R + \varepsilon_t \quad (2)$$

In this case, equation 2 is a hypothesis of a stationary unit root, where $\beta_1 < 1$ and β_0 is constant and the error term (ε_t) is assumed to be independent normally distributed (Björnsson 2014). Also, the mean is zero and a constant variance. Ssekuma (2011) expressed the importance of the series to be stationary because the correlation can occur in a period of nonstationary. Even if the sample is big, the result could be spurious regression.

COINTEGRATION AND LONG RUN ANALYSES

Before proceeding with cointegration analysis, the determination of autoregressive lag-length will be performed. This is based on Liew's (2004) view that most economic data are time series in nature, and that a popular kind of time series model known as autoregressive (AR) model has been directly or indirectly applied in most economic researches. Therefore, the foremost exercise in the application of the AR model is the determination of autoregressive lag-length. By the same token, Asghar and Abid (2007) argued that the delicate part of the time series analysis is the selection of the order of the process based on a finite set of observations. But since a further analysis of that series is based on autoregressive lag-length it is rarely the case that the 'true' order of a process is known.

The cointegration and long-run analyses were done by means of the Johansen (1988) cointegration tests, namely, the Trace and Maximum Eigenvalue tests (Dwyer 2015). Their null hypothesis states that there is no cointegration versus the alternative, which stipulates

that there is cointegration. Johansen cointegration test detects cointegration in variables straight from maximum likelihood estimation instead of depending on the Ordinary Least Squares (Ssekuma 2011). The Johansen cointegration approach is said to be better than the Engle-Granger method because it can calculate more than one cointegration relationship. The trace test consists of the null hypothesis of the r vectors in cointegration (Ssekuma 2011).

This cointegration versus the alternative hypothesis of the n cointegrating vectors is presented as follows:

$$\tau_{trace} = -D \sum_{i=r+1}^n \ln(1 - \gamma_i) \tag{3}$$

The maximum Eigenvalue test is generally a likelihood test that estimates if the highest number of the eigenvalue is zero. It is based on the null hypothesis of the p vector values of cointegration versus the alternative hypothesis $p+1$ vector values

$$\tau_{max} = -D(1 - \gamma_{t+1}) \tag{4}$$

SHORT-RUN ANALYSIS

As specified earlier, the study will employ the VECM mainly for short-run analysis. But this is based on the condition that cointegration is detected in the system. Asari et al. (2011) indicated that VECM is used if cointegration is present amongst variables. This means that there is a definite relationship in the long run, whereas if there is no cointegration, the vector autoregressive (VAR) analysis will be followed. The existence of cointegration leads to the application of the VECM so that the short term characteristics of the variables are created. The implication is that if there is a long term stable relationship amongst the variables, then an error correction model (ECM) must be implemented for both long and short-run occurrences (Komuves & Ramirez 2014).

As indicated by the Granger representation theorem, when variables are cointegrated, there must also be an error correction model (ECM) that describes the short-run dynamics or adjustments of the cointegrated variables towards their equilibrium values (Hansen 2005). ECM consists of the one-period lagged cointegrating equation and the lagged first differences of the endogenous variables and can be estimated by using the VAR method. The general form of the model is;

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + Bx_t + \varepsilon_t \tag{5}$$

Where y_t is the vector of the endogenous variables (GDP, TGGEXP, MINPRG, and MINPREG), x_t is the vector of deterministic variables, and ε_t is a vector of innovations. We can rewrite the VAR model as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \tag{6}$$

where $\Pi = \sum_{i=1}^p A_i - I, \Gamma = - \sum_{j=i+1}^p A_j$.

Equation 6 is then transformed into VAR models as follows;

$$GDP_t = \theta_0 + \sum_{j=1}^p \alpha_j GDP_{t-j} + \sum_{j=1}^p \beta_j TGGEXP_{t-j} + \sum_{j=1}^p \chi_j MINPRG_{t-j} + \sum_{j=1}^p \theta_j MINPREG_{t-j} + \varepsilon_t \tag{7}$$

$$TGGEXP_t = \chi_0 + \sum_{j=1}^p \alpha_j GDP_{t-j} + \sum_{j=1}^p \beta_j TGGEXP_{t-j} + \sum_{j=1}^p \chi_j MINPRG_{t-j} + \sum_{j=1}^p \theta_j MINPREG_{t-j} + \varepsilon_t \tag{8}$$

$$MINPRG_t = \phi_0 + \sum_{j=1}^p \alpha_j GDP_{t-j} + \sum_{j=1}^p \beta_j TGGEXP_{t-j} + \sum_{j=1}^p \chi_j MINPRG_{t-j} + \sum_{j=1}^p \theta_j MINPREG_{t-j} + \varepsilon_t \tag{9}$$

$$MINPREG_t = \varphi_0 + \sum_{j=1}^p \alpha_j GDP_{t-j} + \sum_{j=1}^p \beta_j TGGEXP_{t-j} + \sum_{j=1}^p \chi_j MINPRG_{t-j} + \sum_{j=1}^p \theta_j MINPREG_{t-j} + \varepsilon_t \tag{10}$$

Where j is the lag length, length θ_0, χ_0, ϕ_0 and φ_0 are the constant terms and is an independent and identically distributed error term.

If cointegration is established, then the VAR equations will be transformed into VECM specifications as follows;

$$\Delta GDP_t = \theta_0 + \sum_{j=1}^p \alpha_j \Delta GDP_{t-j} + \sum_{j=1}^p \beta_j \Delta TGGEXP_{t-j} + \sum_{j=1}^p \chi_j \Delta MINPRG_{t-j} + \sum_{j=1}^p \theta_j \Delta MINPREG_{t-j} + \gamma_5 ECM_{t-1} + \varepsilon_t \tag{11}$$

$$\Delta TGGEXP_t = \chi_0 + \sum_{j=1}^p \alpha_j \Delta GDP_{t-j} + \sum_{j=1}^p \beta_j \Delta TGGEXP_{t-j} + \sum_{j=1}^p \chi_j \Delta MINPRG_{t-j} + \sum_{j=1}^p \theta_j \Delta MINPREG_{t-j} + \lambda_5 ECM_{t-1} + \varepsilon_t \tag{12}$$

$$\Delta MINPRG_t = \phi_0 + \sum_{j=1}^p \alpha_j \Delta GDP_{t-j} + \sum_{j=1}^p \beta_j \Delta TGGEXP_{t-j} + \sum_{j=1}^p \chi_j \Delta MINPRG_{t-j} + \sum_{j=1}^p \theta_j \Delta MINPREG_{t-j} + \tau_5 ECM_{t-1} + \varepsilon_t \tag{13}$$

$$\Delta MINPREG_t = \varphi_0 + \sum_{j=1}^p \alpha_j \Delta GDP_{t-j} + \sum_{j=1}^p \beta_j \Delta TGGEXP_{t-j} + \sum_{j=1}^p \chi_j \Delta MINPRG_{t-j} + \sum_{j=1}^p \theta_j \Delta MINPREG_{t-j}$$

$$+ v_5ECM_{t-1} + \varepsilon_t \tag{14}$$

Where α, β, χ and θ are parameters to be estimated and Δ is the difference operator. The parameter estimates γ, λ, τ and v should be negative and less than zero (<0).

The reason behind this is that the error correction coefficient gives the information about the speed in which the model returns to equilibrium after an exogenous shock. As a result, the error correction term should be negatively signed to indicate a move towards long-run equilibrium, and significant to indicate the validity of the long-run equilibrium relationship of the model. In addition, the coefficient of 0 suggests no adjustment one-time period later, while 1 indicates full adjustment (Ahmed & Jie 2019).

DIAGNOSTIC AND STABILITY TESTS

According to DeBenedictis and Giles (1998), in econometrics, there are many specification tests that state that if a model is specified accordingly, there will be weak estimators consistently. Thus, the estimates that function together in the model should be a little different if the sample size is big. Therefore, tests that were used in the residual diagnostic analysis to check misspecifications of the model include serial correlation, normality and heteroscedasticity tests. These tests were mainly used to analyze the adequacy of estimated VECM (Luktepol & Kratzig 2004). On the other hand, the stability of the model should be measured by robust methods that are likely to provide accurate results. With that outlined, Talaş et al. (2013) state that the assumptions of economic variables strategy must be consistent with the nexus amid those variables. In this regard, we employed Brown et al.'s (1975) recursive cumulative sum of residuals (CUSUM) test which includes the structural breaks on linear models and is estimated by the least-squares method. The recursive CUSUM is always restarted to zero posts the detection (Granjon, 2014). The aim is to raise the detection process and to supply it with a good beginning by replacing its initial state when restarting. According to Lee et al. (2003), the CUSUM test relies on the t-statistics.

GENERALIZED IMPULSE RESPONSE FUNCTION

In order to further investigate the statistical significance of innovations of the variables, we employed the generalized impulse response function (GIRF). Its purpose is to examine the dynamic relationships among GDP and its regressors. The GIRF analysis was developed by Pesaran and Shin (1998) based on the work of Koop et al. (1996). Unlike the conventional impulse response method that employs a Cholesky decomposition of the positive definite covariance matrix of the shocks, the GIRF is the revised technique given that the IRF has omissions that were spotted by previous researchers (Hurley 2010). GIRF does not need the orthogonalizing of shocks and

is invariant to the ordering of the variables in the VAR (Pesaran and Shin 1998). This is because the response urge of the variables is the same as the sequences of the VAR, and thus supplies relevant outcomes. The estimation is done by consistently taking one VAR equation to shock and utilize the spread of the decreased vector to work out the results of the other variables (Nazifi & Milunovich 2010).

According to Pesaran (2015), in the context of the VAR model, the GIRF for a system-wide shock, μ_t^0 , is defined by

$$GL_y(n, \mu_t^0, \Omega_{t-1}^0) = E(y_{t+n}|u_t = \mu_t^0, \Omega_{t-1}^0) - E(y_{t+n}|\Omega_{t-1}^0), \tag{15}$$

Where $E(\cdot|\cdot)$ is the conditional mathematical expectation taken with respect to the VAR model, and Ω_{t-1}^0 is a particular historical realization of the process at the time $t - 1$. Pesaran (2015) also noted that the case of the VAR model having the infinite moving average representation, we have

$$GL_y(n, \mu_t^0, \Omega_{t-1}^0) = A_n \mu_t^0, \tag{16}$$

which is independent of the history of the process.

VARIANCE DECOMPOSITION

Finally, the variance decomposition was used to determine how much of the forecast error variance of each variable can be explained by shocks (innovations) to the other variables in the system. The purpose is to analyze and predict the variation of the fluctuation of the variables to examine the possible reaction from the influence of other variables within the same regression equation (Lanne & Nyberg 2014). The variance decomposition is mostly used in social findings to distribute the inputs in different groups in average forecasts from the multivariate models. The approach uses the outcome of the regression analysis to issue characteristics of a varying group in statistics like the mean. In a linear regression model, the main thing is decomposing the variance of the reaction of the dependent variable into parts resulting from the dependent variables together with their errors (Grömping, 2007).

Since the study uses macroeconomic variables which are known to be nonstationary, Seymen (2011) posits that regardless of whether the process includes cointegrated variables, every nonstationary VAR possesses moving averages in first differences given by:

$$\Delta X_t = \mu + \sum_{i=0}^{\infty} \Theta_i w_{t-i}, \tag{17}$$

where Δ is the difference operator such $\Delta X_t = X_t - X_{t-1}$ and, μ is a $K \times 1$ constant vector. Hence, it can be easily shown that the total forecast error variance of the variables X_t is given by the diagonal elements of the matrix $\sum_{i=0}^{h-1} \Theta_i^* \Theta_i^{*'}$ with $\Theta_i^* = \sum_{j=0}^i \Theta_j$ for a forecast horizon of h . The contribution of the structural shock to the forecast error variance of the j^{th} variable for

a given forecast horizon is analogously given by $\sum_{i=0}^{h-1} (e_j' \Theta_i^* e_k)^2$.

RESULTS AND DISCUSSION

This section presents the results of the empirical tests discussed under the estimation techniques section.

UNIT ROOT TEST RESULTS

In line with Libanio (2005), who maintained that the component that solely focuses on the mean is one of the components that have robust results, the best unit root test results were obtained by means of the intercept with no trend and constant model. The results are summarized in Table 1 as follows:

The null hypothesis was not rejected at level, but all the variables became stationary at first difference where the null hypothesis was rejected at a 5% significance level. As indicated in the last column of Table 1, all the variables are integrated of the same order, which allowed us to follow the Johansen cointegration for long-run analysis.

COINTEGRATION ANALYSIS TEST RESULTS

The concept of cointegration allows us to describe the existence of equilibrium or stationary relationship among two, or more time series, each of which is individually nonstationary (Banerjee et al. 1993). It also tells us about the presence of a long-run relationship

between two or more variables because, economically speaking, two variables will be cointegrated if they have a long term relationship. Furthermore, the procedure is established on a unified framework to estimate and test cointegrating relations within the VECM formulation. When cointegration is present, the VEC model will be the appropriate specification to study the interaction between the variables in the system (Hurley 2010; Sbeiti & Haddad 2011).

As indicated in section 3 before proceeding with cointegration analysis, the determination of autoregressive lag length was performed and the results are presented in Table 2.

The true lag length results in Table 2 suggest that the series sample should be lagged once. Since the sample of this study is small, that is, less than sixty observations, the AIC and FPE have the most robust results than the other criteria (Liew 2004).

Since all the variables were found to be cointegrated at order 1, the Johansen cointegration analysis was applied and the results are shown in Table 3. These results suggested that there is one cointegrating equation, which provides evidence of the existence of a long-run economic relationship amongst our variables. The finding of a single cointegrating vector strongly supports the presence of one common stochastic trend in the data set (Apergis et al. 2019).

The evidence is based on the fact that the null hypothesis of no cointegration is rejected by the two tests at 0.05 level, where the test statistic of the Maximum-Eigen value test of 37.777 is greater than the critical value of 27.584. Also, under the Trace test, the test statistic

TABLE 1. Unit root tests results

Variables	Test	T-statistic at intercept	Critical value at 5%	Probability	Results
LGDP	ADF	-3.564 (0)	-2.960	0.013	I(1)
	PP	-3.645 (3)	-2.960	0.010	I(1)
LTGGEXP	ADF	-4.444 (0)	-2.960	0.001	I(1)
	PP	-4.415 (3)	-2.960	0.002	I(1)
LMINPRG	ADF	-4.516 (0)	-2.960	0.001	I(1)
	PP	-4.558 (3)	-2.960	0.001	I(1)
LMINPREG	ADF	-5.091 (0)	-2.960	0.000	I(1)
	PP	-5.090 (2)	-2.960	0.000	I(1)

Notes: Lag length/Bandwidth in a bracket

I(1): Integrated at order 1

*Source: authors' calculations using the data from the SARB

TABLE 2. Lag selection results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	101.358	NA	2.20e-08	-6.281	-6.096	-6.221
1	233.517	221.685*	1.24e-11*	-13.775*	-12.850*	-13.474*
2	248.102	20.701	1.44e-11	-13.684	-12.019	-13.141

*indicates lag order selected by the criterion

*Source: authors' calculations using the data from the SARB

TABLE 3(a). Johansen cointegration tests results

MAXIMUM-EIGEN VALUE				TRACE TEST			
Null hypothesis	Alternative hypothesis	Test statistic	0.05 Critical value	Null hypothesis	Alternative hypothesis	Test statistic	0.05 Critical value
r = 0	r = 1	35.777*	27.584	r = 0	r ≥ 1	55.923*	47.856
r = 1	r = 2	10.898	21.132	r = 1	r ≥ 2	20.146	29.797
r = 2	r = 3	9.237	14.265	r = 2	r ≥ 3	9.247	15.495
r = 3	r = 4	0.010	3.841	r = 3	r ≥ 4	0.010	3.841

*denotes a rejection of the hypothesis at the 0.05 level

*Source: authors' calculations using the data from the SARB

TABLE 3(b). Normalized cointegrating coefficients

LGDP	TGGEXP	LMINPRG	LMINPREG
1.000	-0.021	0.257	-0.680
	(0.011)	(0.019)	(0.048)

Standard error in parentheses

*Source: authors' calculations using the data from the SARB

of 55.92269 is greater than the critical value of 47.856. Moreover, the Johansen cointegration analysis also provided the results of the long-run relationship between the dependent variable and its regressors by means of the normalized cointegrating coefficients provided in Table 3.

In order to get the long-run results, β_1 to β_3 in equation 1 are substituted by values in Table 3 in order to obtain proper parameters and slopes of the coefficients in the model. The long-run equation is presented as follows:

$$LGDP_t = \beta_0 + 0.0201LTGGEXP_t - 0.257LMINPRG_t + 0.680LMINPREG_t + \varepsilon_t \quad (18)$$

Therefore, the long-run results indicate that both the LTGGEXP and LMINPREG have a positive relationship with LGDP, whereas LMINPRG relates negatively to the dependent variable. The values of the coefficients indicate that a 1% adjustment of both the LTGGEXP and LMINPREG brings about a 2% and 68% increase in LGDP, respectively. On the other hand, a 1% change in MINPRG brings about a 26% decrease in LGDP in South Africa.

Our long-run results indicate that mining production has a very large effect, albeit negative or positive, on economic growth. The possible reason behind this might be the fact that even though the relative contribution of mining to South Africa's GDP has declined over the past 10 to 20 years, the industry remains a cornerstone of the economy, making a significant contribution to economic activity, job creation, and foreign exchange earnings, and accounting for about 18% of GDP (8.6% direct, 10% indirect and induced) (Kearny 2012). As indicated in the literature, mining plays a significant role in the South African economy. Therefore, any shock to the industry is likely to cause a significant reaction in the economy.

SHORT-RUN TEST RESULTS

The VECM results which were employed mainly for short-run analysis are summarized in Table 4.

The error correction term (ECT) is statistically and economically significant and assumes the expected

TABLE 4. VECM test results

Dependent variable: D(LGDP)			
Variable	Coefficient	Standard error	T-statistics
ECT (-1)	-0.613	0.134	-4.583
C	0.002	0.005	4.675
D (LGDP (-1))	0.366	0.140	2.613
D (LTGGEXP (-1))	-0.031	0.013	-2.311
D (LMINPRG (-1))	0.092	0.068	1.352
D (LMINPREG (-1))	-0.069	0.086	-0.805
R-Squared	0.643		
Adjusted R-Squared	0.571		

Note: D=differenced

*Source: authors' calculations using the data from the SARB

negative sign. The measured coefficient of the error correction ECT (-0.613) suggests that 61.32% of the disequilibrium between GDP and independent variables is corrected at a higher speed. The negatively signed ECT shows a move towards long-run equilibrium. On the other hand, the significant t-statistic indicates the validity of the long-run equilibrium relationship of the model. In addition, the direction of causality can be established through this model, since, unlike the standard Granger causality test, it takes into consideration an additional channel of causation through the error correction mechanism (ECM) term (Hurley 2010). The R-squared and the adjusted R-squared show that the independent variables explain more than the respective 64% and 57% of the variation in GDP.

DIAGNOSTIC AND STABILITY TESTS RESULTS

The diagnostic test results are presented in Table 5 and the stability test results are in Figures 1 and 2, respectively.

As indicated in Table 5, the null hypothesis is not rejected. This means that the model has passed all the diagnostic tests which were performed. Hence, it was deemed to be well specified. Likewise, stability tests were conducted to determine the stability of the model by monitoring any sign of the fluctuations outside the five percent level of significance, which could be that the variance is unstable, and if inside, it indicates the opposite. The results of the two tests are presented in Figures 1 and 2 respectively, indicating that the model is within the 0.05 level of significance, suggesting that the model was stable throughout the period of study.

TABLE 5. Summary of the diagnostic test results

Test	Null hypothesis (H ₀)	Statistics	P-Value	Conclusion
Breusch -Godfrey LM	No serial correlation	5.781	0.056	Do not reject H ₀
Glesjer	No heteroskedasticity	0.966	0.809	Do not reject H ₀
White	No heteroskedasticity	4.833	0.849	Do not reject H ₀
Jarque-Bera	Normality	0.708	0.704	Do not reject H ₀

Note: H₀ = Null hypothesis

*Source: authors' calculations using the data from the SARB

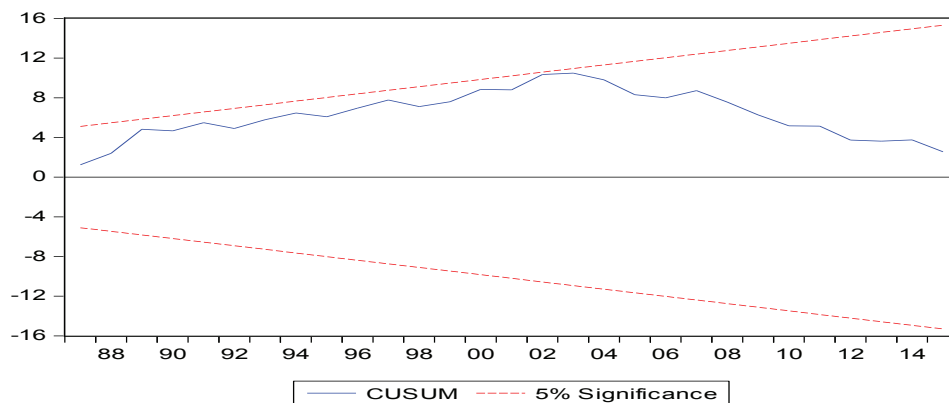


FIGURE 1. CUSUM results

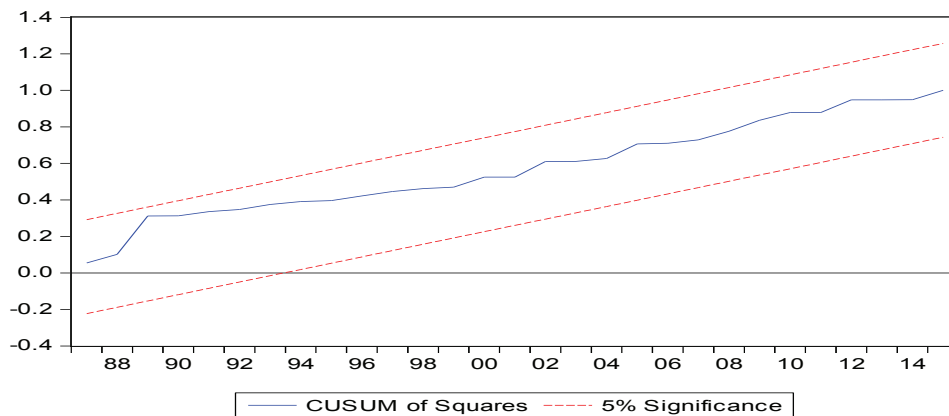


FIGURE 2. CUSUMQ results

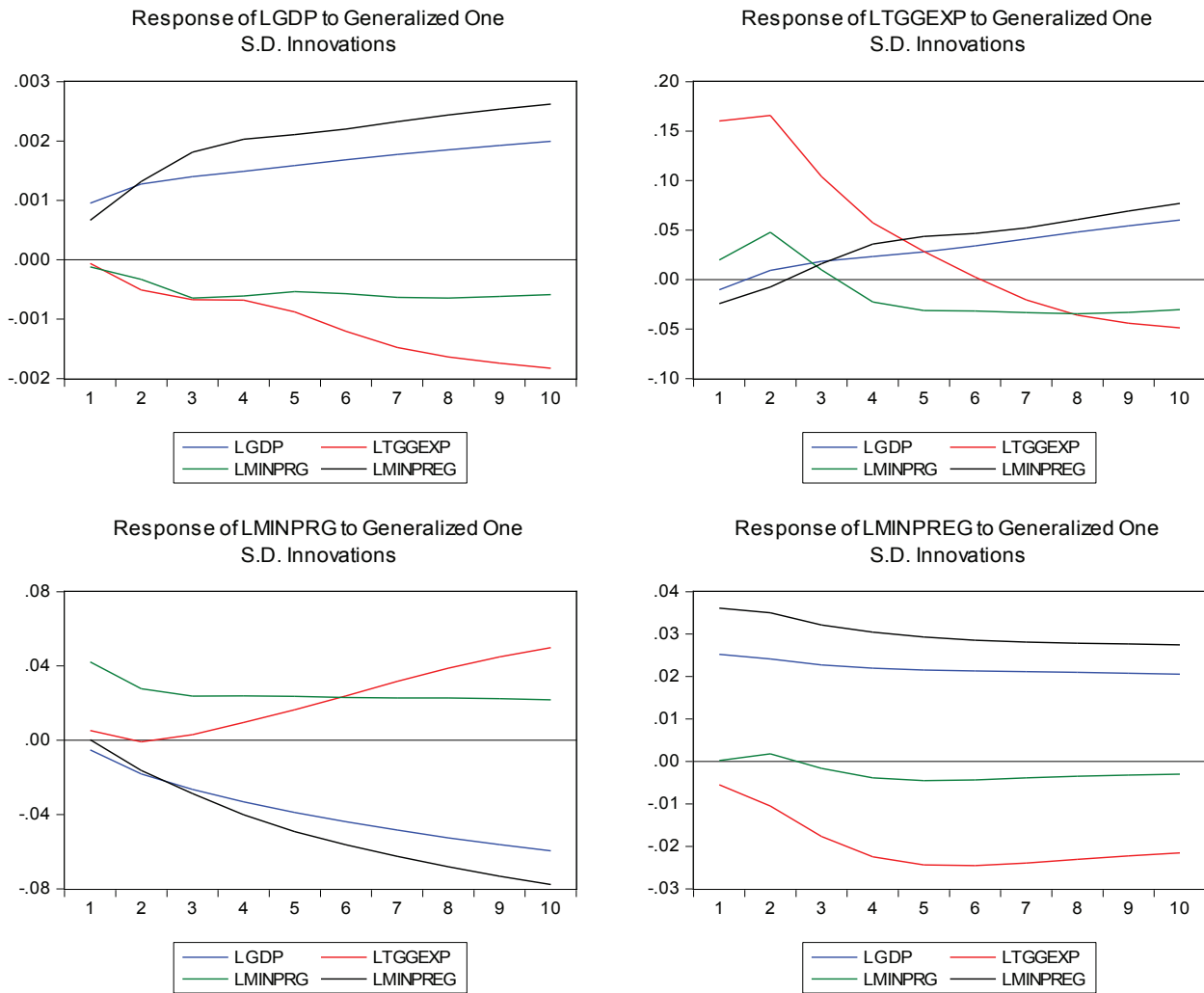


FIGURE 3. Generalized Impulse Response Function

GENERALIZED IMPULSE RESPONSE FUNCTION RESULTS

This technique was employed to trail the time area of a variable reply from variables to urge the function’s shocks. The technique helps to provide both short and long-term relationships amid the variables using the decomposition method. The results of the response to a generalized one standard innovation of variables are presented in Figure 3. The VAR was lagged once as suggested by the lag criteria in this study. A period of ten years was used to check the future reaction of the variables. Firstly, the dependent variable is observed against itself. So, if the GDP has one standard deviation (SD) shock, the results suggest that it affects itself steadily in a positive way for the whole period of study.

The results indicate that if there is a one standard deviation shock in GDP, LTGGEXP responds positively and remain steady from four to ten years. Thus, the results suggest that there is a positive reaction from LTGGEXP to the shock. On the other hand, if there is a one standard deviation shock, the dependent variable affects the

MINPRG variable. The results assume that the influence will be negative where it visually suggests a decline from one year to year ten. From year one to year three, the results show a slightly positive outcome.

VARIANCE DECOMPOSITION RESULTS

As indicated earlier, the purpose of this test was to determine how much of the forecast error variance of each variable can be explained by shocks to other variables in the system. Table 6 indicates patterns of possible shocks and reactions of year three and year ten. The dependent variable is evaluated against the independent variables.

In the short-run, looking at the third year, the innovation to LGDP shows a 69.804% variation of the fluctuation of the LGDP, which suggests that it is significant to its own shock. The LTGGEXP suggests an insignificant influence with 1.743%, as well as the LMINPRG, which assumes a 3.366. Although not very great, the LMINPREG is more than the previous two, with

TABLE 6. Variance decomposition results

VARIABLE	PERIOD	LEXGDP	LTTLEXP	LMINPRG	LMINPRE
LGDP	3	69.804	1.743	3.366	25.088
	10	56.394	0.649	4.320	38.637
LTGGEXP	3	8.675	88.352	1.964	1.009
	10	15.310	76.841	0.955	6.895
LMINPRG	3	10.067	0.642	82.356	6.935
	10	19.244	2.820	54.353	23.583
LMINPREG	3	54.230	0.935	3.230	41.605
	10	54.881	3.834	6.495	34.791

*Source: authors' calculations using the data from the SARB

25.088%. In the long run, the variation of the fluctuation as its own shock suggests a visible influence even though there is a slight decline which results in 56.394%. The LTGGEXP showed a decrease of 0.649, whereas LMINPRG and LMINPREG increased by 4.320% and 38.637%, respectively. LMINPREG suggests a greater influence on LGDP. Likewise, the LTGGEXP shows a variation of fluctuation of its own shock at 88.352% and the LMINPRG at 82.356%. While the other variables' shock seems to have much impact on these two variables in the short run. On the other hand, LMINPREG has different results because LGDP suggests a greater variance of fluctuation than its own shock in the short run with 54.230% from LGDP and 41.605% as its own shock. The long-run for these variables indicates a visible decrease in the variation of fluctuation but still suggests a great influence.

SUMMARY AND CONCLUSIONS

The purpose of this study was to examine the relationship between mining production and economic growth in South Africa. Production in the mining sector is crucial since minerals are primary inputs on the GDP. The Johansen (1988) cointegration analysis proved that there was a long-run economic relationship amongst the variables. Mining production excluding gold has a positive influence on economic growth, whereas mining production in gold was found to have a negative relationship with growth. This is in line with Kantor (2013), who found that mining, particularly gold and platinum, had a negative impact on GDP. This concern is captured by Hermanus (2017), who noted that over the preceding decade, the rate of gold production in South Africa declined more rapidly than that of other top 10 producers at -7.7% per annum. Hermanus (2017) further noted that without systemic changes in gold mining methods, the sector is expected to continue to shrink so that by 2025, production is expected to have halved relative to 2015 levels, and employment levels are expected to have declined to 43% of 2015 levels, or 68 000 employees. In addition, the results seem to be in line with the notion by Auty's (2001) natural

resource curse theory that countries rich in natural resources were not able to use their wealth to improve their economies and how they experienced lower economic growth.

Finally, the error correction term was found to be statistically and economically significant and assumed the expected negative sign which means that the whole system will revert back to equilibrium in the long-run. The model also passed all the diagnostic and stability tests, hence it was deemed to be well specified. Therefore, based on these results and similar results from the literature, the study recommends that given the important contribution of the mining sector in the South African economy, both the government and mining companies should reconceptualize how mining can be undertaken profitably to the benefit of society. Borrowing from Fan et al. (2017) the government should increase aid to encourage the mineral companies to do scientific research and pay more attention to the cultivation of technical personnel.

Thus, policies from regulators in this industry should focus on implementing relief for potential investors. If efficiency is practiced for investment attraction into the mining production, as with this investment infrastructure, it will lessen the cost of capital for potential investors. This is in line with Vegter (2018), who emphasized that it is a matter of considerable urgency that the present malaise in the mining industry is decisively addressed through policy measures that radically simplify laws and ease regulations that involve empowerment principles to reduce economic drag that lower the tax burden and significantly improve labor flexibility.

REFERENCES

- Ahmed, N.M. & Jie, L. 2019. A Vector Error Correction Model (VECM) Approach in Explaining the Impact of Livestock Export on Economic Growth in Somalia. *Journal of Economics and Finance* 10: 47-54.
- Alpha, B.B. & Ding, Y. 2016. A study on the impact of natural resources endowment on economic growth: Empirical evidence from Mali. *Journal of Economics and Development Studies* 4: 81-103.

- Apergis, N., Arusha, C., Naceur, K., & Iraklis, A. 2019. Do gold prices respond to real interest rate? Evidence from the Bayesian Markov Switching VECM Model - Journal of International Financial Markets, Institutions and Money 60: 134-148.
- Arltova, M. & Fedorová, D. 2016. Selection of Unit Root Test on the Basis of Length of the Time Series and Value of Ar (1) Parameter. *Statistika* 96: 47-64.
- Arrow, K. 1962. The economic implications of learning by doing. *Review of Economic Studies* 29: 155-173.
- Asari, F., Baharuddin, N., Jusoh, N., Mohamad, Z., Shamsudin, N. & Jusoff, K. 2011. A Vector Error Correction Model (VECM) Approach in explaining the relationship between interest rate and inflation toward exchange rate volatility. *World Applied Sciences Journal* 12: 49-56.
- Asghar, Z. & Abid, I. 2007. Performance of Lag Length Selection Criteria in Three Different Situations. 40042. Munich *Personal RePEc Archive*. MPRA. Islamabad.
- Auty, R. 1993. *Sustaining Development in Mineral Economies: The Resource Curse Thesis*. New York: Oxford University Press.
- Auty, R. 2001. *Resource Abundance and Economic Development*. New York: Oxford University Press.
- Awolusi, O.D. 2015. *Mining Sector and Economic Growth in Southern African Economies: A Panel Data Analysis*, Pretoria, available at <https://www.tips.org.za/research-archive> (accessed 30 October 2019).
- Banerje, A., Dolado, J. J., Galbraith, J. W. & Hendry, D. 1993. Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data. Clarendon Press. Oxford University Press.
- Baxter, R. 2012. The global economic crisis and its impact on South Africa and the country's mining industry, *South African Reserve Bank* 105-116.
- Best, M.E. 2015. *Mineral Resources, Treatise on Geophysics: Second Edition* 11: 525-556.
- Bhorat, H. & Kimani, M. 2018. *South Africa's Growth Trap: The Constraints on Economic Growth and the Role of Water*. Cape Town.
- Björnsson, P. 2014. PPP mean reversion estimation for Iceland. A unit root & single equation approach using new long-run time-series. Retrieved from University of Iceland web site: <https://skemman.is/bitstream/1946/17107/3/MScThesis.pdf> (accessed 26 August 2016).
- Boumparis, P., Costas, M., & Theodore, P. 2019. Non-performing loans and sovereign credit ratings. *International Review of Financial Analysis* 64: 301-314.
- Brown, R., Durbin, J. & Evans, J. 1975. Techniques for testing the constancy of regression relationships over time. *Journal of the royal statistical society* 37: 150-191.
- Canuto, O. & Cavallari, M. 2012. Natural Capital and the Resource Curse. *Economic Premise* 83: 1-5.
- Davidson, R. & MacKinnon, J.G. 1993. *Estimation and Inference in Econometrics*. Oxford University Press.
- Debenedictis, L.F. & Giles, D.E.A. 1998. *Diagnostic Testing in Econometrics: Variable Addition, RESET, and Fourier Approximations*. British Columbia: Victoria.
- Di Boscio, N. 2010. Mining enterprises and regional economic development: an explanatory analysis of the sustainable development model. Unpublished Ph.D. Diss., London School of Economics & Political Science, London, United Kingdom: <https://core.ac.uk/download/pdf/4187768.pdf>
- Dickey, D.A. & Fuller, W.A. 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association* 74 (366a). Taylor & Francis: 427-31.
- Dwyer, G.P. 2015. The Johansen Tests for Cointegration and Eigenvalues. <http://jerrydwyer.com.pdf>. (accessed 21 August 2017).
- Ericsson, M., & Olof, L. 2019. Mining's contribution to national economies between 1996 and 2016. *Mineral Economics* 32: 223-250.
- Fan, S., Jingjing, Y., & Jingshua, S. 2017. Innovation and economic growth in the mining industry. Evidence from China's listed companies. *Resources Policy* 54: 25-42.
- Fedderke, J. & Pirouz, F. 2002. The Role of Mining in the South African Economy, SAJEMS NS 5: 1-34.
- Frankel, M. 1962. The production function in allocation and growth: a synthesis. *American Economic Review* 52: 996-1010.
- Granjon, P. 2014. The CUSUM algorithm - a small review. HAL Id: hal-00914697 2-19.
- Grömping, U. 2007. Estimators of Relative Importance in Linear Regression Based on Variance Decomposition. *The American Statistician* 6: 139-147.
- Hansen, P.R. 2005. Granger's Representation Theorem: A Closed-Form Expression for I(1) Processes. *Econometrica* 8: 23-38.
- Hanusch, M. 2018. *Republic of South Africa Systematic Country Diagnostic: An Incomplete Transition Overcoming the Legacy of Exclusion in South Africa*, Washington DC.
- Harvey, R. 2014. Mining and Development Lessons Learnt from South Africa and Beyond. *Policy Briefing* 86: 1-3.
- Hermanus, M. 2017. Mining redesigned - Innovation and technology needs for the future-A South African perspective, *Journal of the Southern African Institute of Mining and Metallurgy* 117: 811-818.
- Hlavová, N. 2015. The impact of mineral resources on economic growth, *International Journal of Arts and Commerce* 4: 100-110.
- Hurley, D. 2010. A generalized impulse response investigation of U.S. long and short-term interest yields and Asian holdings of U.S. treasuries. *Journal of International and Global Economic Studies* 68-86.
- Hussain, S., Chaudhry, I. & Malik, S. 2009. Natural Resource Abundance and Economic Growth in Pakistan. *European Journal of Economics, Finance and Administrative Sciences* 15: 189-98.
- James, A. 2014. The Resource Curse: A Statistical Mirage? OxCarre Research Paper 147: 1-14.
- Johansen, 1988. Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control* 12: 231-54.
- Kane-Berman, J. 2018. *The Impact of Mining on the South African Economy and Living Standards, International Race Relations*, available at [https://doi.org/10.1016/S0301-4207\(00\)00013-1](https://doi.org/10.1016/S0301-4207(00)00013-1).
- Kantor, B. 2013. *How important is mining in the SA economy? It depends on how you measure it*. <http://www.zaeconomist.com/sa-economy>.
- Kearny, L. 2012. *Mining and Minerals in South Africa*. SouthAfrica.Info. 2012. <https://www.brandsouthafrica.com/investments-immigration/business/economy/mining-and-minerals-in-south-africa>.

- Komuves, Z. & Ramirez, M. 2014. Economic infrastructure, private capital formation and FDI inflows to Hungary: A unit root and cointegration analysis with structural breaks. *Atlantic Economic Journal*, 367-382.
- Koop, G., Pesaran, M.H., & Potter, S. 1996. Impulse Response Analysis in Nonlinear Multivariate Models. *Journal of Econometrics* 74: 119-47.
- Lanne, M., & Nyberg, H. 2014. Generalized Forecast Error Variance Decomposition for Linear and Nonlinear Multivariate Models. *CREATES Research Paper 2-5*.
- Lee, S., Na, O., & Na, S. 2003. On the CUSUM of squares test for variance change in nonstationary and nonparametric time series models. *The Institute of Statistical Mathematics* 55(3): 467-485.
- Libanio, G. 2005. Unit root in macroeconomic time series: theory, implications, and evidence. *Nova Economia* 15: 1-10.
- Liew, V. 2004. Which Lag Length Selection Criteria Should We Employ? *Economics Bulletin* 3: 1-9.
- Luktepol, H., & Kratzig, M. 2004. *Applied Time Series Econometrics*. Cambridge University Press 1-12.
- Mahonye, N., & Mandishara, L. 2015. Mechanism Between Mining Sector and Economic Growth in Zimbabwe; Is it a Resource Curse? *Environmental Economics (Open-access)* 6: 81-88.
- Mavrotas, G., Murshed, S., & Torres, S. 2011. Natural Resource Dependence and Economic Performance in the 1970-2000 Period. *Review of Development Economics* 5: 124-138.
- Mobarak, A. & Karshenasan, A. 2012. The impact of institutional quality on the relationship between resource abundance and economic growth. *Iranian Economic Review* 16: 1-14.
- National Treasury. 2019. *Medium Term Budget Policy Statement 2019 National Treasury Republic of South Africa*, available at www.treasury.gov.za. (accessed 1 November 2019).
- Nazifi, F., & Milunovich, G. 2010. Measuring the impact of carbon allowance trading on energy prices. *Sage Publications: Energy & Environment* 367-383.
- Newey, W.K., & West, K.D. 1987. A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica* 55: 703-708.
- Pelagatti, M.M. 2013. Nonparametric Tests for Event Studies Under Cross-Sectional Dependence, *SSRN Electronic Journal*, 244.
- Pesaran, M.H. 2015. *Time Series and Panel Data Econometrics*. 1st ed. Oxford: Oxford University Press.
- Pesaran, M.H. & Shin, Y. 1998. Generalized Impulse Response Analysis in Linear Multivariate Models'. *Economics Letters* 58: 17-29.
- Phillips, P.C.B., & Perron, P. 1988. Testing for a Unit Root in Time Series Regression. *Biometrika* 75: 335-46.
- Roy, B., Sarkar, S., & Mandal, N. 2013. Natural Resource Abundance and Economic Performance: A Literature Review. *Scientific Research* 1: 148-155.
- Saadat, W. 2016. Impact of mineral resources on economic growth of Pakistan. *Journal of Resources Development and Management* 20: 105-111.
- Sachs, J.D., & Warner, AM. 1995. Natural Resource Abundance and Economic Growth. *NBER Working Paper 5398*. NBER.
- Sbeiti, W., & Haddad, A. 2011. Stock Market Dynamic in Oil-Dependent Economies: Evidence from the GCC Countries. *International Journal Research of Applied Finance* 2: 1-37.
- Seymen, A. 2011. A Critical Note on the Forecast Error Variance Decomposition. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1266093>.
- Shumway, R., & Stoffer, D. 2017. *Time Series Analysis and Its Applications: With R Examples*. 4th ed. Heidelberg: Springer.
- Ssekuma, R. 2011. A study of cointegration models with applications. *University of South Africa* 6-27.
- Statistics South Africa. 2015. Mining: Production and sales (preliminary), *Statistics South Africa*, No. April: 1-13.
- Talaş, E., Kaplan, F., & Çelik, A. 2013. Model Stability Test of Money Demand by Monthly Time Series Using CUSUM and MOSUM Tests: Evidence from Turkey. *Sciedu Press: Research in World Economy* 36-40.
- Vegter, I.V.O. 2018. *Why Mining Still Matters: The Socio-Economic Importance of the Mining Industry*, Johannesburg, available at <https://irr.org.za/reports/occasional-reports>.
- Wasserman, H. 2019. South Africa's economy is shrinking at an alarming rate – and only oranges and interest rates are offering hope, *Business Insider*.
- Zivot, Eric & Donald W.K. Andrews. 1992. Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business & Economic Statistics* 10: 251-270.

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