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SUMAR – SOMMAIRE – CONTENTS – INHALT

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CAUSALITY BETWEEN PUBLIC DEBT, PUBLIC DEBT SERVICE AND ECONOMIC GROWTH IN AN EMERGING ECONOMY

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Abstract: This paper explores the causality between public debt, public debt service and economic growth in South Africa covering the period 1970 – 2017. The study employs the autoregressive distributed lag (ARDL) bounds testing approach to cointegration and the multivariate Granger-causality test. The empirical results indicate that there is unidirectional causality from economic growth to public debt, but only in the short run. However, the study fails to establish any causality between public debt service and economic growth, both in the short run and long run. In line with the empirical evidence, the study concludes that it is economic growth that drives public debt in South Africa, and that the causal relationship between public debt and economic growth is sensitive to the timeframe considered. The paper recommends policymakers in South Africa to consider growth-enhancing policies in the short run, since poor economic performances may lead to high public debt levels.

JEL Classification: H63, O47

Keywords: Economic growth, Granger-causality, public debt, public debt service, South Africa, ARDL

1. Introduction

The linkage between government debt and macroeconomic stability has remained a hotly contested issue in the literature. On the one hand, there is a rich body of theoretical literature that argues that deficit financing crowds out private sector investment and leads to depressed levels of output in the long run (Mankiw, 2000;

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Saint-Paul, 1992; Modigliani, 1961; Domar, 1944). There is another theory that validates that public debt induces economic growth by stimulating aggregate demand and overall output – through enhancing gross savings and domestic financial markets (Elmendorf and Mankiw, 1999; Chenery and Strout, 1966; Wagner, 1893). Another divergent view argues that fiscal operations have a neutral impact on economic growth (Barro, 1990; 1979). Outside the theories discussed above, there is another theory that validates the existence of a nonlinear relationship between public debt and economic growth (Sachs, 1989). These varying theoretical views have been tested empirically, and until now, there is no consensus on the matter.

On the other hand, the bulk of past empirical work has largely focused on the impact of public debt on economic growth, and public debt service on economic growth, with mixed results – disregarding the possibility of causality between the variables (Huang et al., 2018; Gómez-Puig and Sosvilla-Rivero; 2018; Owusu-Nantwi and Erickson, 2016; Kobayashi, 2015; Dogan and Bilgili, 2014; Kourtellos et al., 2013; Balcilar, 2012). The analysis further revealed that public debt enjoyed more coverage than its debt service counterpart as proven by more studies on the impact of public debt than on the impact of public debt service on economic growth. The few studies on the impact of public debt service on economic growth include Serieux and Sammy (1999), Elbadawi et al. (1997) and Savvides (1992). Nevertheless, it is equally essential to determine the causal relationship between public debt and economic growth, and between public debt service and economic growth for effective policy making that guarantees both sustainable economic growth and public debt sustainability.

Motivated by these developments, this paper contributes to the existing body of literature in four main ways. First, the paper simultaneously tests the direction of causality between public debt and economic growth, and between public debt service and economic growth in South Africa over the last forty-seven years to 2017. Second, the paper applies the dynamic multivariate Granger-causality model because of its many superior properties over bivariate causality frameworks – such as minimizing the omission-variable-bias, eliminating spurious correlations and also increasing the general validity of the causation test (Ferreira, 2009; Odhiambo, 2008; Lutkepohl, 1982). The causal relationship among variables after factoring in intermittent variables can alter the direction of causality or the magnitude of variables (Odhiambo, 2009; Lin, 2008).

Third, according to Donayre and Taivan (2017), most previous studies that have focused on the causality between public debt and economic growth, and between public debt service and economic growth have neglected the testing of possible cointegrating relationships – widening the possibilities of estimating spurious correlations. Among such studies are those by Panizza and Presbitero (2013), Baum et al. (2013), and Woo and Kumar (2015). This paper addresses this issue by accentuating the importance of cointegrating relationships using the ARDL bounds testing approach, which has been found to have many advantages when compared to other conventional cointegration techniques. For example, the ARDL approach to cointegration presents unbiased regression estimates of the long-run model, even in cases where some variables are endogenous (Odhiambo, 2009). Finally, unlike most previous studies that made causality inferences based on a panel of countries (Ferreira, 2009; Amoateng and Amoako-Adu, 1996), this paper focuses on South Africa only; hence, the results are country-specific.

The remainder of the paper is organized as follows: Section 2 summarizes the dynamics of public debt, public debt service and economic growth in South Africa. In Section 3, the paper reviews theoretical and empirical literature on the causal linkages between public debt, public debt service and economic growth. Section 4 explains the research methodology; while Section 5 presents the empirical findings and results discussion. Finally, Section 6 outlines the concluding remarks on the paper.

2. Public debt, public debt service and economic performance in South Africa: An overview

The evolution of public debt, public debt service and economic growth in South Africa over the period from 1970 to 2017 has been largely influenced by the political developments in the country; the government's drive to develop the economy; and also, by the structural economic changes – including movements in domestic and foreign interest rates, exchange rates and inflation rates (National Treasury, 2018; 1995; International Monetary Fund "IMF", 2005). In the 1970s and 1980s, the inordinate rise in public debt was partly due to active participation by the government in both market processes and infrastructure development, which greatly expanded state expenditures – leading to debt financing (Faulkner and Loewald, 2008). The combined effect of: (1) exchange control regulations and stringent asset requirements; (2) international isolation; (3) high world interest rates; and (4) new government borrowing preferences, all contributed to limited access to international finance, resulting in the haste to develop a vibrant domestic debt market to fund growing budget deficits (Government of South Africa "GSA", 2014; South African Reserve Bank "SARB", 2006; Moss and Obery, 1987). As a consequence, unlike most African states, South Africa has a high proportion of its public debt denominated in local currency (Rands), with a small proportion of the country's domestic debt being held by non-residents (National Treasury, 2018).

With the demise of the apartheid regime in 1994, the new South African government inherited foreign public debt worth more than R14 billion, owed mostly to the private banks in Germany, Switzerland, the United Kingdom and the United States of America (National Treasury, 1995). Since then, the country has also embarked on the fiscal, economic and financial reforms which ultimately fashioned the current structure, composition and trends of its public debt, public debt repayment costs and economic growth process. The South African government's modest economic and financial reforms after 1994 did not only reduce the country's foreign public debt stock, but also made the domestic government securities more attractive to both residents and non-residents (National Treasury, 2012).

Additionally, the increased issuance of government bonds from 1996 to 2017 broadened the sources of funding the fiscal financial requirements and also stimulated the growth of the country's bond market (National Treasury, 2012; 1998). The other key aim of the government in increasing domestic debt instruments and in lengthening their maturing periods was to limit and spread domestic public debt service costs (SARB, 2016; National Treasury, 2012). By December 2017, the aggregate public debt in South Africa amounted to R2.5 trillion (or 50.7% of gross domestic product "GDP"), while aggregate public debt repayment costs totaled R163.2 billion (or 3.5% of GDP)

(National Treasury, 2018). Overall, the rise in aggregate public debt since 2000, mostly the domestic component, has been a cumulative effect of the need to finance rising annual budget deficits and to refinance maturing government debt securities (National Treasury, 2018; 2012).

Regarding economic growth, the South African economy has grown by an average of 2.3% between 1980 and 2017 (World Bank, 2018a). In the main, South Africa experienced two explicit economic growth phases; 1980 to 1992 and 1993 to 2017. In phase one, 1980 – 1992, economic growth rates were not impressive – this was against a backdrop of the intensification of international political, economic and financial sanctions on the apartheid regime, which dried up funding for new state projects and increased political uncertainty (World Bank, 2018a; 2018b; Clark, 1994). The economic growth rates during this period, 1980 – 1992, were thus moderate, spiking around 2.1% of GDP – with swings reaching a period low of a negative 1.8% in 1983 and a period high of about 5.1% in 1984 (World Bank, 2018a).

From 1993 until 2009, economic growth rates steadily increased, whereas, from 2010, the country has had a negative economic growth trajectory up until 2017 (World Bank, 2018a). On the whole, after 1994, the South African economy made a remarkable economic rebound following the adoption of stern structural policies, which stressed on among other things, trade liberalization, removal of discriminatory labor policies and practises, restructuring and privatization of some state-owned businesses, sectoral deregulation and real exchange rate stabilization (World Bank, 2018a; 2001; GSA, 2014; 1996; 1994). Figure 1 displays the public debt, public debt service and economic growth trends in South Africa for the period 1980 – 2017. Public debt (PD) and public debt service (PDS) are both expressed as a percentage of real GDP (RGDP), while economic growth is measured by the annual growth rate of RGDP per capita (y).

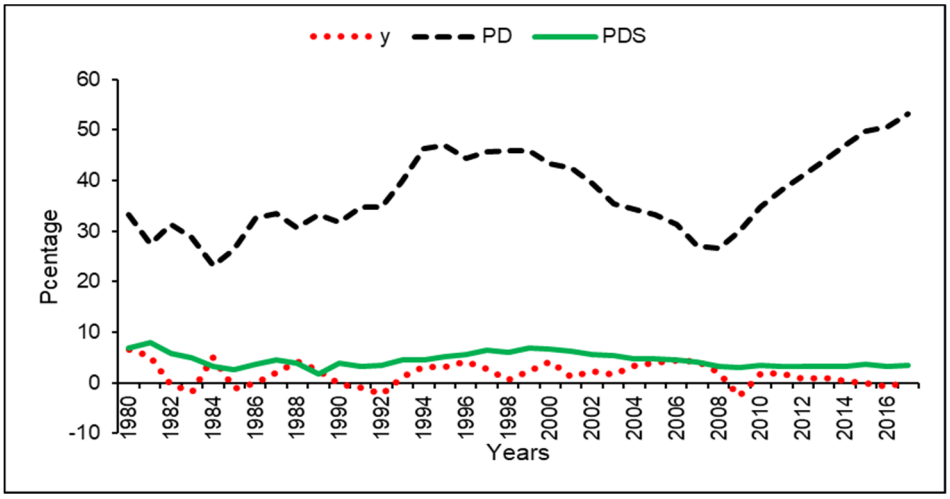

Fig 1: Public debt, public debt service and economic growth trends in South Africa (1980-2017)

Source: Authors' computations based on World Bank (2018a) databank

The evolvement of public debt in South Africa, as shown in Figure 1, can be put into three specific periods: 1980 – 1994, 1995 – 2008 and 2009 – 2017. The first period, 1980 – 1994, is defined by rising public debt levels, resulting from growing fiscal deficits, which reached a period peak of 47% of GDP in 1994 (Statistics South Africa, 2017). During this period, the country was under economic sanctions levied by the international community (Clark, 1994). Government debt service costs were, however, falling owing to rising inflation rates, which had a reducing effect on the real monetary value on the domestic public debt (World Bank, 2018a).

In the second period, 1995 – 2008, a downward trajectory in both public debt/RGDP and public debt service/RGDP ratios is evident. This period coincides with massive economic and financial reforms, which lessened the government debt repayment costs (National Treasury, 2012). Also, in this period, 1995 – 2008, there was massive industrialization and expansion of the country's export sector. Economic growth rates steadily recovered from the 2001 bottom of 1.2% to a peak of about 4.6% in 2006 but slid back again to a negative 2.6% in 2009 (World Bank, 2018a).

In the last phase, 2009 – 2017, there is a noticeable upward trend in both the public debt/RGDP and public debt service/RGDP ratios, which can be attributed to the tail-effects of the 2008 global financial crisis and also to the introduction of new government debt instruments (National Treasury, 2018; 2016; 2012). The corresponding economic growth rates were also not impressive during the period, portraying an overall downward trend.

3. Literature review

In economic theory, there are two main arguments on the causal relationship between public debt and economic growth, and between public debt service and economic growth. First, is the Keynesian view, which argues that at moderate levels of public debt, fiscal policy is growth-enhancing (Elmendorf and Mankiw, 1999). This argument is confirmed by Barro (1979)'s view that public debt could be used to smoothen distortionary taxation and to induce economic growth by stimulating aggregate demand and output in the short run. Expansionary government policies that lead to public debt accumulation are argued to have a positive multiplier effect on both short-term and long-term economic growth – the law of increasing state activity (DeLong and Summers, 2012; Wagner, 1911). Second, is the Classical view that argues that public debt and public debt service negatively affects the productivity of public expenditures through crowding out private capital and the overall outflow of income (Teles and Mussolini, 2014; Saint-Paul, 1992; Modigliani, 1961).

Empirically, the direction of causality between public debt and economic growth, and between public debt service and economic growth has undergone a limited examination as the majority of past studies have focused more on the impact between the variables. Of the few studies that explicitly focused on the direction of causality between public debt and economic growth, and between public debt service and economic growth, the results are mixed depending partly on the methodology used and a set of other heterogeneous factors. Among the countries analyzed, there is evidence of unidirectional causality and bidirectional causality between public debt and real

economic growth; and between public debt service and real economic growth. Furthermore, there is also empirical evidence that supports the neutrality hypothesis between the variables.

While the majority of the studies have used the time-series Granger-causality test (Donayre and Taivan, 2017; Gómez-Puig and Sosvilla-Rivero, 2015), a few others have employed either the panel data Granger-causality test (Woo and Kumar, 2015; Jalles, 2011; Ferreira, 2009; Abbas and Christensen, 2007) or the instrumental variable approach (Panizza and Presbitero, 2014; Reinhart and Rogoff, 2010). A summary of the empirical review of studies on the causality between public debt and economic growth, and between public debt service and economic growth is given in Table 1.

Table 1: Empirical studies on the causality between public debt and economic growth, between public debt service and economic growth

Studies consistent with causality between public debt and economic growth		
Methodology	Outcome	Studies
Time-series Granger-causality	Debt → Growth	Donayre and Taivan, 2017; Gómez-Puig and Sosvilla-Rivero, 2015
	Debt ← Growth	Donayre and Taivan, 2017; Gómez-Puig and Sosvilla-Rivero, 2015; Kobayashi, 2015
	Debt ↔ Growth	Donayre and Taivan, 2017; Owusu-Nantwi and Erickson, 2016
	No causality	Donayre and Taivan, 2017; Gómez-Puig and Sosvilla-Rivero, 2015
Panel data Granger-causality	Debt ← Growth	Woo and Kumar, 2015
	Debt ↔ Growth	Ferreira, 2009; Abbas and Christensen, 2007
Instrumental variable approach	No causality	Panizza and Presbitero, 2014; Reinhart and Rogoff, 2010
Studies consistent with causality between public debt service and economic growth		
Methodology	Outcome	Studies
Time-series Granger-causality	Debt service → Growth	Karagol, 2002
Panel data Granger-causality	Debt service → Growth	Afxentiou, 1993
	Debt service ↔ Growth	Amoateng and Amoako-Adu, 1996
	No causality	Jalles, 2011

Source: Authors' computation

In Table 1, more studies have been conducted on the causality between public debt and economic growth than between public debt service and economic growth. Basing on the number of studies, the dominant causal flow in Table 1 is from

economic growth to public debt. However, no dominant causal flow was ascertained between public debt service and economic growth because the literature is still at a nascent stage.

4. Research methodology

4.1 Estimation techniques

This paper employs a multivariate Granger-causality model within an autoregressive distributed lag (ARDL) bounds testing context, with a view to investigate the causality between public debt and economic growth, and between public debt service and economic growth, along with other control variables. According to Granger (1969) and Sims (1972), one variable Granger-causes another variable, given an information set, if past information about the former can improve the prediction of the latter based solely on its own past information. In other words, information on the evolution of one time-series minimizes the forecast errors of the other, implying that the latter does not evolve independently of the former (Lin, 2008). To increase the general validity of the causation test, as well as to eliminate spurious correlations, the paper incorporated two control variables to create a multivariate Granger-causality model. The two intermittent variables are fiscal balance and savings.

Prior to the application of the afore-described error correction model (ECM) based causality test, the paper utilizes the ARDL approach to confirm the existence or absence of a long-run relationship among the variables. The choice of the ARDL approach to cointegration is based on its strengths over the residual-based approach by Engle and Granger (1987), and the full maximum likelihood approach by Johansen and Juselius (1990). First, the ARDL approach captures the short-run and long-run relationships simultaneously, and the t-statistics from the ARDL procedure are valid, and its long-run estimates are reliable and unbiased (Pesaran and Shin, 1999). Second, the ARDL approach to cointegration provides robust results even in cases of small or finite sample sizes (Narayan, 2005). Lastly, the ARDL approach can produce sound results even when regression variables have a mixture of order of integration not exceeding one (Pesaran et al., 2001).

The computed F-statistic is equated to the critical values provided by Pesaran et al. (2001). If the computed F-statistic exceeds the upper critical value, the null hypothesis of no cointegration is rejected; while the null hypothesis of no cointegration cannot be rejected if the F-statistic falls below the lower bounds critical value. Finally, if the F-statistic falls between the lower and upper bounds, then the cointegration result becomes inconclusive.

To determine the optimal lag structure for each variable, the paper uses the Schwartz-Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC). According to Cheung and Lai (1993), both the AIC and BIC methods perform well in finite samples provided that the true error structure has a finite and autoregressive representation. Principally, the importance of selecting the right lag length for each variable is that it lessens the bias that arises from under-parameterization of a model, as well as the loss in efficiency resulting from its over-parameterization (Thornton and Batten, 1985). Table 2 gives a description of each variable included in the study.

Table 2: Variable description

Variable	Description
y	Annual growth rate of RGDP per capita (a proxy for economic growth)
PD	Public debt/RGDP ratio (a proxy for public debt)
PDS	Public debt service/RGDP ratio (a proxy for public debt service)
FB	Fiscal balance/RGDP ratio (a proxy of fiscal balance)
SAV	Gross domestic savings/RGDP ratio (a proxy for savings)

Source: Authors' computation

4.2 Empirical model specification and data sources

This paper applies two models, Model 1 and Model 2. In Model 1, the paper examines the causality between public debt and economic growth, whereas, in Model 2, the causality between public debt service and economic growth is considered. Two control variables, that is, fiscal balance and savings were added to each of the two models. A system of cointegration equations for Model 1 in this study is expressed as follows:

ARDL specification for Model 1 (y, PD, FB and SAV)

$$\Delta y_t = \phi_0 + \sum_{i=1}^{n} \phi_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \phi_{2i} \Delta PD_{t-i} + \sum_{i=0}^{n} \phi_{3i} \Delta FB_{t-i} + \sum_{i=0}^{n} \phi_{4i} \Delta SAV_{t-i}$$

$$+ \phi_5 y_{t-1} + \phi_6 PD_{t-1} + \phi_7 FB_{t-1} + \phi_8 SAV_{t-1} + \varepsilon_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

$$\Delta PD_t = \lambda_0 + \sum_{i=0}^{n} \lambda_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta PD_{t-i} + \sum_{i=0}^{n} \lambda_{3i} \Delta FB_{t-i} + \sum_{i=0}^{n} \lambda_{4i} \Delta SAV_{t-i}$$

$$+ \lambda_5 y_{t-1} + \lambda_6 PD_{t-1} + \lambda_7 FB_{t-1} + \lambda_8 SAV_{t-1} + \varepsilon_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.2)$$

$$\Delta FB_t = \beta_0 + \sum_{i=0}^{n} \beta_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta PD_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta FB_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta SAV_{t-i}$$

$$+ \beta_5 y_{t-1} + \beta_6 PD_{t-1} + \beta_7 FB_{t-1} + \beta_8 SAV_{t-1} + \varepsilon_{3t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.3)$$

$$\Delta SAV_t = \omega_0 + \sum_{i=0}^{n} \omega_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \omega_{2i} \Delta PD_{t-i} + \sum_{i=0}^{n} \omega_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \omega_{4i} \Delta SAV_{t-i}$$

$$+ \omega_5 y_{t-1} + \omega_6 PD_{t-1} + \omega_7 FB_{t-1} + \omega_8 SAV_{t-1} + \varepsilon_{4t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.4)$$

Where ϕ_0, λ_0, β_0 and ω_0 are respective constants; $\phi_1 - \phi_4$, $\lambda_1 - \lambda_4$, $\beta_1 - \beta_4$ and $\omega_1 - \omega_4$ are respective short-run coefficients; $\phi_5 - \phi_8$, $\lambda_5 - \lambda_8$, $\beta_5 - \beta_8$ and $\omega_5 - \omega_8$ are respective long-run coefficients; $\varepsilon_1 - \varepsilon_4$ are the error terms; Δ is the difference operator; n is the lag length; t is the time period; and all the other variables are as described in Table 2.

ECM-based Granger-causality for Model 1 (y, PD, FB and SAV)

Following Donayre and Taivan (2017), and based on the work of Pesaran and Shin (1999) and Pesaran et al. (2001), the ECM-based multivariate Granger-causality model in this study, for Model 1, is expressed as:

$$\Delta y_t = \phi_0 + \sum_{i=1}^{n} \phi_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \phi_{2i} \Delta PD_{t-i} + \sum_{i=1}^{n} \phi_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \phi_{4i} \Delta SAV_{t-i}$$

$$+ \phi_9 ECM_{t-1} + \mu_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.5)$$

$$\Delta PD_t = \lambda_0 + \sum_{i=1}^{n} \lambda_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta PD_{t-i} + \sum_{i=1}^{n} \lambda_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \lambda_{4i} \Delta SAV_{t-i}$$

$$+ \lambda_9 ECM_{t-1} + \mu_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.6)$$

$$\Delta FB_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta PD_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta SAV_{t-i}$$

$$+ \beta_9 ECM_{t-1} + \mu_{3t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.7)$$

$$\Delta SAV_t = \omega_0 + \sum_{i=1}^{n} \omega_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \omega_{2i} \Delta PD_{t-i} + \sum_{i=1}^{n} \omega_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \omega_{4i} \Delta SAV_{t-i}$$

$$+ \omega_9 ECM_{t-1} + \mu_{4t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.8)$$

Where ϕ_9, λ_9, β_9 and ω_9 are coefficients of ECM_{t-1}; ECM_{t-1} is the error correction term lagged by one period; and all the other variables are as described in the cointegration model (Model 1).

ARDL specification for Model 2 (y, PDS, FB and SAV)

$$\Delta y_t = \psi_0 + \sum_{i=1}^{n} \psi_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \psi_{2i} \Delta PDS_{t-i} + \sum_{i=0}^{n} \psi_{3i} \Delta FB_{t-i} + \sum_{i=0}^{n} \psi_{4i} \Delta SAV_{t-i} + \psi_5 y_{t-1} + \psi_6 PDS_{t-1} + \psi_7 FB_{t-1} + \psi_8 SAV_{t-1} + \varepsilon_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

$$\Delta PDS_t = \rho_0 + \sum_{i=0}^{n} \rho_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \rho_{2i} \Delta PDS_{t-i} + \sum_{i=0}^{n} \rho_{3i} \Delta FB_{t-i} + \sum_{i=0}^{n} \rho_{4i} \Delta SAV_{t-i} + \rho_5 y_{t-1} + \rho_6 PDS_{t-1} + \rho_7 FB_{t-1} + \rho_8 SAV_{t-1} + \varepsilon_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

$$\Delta FB_t = \propto_0 + \sum_{i=0}^{n} \propto_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \propto_{2i} \Delta PDS_{t-i} + \sum_{i=1}^{n} \propto_{3i} \Delta FB_{t-i} + \sum_{i=0}^{n} \propto_{4i} \Delta SAV_{t-i} + \propto_5 y_{t-1} + \propto_6 PDS_{t-1} + \propto_7 FB_{t-1} + \propto_8 SAV_{t-1} + \varepsilon_{3t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

$$\Delta SAV_t = \delta_0 + \sum_{i=0}^{n} \delta_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \delta_{2i} \Delta PDS_{t-i} + \sum_{i=0}^{n} \delta_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \delta_{4i} \Delta SAV_{t-i} + \delta_5 y_{t-1} + \delta_6 PDS_{t-1} + \delta_7 FB_{t-1} + \delta_8 SAV_{t-1} + \varepsilon_{4t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

Where ψ_0, ρ_0, $\propto_0$ and δ_0 are respective constants; $\psi_1 - \psi_4$, $\rho_1 - \rho_4$, $\propto_1 - \propto_4$ and $\delta_1 - \delta_4$ are respective short-run coefficients; $\psi_5 - \psi_8$, $\rho_5 - \rho_8$, $\propto_5 - \propto_8$ and $\delta_5 - \delta_8$ are respective long-run coefficients; $\varepsilon_1 - \varepsilon_4$ are the error terms; Δ is the difference operator; n is the lag length; t is time period; and all the other variables are as described in Table 2.

ECM-based Granger-causality for Model 2 (y, PDS, FB and SAV)

$$\Delta y_t = \psi_0 + \sum_{i=1}^{n} \psi_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \psi_{2i} \Delta PDS_{t-i} + \sum_{i=1}^{n} \psi_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \psi_{4i} \Delta SAV_{t-i} + \psi_9 ECM_{t-1} + \mu_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

$$\Delta PDS_t = \rho_0 + \sum_{i=1}^{n} \rho_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \rho_{2i} \Delta PDS_{t-i} + \sum_{i=1}^{n} \rho_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \rho_{4i} \Delta SAV_{t-i} + \rho_9 ECM_{t-1} + \mu_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.6)$$

$$\Delta FB_t = \propto_0 + \sum_{i=1}^{n} \propto_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \propto_{2i} \Delta PDS_{t-i} + \sum_{i=1}^{n} \propto_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \propto_{4i} \Delta SAV_{t-i}$$

$$+ \propto_9 ECM_{t-1} + \mu_{3t} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2.7)$$

$$\Delta SAV_t = \delta_0 + \sum_{i=1}^{n} \delta_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} \delta_{2i} \Delta PDS_{t-i} + \sum_{i=1}^{n} \delta_{3i} \Delta FB_{t-i} + \sum_{i=1}^{n} \delta_{4i} \Delta SAV_{t-i}$$

$$+ \delta_9 ECM_{t-1} + \mu_{4t} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2.8)$$

Where ψ_9, ρ_9, $\propto_9$, and δ_9 are coefficients of ECM_{t-1}; ECM_{t-1} is the error correction term lagged by one period; and all the other variables are as described in the cointegration model (Model 2).

The paper utilized annual time-series data from 1970 to 2017 for all the variables in Models 1 and 2. The annual time-series data for these variables is taken from the World Bank World Development Indicators database (World Bank, 2018a). Further, the paper employed the Microfit 5.01 econometric package to run all independent regressions.

5. Empirical findings and results discussion

Although the ARDL bounds test procedure does not require all variables to be integrated of the same order, the approach requires that all variables be integrated of order of a maximum of one (Pesaran et al., 2001). The results of Dickey Fuller Generalized Least Square (DF-GLS) and Perron (1997) unit root test (PPURoot) are presented in Table 3.

Table 3: Unit root test results – all variables

Variable	DF-GLS				PPURoot			
	Stationarity of all Variables in Levels		Stationarity of all Variables in First Difference		Stationarity of all Variables in Levels		Stationarity of all Variables in First Difference	
	With Intercept	*With Intercept and Trend*	*With Intercept*	*With Intercept and Trend*	*With Intercept*	*With Intercept and Trend*	*With Intercept*	*With Intercept and Trend*
y	-4.928***	-4.946***	-	-	-5.578**	-5.588**	-	-
PD	-1.692*	-1.921	-	-5.444***	-2.319	-2.781	-6.072***	-6.006***
PDS	-1.336	-2.279	-5.131***	-6.500***	-3.902	-3.769	-7.688***	-7.636***

Variable	DF-GLS				PPURoot			
	Stationarity of all Variables in Levels		Stationarity of all Variables in First Difference		Stationarity of all Variables in Levels		Stationarity of all Variables in First Difference	
	With Intercept	*With Intercept and Trend*	*With Intercept*	*With Intercept and Trend*	*With Intercept*	*With Intercept and Trend*	*With Intercept*	*With Intercept and Trend*
FB	-2.648***	-2.794	-	-6.537***	-3.340	-3.274	-7.596***	-7.253***
S	-1.279	-1.765	-4.932***	-5.566***	-3.310	-3.491	-7.049***	-7.508***

*Note: *, ** and *** imply the rejection of the null hypothesis of non-stationarity at 10%, 5% and 1% significance levels, respectively.*
Source: Authors' computation by using EViews 9.01 software

Even though the unit root test results vary from one test to the other, overall, the variables are either integrated of order zero or one, thus confirming the aptness of the ARDL bounds estimation technique. The next stage is to test for the presence or absence of long-run equilibrium relationship among regression variables in the two models using a bounds F-statistic test. Table 4 presents the cointegration results for Model 1 and Model 2.

Table 4: Bound F-test for cointegration results – Models 1 and 2

Pane A: Model 1 – Public debt and economic growth			
Dependent Variable	Function	F-statistic	Cointegration Status
y	F(y| PD, FB, S)	4.538**	Cointegrated
PD	F(PD| y, FB, S)	2.407	Not cointegrated
FB	F(FB| y, PD, S)	1.537	Not cointegrated
S	F(S| y, PD, FB)	3.784*	Cointegrated
Panel B: Model 2 – Public debt service and economic growth			
Dependent Variable	Function	F-statistic	Cointegration Status
y	F(y| PDS, FB, S)	6.200***	Cointegrated
PDS	F(PDS| y, FB, S)	3.850*	Cointegrated
FB	F(FB| y, PDS, S)	2.335	Not cointegrated
S	F(S| y, PDS, FB)	3.112	Not cointegrated

Asymptotic critical values (unrestricted intercept and no trend)						
Pesaran et al. (2001: 300) Table CI(iii) Case III	10%		5%		1%	
	I(0)	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*
	2.72	3.77	3.23	4.35	4.29	5.61

*Note: *, ** and *** imply statistical significance at 10%, 5% and 1%, respectively.*
Source: Authors' computation by using Microfit 5.01 software

The cointegration results reported in Table 4 establish that cointegration exists in the economic growth and savings functions for Model 1 [Panel A], and in the economic growth and public debt service functions for Model 2 [Panel B]. The findings in Models 1 and 2 are validated by the respective F-statistics of each function vis-à-vis the Pesaran et al.'*s* (2001) asymptotic critical values. The existence of cointegration in these functions indicate the presence of causality in at least one direction (Muyambiri and Odhiambo, 2018; Sims, 1972). Therefore, the paper proceeds to establish the direction of causality between public debt and economic growth, and between public debt service and economic growth by running an ECM-based causality test. The empirical results of the Granger-causality test for Model 1 and Model 2 for South Africa are presented in Table 5, Panel A and Panel B, respectively.

Table 5: Granger-causality test results – Models 1 and 2

Panel A: Model 1 – Public debt and economic growth					
Dependent Variable	F-statistics [probability]				ECT_{t-1} [t-statistics]
	Δy_t	ΔPD_t	ΔFB_t	ΔS_t	
Δy_t	-	1.739 [0.179]	2.468* [0.080]	3.143* [0.054]	-0.376*** [-4.520]
ΔPD_t	2.316* [0.051]	-	0.465 [0.632]	1.333 [0.256]	-
ΔFB_t	0.879 [0.462]	1.905 [0.148]	-	0.845 [0.479]	-
ΔS_t	2.108 [0.118]	2.802* [0.055]	1.339 [0.279]	-	-0.134* [-1.727]
Panel B: Model 2 – Public debt service and economic growth					
Dependent Variable	F-statistics [probability]				ECT_{t-1} [t-statistics]
	Δy_t	ΔPDS_t	ΔFB_t	ΔS_t	
Δy_t	-	1.002 [0.323]	5.254** [0.027]	3.753* [0.060]	-0.369*** [-4.574]
ΔPDS_t	0.274 [0.604]	-	1.577 [0.217]	8.030*** [0.003]	-0.244** [-2.628]
ΔFB_t	1.119 [0.296]	0.004 [0.948]	-	1.579 [0.216]	-
ΔS_t	2.993* [0.091]	0.671 [0.418]	0.746 [0.393]	-	-

*Note: *, ** and *** imply statistical significance at 10%, 5% and 1% levels, respectively.*
Source: authors' computation by using Microfit 5.01 software

The empirical results reported in Table 5, Panel A for Model 1, reveal that there is short-run unidirectional causality from economic growth (y) to public debt (PD). This outcome is confirmed by the corresponding F-statistic of economic growth (Δyt) in the public debt (ΔPDt) function, which is statistically significant. The causality results for Model 1 indicate that it is economic growth that drives public debt in South Africa. This result is not unique to this study as it is consistent with the finding in Donayre and Taivan (2017).

Other results of Model 1 presented in Panel A confirm that, in South Africa, there is: (i) unidirectional causal flow from fiscal balance to economic growth, irrespective of whether the causality is estimated in the short run or in the long run; (ii) unidirectional causality between savings and economic growth, both in the short run and long run; (iii) short-run and long-run causal flow from public debt to savings; and (iv) no causality between fiscal balance and public debt, and between fiscal balance and savings.

Empirical results presented in Table 5, Panel B for Model 2, where public debt service, fiscal balance, savings and economic growth are variables, indicate that in South Africa there is no short-run or long-run causality between public debt service and economic growth. This result is confirmed by the corresponding F-statistics of ΔPDS in the economic growth function (Δyt) and that of Δyt in the public debt service function (ΔPDSt), which are both statistically insignificant. This finding is in line with empirical evidence from Jalles (2011).

Other results of Model 2 reported in Panel B confirm that, in South Africa, there is: (i) distinct short-run and long-run unidirectional causality from fiscal balance to economic growth; (ii) short-run bidirectional causality from savings to economic growth; (iii) long-run unidirectional causality from savings to economic growth; (iv) distinct short-run and long-run unidirectional causality from savings to public debt service; and (v) no causality between savings and fiscal balance, and between public debt service and fiscal balance.

6. Conclusions

In this paper, the causality between public debt and economic growth is examined in South Africa for the period 1970 – 2017. The paper makes use of two models, namely, Model 1 and Model 2. Model 1 is composed of public debt, economic growth, fiscal balance and savings; whereas Model 2 is composed of public debt service, economic growth, fiscal balance and savings. Fiscal balance and savings were used as intermittent variables to overcome the limitations of bivariate causality test, such as the omission-variable-bias. The paper employed the ARDL bounds testing procedure for cointegration and the ECM-based Granger-causality test to explore the underlying relationships.

This paper explicitly contributes to the existing theoretical and empirical literature on the debt-growth nexus in four main ways. First, contrary to most past studies on the subject that analyzed only the causality between public debt and economic growth, this paper extends the causality analysis to public debt service and economic growth as well (Donayre and Taivan, 2017; Gómez-Puig and Sosvilla-Rivero, 2015; Kobayashi, 2015). Second, regarding modelling, the study employs a

multivariate causality model, which has been confirmed to perform better than the bivariate model. The traditional bivariate model used in past studies is known to suffer from variable-omission-bias (Odhiambo, 2008). The chosen multivariate Granger-causality approach has the advantage of eliminating spurious correlations and increasing the general validity of the causation test (Lutkepohl, 1982). Third, unlike most past studies on the subject which make inferences based on cross-sectional Granger-causality tests, this paper performs causal tests for a specific country, South Africa (Donayre and Taivan, 2017; Panizza and Presbitero, 2014). The chosen approach in this paper has the advantage of capturing country-specific factors. Lastly, most previous studies on the subject neglected the testing of possible cointegrating relationships – widening the possibilities of estimating spurious correlations, such as those by Panizza and Presbitero (2013), Baum et al. (2013), and Woo and Kumar (2015). This paper addresses this issue by highlighting the significance of cointegrating relationships using the ARDL bounds testing procedure, which has been found to have superior properties when compared to other conventional cointegration techniques (see Odhiambo, 2009).

The study reveals that for South Africa, there is short-run unidirectional causal flow from economic growth to public debt. However, the study fails to establish any causality between public debt service and economic growth, both in the short run and long run. In line with these results, the study concludes that it is economic growth that drives public debt in South Africa, and that the causal relationship between public debt and economic growth is sensitive to the timeframe considered. The study, therefore, recommends that appropriate economic growth-enhancing policies should be intensified in South Africa in order to uphold a sustainable public debt level. In the main, the findings of this study not only contribute to the on-going debate on the relationship between public debt and economic growth, and between public debt service and economic growth, but also help in policy formulation in South Africa.

Although the paper used two intermittent variables to avoid model misspecification and increase the predictive power of the models, other important variables could be included, such as, but not limited to, quality of public sector institutions and macroeconomic uncertainty. These variables were omitted in the study due to the unavailability of reliable time-series data. As the data of these and other variables become available, it would be ideal for future studies on the subject to establish whether the results would change significantly after incorporating these variables.

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A KEYNESIAN APPROACH TO FISCAL POLICY FOR FULL EMPLOYMENT AND CONTINUOUS TIME DEBT DYNAMICS

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Abstract: It is widely argued that public debt is a burden on the future generations. We analyze another aspect of public debt as an economic stimulus program, that is, the measure to realize full employment from an under-employment state. Using a continuous time version of a dynamic analysis of debt-to-GDP ratio we show that a fiscal policy to realize full employment from a state of under-employment can reduce the debt-to-GDP ratio. More precisely we show that the larger the extra growth rate (increasing rate) of real GDP by a fiscal policy is, the smaller the debt-to-GDP ratio at the time when full employment is realized is. Also we show that even if the marginal propensity to consume is very small (including zero), an aggressive fiscal policy can realize full employment without increasing the debt-to-GDP ratio. Further, we consider a condition to realize full employment from a state of under-employment within one year without increasing debt-to-GDP ratio.

JEL classification: E12, E24, E62

Keywords: full employment, debt-to-GDP ratio, continuous time debt dynamics

1. Introduction

It is widely argued that public debt is a burden on the future generations. There are many studies about the burden of public debt in a full employment state and an under-employment state such as Lerner (1944), Diamond (1965), Barro (1974), Rankin (1986), Sen (2002), Ono (2011), Tanaka (2013) and Otaki (2015). Otaki (2015), by using an overlapping generations model, showed that public debt lowers the future generation's welfare in the situation of under-employment. Using a simple textbook multiplier model, Ono (2011) showed that an increase in a wasteful public spending under a balanced budget or a loan budget without money illusion raises GDP, but it

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is not effective because the household's consumption does not change. J. Tanaka (2013) studied the welfare effects of fiscal policies in an under-employment economy using a fixed price non-Walrasian overlapping generations model[1], and showed that in all three cases, (1) wasteful spending, (2) an inter-generational income transfer, and (3) an intra-generational income transfer between different groups of households, there is no burden of public debt. These are studies of the welfare effects of public debt in a situation of under-employment. On the other hand, for example, Sen (2002) analysed the welfare effects of public debt in a situation of full employment.

The focus of this paper is different from that of these studies. We analyze another aspect of public debt as an economic stimulus program, that is, the measure to realize full employment from an under-employment state. Watts and Sharpe (2016) presented a discrete time version of dynamic analysis of debt-to-GDP ratio, and showed that an aggressive fiscal policy can reduce the debt-to-GDP ratio. Generalizing their model we present a continuous time version of a dynamic analysis of debt-to-GDP ratio, and examine the effects of a fiscal policy which realizes full employment from a state of under-employment or with deflationary GDP gap[2]. Under-employment state arises due to aggregate demand shortage. As discussed in Mitchell, Wray, and Watts (2019) sustained unemployment imposes significant social costs such as loss of current national output and income, skill loss, and so on. Therefore, it is valuable that full employment is realized in the short term.

We consider time required to realize full employment from a state of under-employment, and examine the debt-to-GDP ratio at the time when full employment is realized. The government increases its expenditure to accelerate the economic growth until full employment is realized. The extra growth rate (increasing rate) of the government expenditure over the ordinary growth rate (the growth rate of the full employment real GDP) depends on the target growth rate of real GDP over ordinary growth rate, the share of the government expenditure in real GDP, and the magnitude of multiplier effects. We show that a fiscal policy to realize full employment from a state of under-employment can reduce the debt-to-GDP ratio, and that the larger the extra growth rate (increasing rate) of real GDP by a fiscal policy is, the smaller the debt-to-GDP ratio at the time when full employment is realized is. Also we show that even if the marginal propensity to consume is very small (including zero), an aggressive fiscal policy can realize full employment without increasing the debt-to-GDP ratio.

In the next section we consider a steady state of continuous time debt dynamics, and analyze the effects of a fiscal policy to realize full employment. In Section 3 we present some graphical simulations based on plausible assumptions of variables. In Appendix we present a derivation of multiplier in a dynamic overlapping generations model according to Otaki (2007, 2009).

Let g be the growth rate of the full employment real GDP, ρ be the extra growth rate of real GDP over g by a fiscal policy (the growth rate of real GDP is

[1] According to J. Tanaka (2013) the first attempt to present a non-Walrasian overlapping generations model is Rankin (1986). He examined the effects of a permanent increase in public debt stock on capital accumulation.

[2] In another paper we have presented an analysis and a simulation of fiscal policy for full employment using a discrete time version of debt dynamics.

$g+\rho$) in a state of under-employment, and γ be the extra growth rate of the government expenditure over g by a fiscal policy (the growth rate of the government expenditure is $g+\gamma$). The main results are as follows.

1. The larger the value of ρ is, the faster the full employment state is realized. (Figure 1)

2. The larger the value of ρ is, the smaller the debt-to-GDP ratio at the time when full employment is realized is, that is, the more aggressive the fiscal policy is, the smaller the debt-to-GDP ratio at the time when full employment is realized is. (Figure 3)

The reason for this result is as follows. The smaller the value of ρ is, the longer the time we need to realize full employment is. On the other hand, as stated in 5 below (Proposition 1), the share of the government expenditure in real GDP at the time when full employment is realized does not depend on ρ. Therefore, when ρ is small, the accumulated budget deficit including burden of interest is large.

3. When the value of ρ is larger than the critical value, the fiscal policy to realize full employment reduces the debt-to-GDP ratio. (Figure 4)

4. By a fiscal policy, first the debt-to-GDP ratio increases, and then it decreases. (Figure 5 and 6)

5. The share of the government expenditure in real GDP at the time when full employment is realized does not depend on the values of ρ and γ. (Proposition 1)

6. Even if the marginal propensity to consume is very small, an aggressive fiscal policy can realize full employment without increasing debt-to-GDP ratio (Subsection 3.10).

The main conclusion of this paper is that full employment can be realized by an aggressive fiscal policy with smaller debt-to-GDP ratio than before the fiscal policy.

An increase in the government expenditure may induce a rise in the interest rate. Since the higher the interest rate is, the larger the debt-to-GDP ratio is (Subsection 3.9), we need an appropriate monetary policy which maintains the low interest rate[3].

2. Continuous time debt dynamics

We consider a continuous time version of debt dynamics. The variables are as follows.

c: marginal propensity to consume, $0 < c < 1$[4],
τ: tax rate, $0 < \tau < 1$,

$$\beta = 1 - c(1-\tau),\ 0 < \beta < 1,$$

[3] Of course, a rise in the interest rate may reduce the investment.

[4] About consumption functions in a dynamic Keynesian model please see Otaki (2007, 2009). In Appendix we present a derivation of multiplier by an overlapping generations model of consumption.

$Y(0)$: real GDP at time 0,
$Y(t)$: real GDP at time t, $t \geq 0$,
$Y_m(0)$: full employment real GDP at time 0,
$Y_m(t)$: full employment real GDP at time t, $t \geq 0$,

$$\zeta = \frac{Y_m(0)}{Y(0)}, \ \zeta > 1,$$

$\tilde{t}$: the time at which full employment is realized, $\tilde{t} > 0$,
$G(0)$: government expenditure at time 0,
$G(t)$: government expenditure at time t,
$T(0)$: tax revenue at time 0,
$T(t)$: tax revenue at time t,

$$\alpha = \frac{G(0)}{Y(0)},$$

$B(0)$: government budget surplus at time 0,
$B(t)$: government budget surplus at time t,

$$b(0) = \frac{B(0)}{Y(0)},$$
$$b(t) = \frac{B(t)}{Y(t)},$$

$D(0)$: government debt at time 0,
$D(t)$: government debt at time t,

$$d(0) = \frac{D(0)}{Y(0)},$$
$$d(t) = \frac{D(t)}{Y(t)},$$

d^*: the steady state value of $d(t)$,
g: the growth rate of the full employment real GDP, $g > 0$,
ρ: the extra growth rate of real GDP by a fiscal policy, $\rho > 0$,
γ: the extra growth rate of the government expenditure by a fiscal policy, $\gamma > 0$,
r: interest rate.

The unit of time is a year. We assume $g + \rho > r$.

Using approximations of exponential functions, we also show the following result (Proposition 2).

If the full employment state is realized within one year, $d(0)$ and $b(0)$ have the steady state values, and the propensity to consume c satisfies the following condition

$$c > 1 - \frac{2}{1-\tau} d(0),$$

then the debt-to-GDP ratio at the time when the full employment state is realized is smaller than that before the fiscal policy. If $d(0) > 0.5$, this condition is always satisfied for even very small (including zero) propensity to consume.

2.1. A steady state

First we examine a steady state of debt dynamics. At the steady state

$$Y(t) = e^{gt}Y(0), \qquad G(t) = e^{gt}G(0), \qquad T(t) = e^{gt}T(0).$$

Thus,

$$B(t) = T(t) - G(t) = e^{gt}B(0).$$

The derivative of $D(t)$ with respect to t is

$$D'(t) = rD(t) - B(t).$$

$D(t)$ is calculated as

$$\begin{aligned} D(t) &= e^{rt}D(0) - \int_0^t e^{r(t-s)}B(s)ds = e^{rt}D(0) - \int_0^t e^{r(t-s)}e^{gs}B(0)ds \\ &= e^{rt}D(0) - e^{rt}B(0)\int_0^t e^{(g-r)s}ds = e^{rt}D(0) - e^{rt}B(0)\left[\frac{e^{(g-r)s}}{g-r}\right]_0^t \\ &= e^{rt}D(0) - e^{rt}B(0)\frac{e^{(g-r)t}-1}{g-r}. \end{aligned}$$

$e^{r(t-s)}$ denotes a burden of interest between s and t. Since $Y(t) = e^{gt}Y(0)$,

$$\frac{D(t)}{Y(t)} = e^{(r-g)t}\frac{D(0)}{Y(0)} - e^{(r-g)t}\frac{B(0)}{Y(0)}\frac{e^{(g-r)t}-1}{g-r}.$$

Therefore, the debt-to-GDP ratio at time t is obtained as follows.

$$d(t) = e^{(r-g)t}d(0) - e^{(r-g)t}b(0)\frac{e^{(g-r)t}-1}{g-r}.$$

At the steady state

$$d(t) = d(0) = d^*.$$

Then,

$$d^* = \frac{0}{1-e^{(r-g)t}}\left[b(0)\frac{1-e^{(r-g)t}}{r-g}\right] = \frac{b(0)}{r-g}. \tag{1}$$

2.2. Fiscal policy for full employment

We assume that there exists a deflationary GDP gap, that is, $Y(0)$ is smaller than the full employment real GDP, $Y_m(0)$, at time 0. Then, $\zeta > 1$. Since $Y_m(t)$ increases at the rate g,

$$Y_m(t) = e^{gt}Y_m(0).$$

The government increases the growth rate of its expenditure from g to $g+\gamma$ to increase the growth rate of real GDP from g to $g+\rho$ so as to realize full employment. Then,

$$Y(t) = e^{(g+\rho)t}Y(0).$$

Suppose that at time $\tilde{t}$

$$e^{(g+\rho)\tilde{t}}Y(0) = e^{g\tilde{t}}Y_m(0),$$

that is, full employment is realized at $\tilde{t}$. Then, we have

$$e^{\rho\tilde{t}} = \zeta.$$

$\tilde{t}$ is obtained as follows.

$$\tilde{t} = \frac{\ln\zeta}{\rho}. \tag{2}$$

The larger the value of ρ is, the faster the full employment state is realized. Since $G(t)$ increases at the rate $g+\gamma$,

$$G(t) = e^{(g+\gamma)t}G(0).$$

We examine the relation between ρ and γ. The increase in real GDP over the ordinary growth is brought by the *multiplier effect* of an increase in the government expenditure over the ordinary growth. Therefore, we have the following relation

$$\frac{1}{\beta}\left[e^{(g+\gamma)\tilde{t}} - e^{g\tilde{t}}\right]G(0) = \left[e^{(g+\rho)\tilde{t}} - e^{g\tilde{t}}\right]Y(0).$$

This means

$$\frac{1}{\beta}\left(e^{\gamma\tilde{t}} - 1\right)G(0) = \left(e^{\rho\tilde{t}} - 1\right)Y(0).$$

And so

$$\frac{\alpha}{\beta}\left(e^{\gamma\tilde{t}} - 1\right) = e^{\rho\tilde{t}} - 1,$$

or

$$e^{\gamma\tilde{t}} = \frac{\beta}{\alpha}\left(e^{\rho\tilde{t}} - 1\right) + 1.$$

Since $\zeta = e^{\rho\tilde{t}}$,

$$e^{\gamma\tilde{t}} = \frac{\beta}{\alpha}(\zeta - 1) + 1.$$

Thus,

$$\gamma = \frac{\rho\ln\left[\frac{\beta}{\alpha}(\zeta-1)+1\right]}{\ln\zeta}. \tag{3}$$

$B(t)$ is the sum of the budget surplus growing by g from $B(0)$ and the budget surplus brought by the fiscal policy. It is written as

$$B(t) = e^{gt}B(0) + \tau\left(e^{(g+\rho)t} - e^{gt}\right)Y(0) - \left(e^{(g+\gamma)t} - e^{gt}\right)G(0).$$

The derivative of $D(t)$ with respect to t is

$$D'(t) = rD(t) - B(t)$$
$$= rD(t) - e^{gt}B(0) - \tau\left(e^{(g+\rho)t} - e^{gt}\right)Y(0) + \left(e^{(g+\gamma)t} - e^{gt}\right)\alpha Y(0).$$

Therefore,

$$D(t) = e^{rt}D(0) - B(0)\int_0^t e^{(t-s)r}e^{gs}ds - \tau Y(0)\int_0^t e^{(t-s)r}\left(e^{(g+\rho)s} - e^{gs}\right)ds$$
$$+\alpha Y(0)\int_0^t e^{(t-s)r}\left(e^{(g+\gamma)s} - e^{gs}\right)ds$$
$$= e^{rt}D(0) - e^{rt}B(0)\int_0^t e^{(g-r)s}ds - e^{rt}\tau Y(0)\int_0^t \left(e^{(g+\rho-r)s} - e^{(g-r)s}\right)ds$$
$$+e^{rt}\alpha Y(0)\int_0^t \left(e^{(g+\gamma-r)s} - e^{(g-r)s}\right)ds.$$

Since

$$Y(t) = e^{(g+\rho)t}Y(0),$$

we get

$$d(t) = e^{(r-g-\rho)t}d(0) - e^{(r-g-\rho)t}b(0)\int_0^t e^{(g-r)s}ds$$
$$-e^{(r-g-\rho)t}\tau\int_0^t \left(e^{(g+\rho-r)s} - e^{(g-r)s}\right)ds + e^{(r-g-\rho)t}\alpha\int_0^t \left(e^{(g+\gamma-r)s} - e^{(g-r)s}\right)ds$$
$$= e^{(r-g-\rho)t}d(0) - e^{(r-g-\rho)t}b(0)\left[\frac{e^{(g-r)s}}{g-r}\right]_0^t - e^{(r-g-\rho)t}\tau\left[\frac{e^{(g+\rho-r)s}}{g+\rho-r} - \frac{e^{(g-r)s}}{g-r}\right]_0^t$$
$$+e^{(r-g-\rho)t}\alpha\left[\frac{e^{(g+\gamma-r)s}}{g+\gamma-r} - \frac{e^{(g-r)s}}{g-r}\right]_0^t$$
$$= e^{(r-g-\rho)t}d(0) - e^{(r-g-\rho)t}b(0)\left[\frac{e^{(g-r)t}-1}{g-r}\right]$$
$$- e^{(r-g-\rho)t}\tau\left[\frac{e^{(g+\rho-r)t}-1}{g+\rho-r} - \frac{e^{(g-r)t}-1}{g-r}\right]$$
$$+e^{(r-g-\rho)t}\alpha\left[\frac{e^{(g+\gamma-r)t}-1}{g+\gamma-r} - \frac{e^{(g-r)t}-1}{g-r}\right].$$

Thus,

$$d(t) = e^{(r-g-\rho)t}d(0) - b(0)\left[\frac{e^{-\rho t} - e^{(r-g-\rho)t}}{g-r}\right] \tag{4}$$
$$-\tau\left[\frac{1-e^{(r-g-\rho)t}}{g+\rho-r} - \frac{e^{-\rho t} - e^{(r-g-\rho)t}}{g-r}\right] + \alpha\left[\frac{e^{(\gamma-\rho)t} - e^{(r-g-\rho)t}}{g+\gamma-r} - \frac{e^{-\rho t} - e^{(r-g-\rho)t}}{g-r}\right].$$

Let $t = \tilde{t}$. Then,

$$d(\tilde{t}) = e^{-\rho\tilde{t}}e^{(r-g)\tilde{t}}d(0) - e^{-\rho\tilde{t}}b(0)\left[\frac{1-e^{(r-g)\tilde{t}}}{g-r}\right] \tag{5}$$
$$-e^{-\rho\tilde{t}}\tau\left[\frac{e^{\rho\tilde{t}}-e^{(r-g)\tilde{t}}}{g+\rho-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right] + e^{-\rho\tilde{t}}\alpha\left[\frac{e^{\gamma\tilde{t}}-e^{(r-g)\tilde{t}}}{g+\gamma-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right]$$
$$= \frac{1}{\zeta}\left\{e^{(r-g)\tilde{t}}d(0) - b(0)\left[\frac{1-e^{(r-g)\tilde{t}}}{g-r}\right] - \tau\left[\frac{\zeta-e^{(r-g)\tilde{t}}}{g+\rho-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right]\right.$$
$$\left. +\alpha\left[\frac{e^{\gamma\tilde{t}}-e^{(r-g)\tilde{t}}}{g+\gamma-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right]\right\}.$$

From (5),

$$d(\tilde{t}) - d(0) = \frac{1}{\zeta}\left\{\left[e^{(r-g)\tilde{t}} - \zeta\right]d(0) - b(0)\left[\frac{1-e^{(r-g)\tilde{t}}}{g-r}\right]\right. \tag{6}$$
$$\left. -\tau\left[\frac{\zeta-e^{(r-g)\tilde{t}}}{g+\rho-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right] + \alpha\left[\frac{e^{\gamma\tilde{t}}-e^{(r-g)\tilde{t}}}{g+\gamma-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right]\right\}.$$

Because $e^{(r-g)\tilde{t}} - \zeta = e^{(r-g)\tilde{t}} - e^{\rho\tilde{t}} < 0$ by $g+\rho > r$ or $r-g < \rho$, (6) is decreasing with respect to $d(0)$. γ is obtained from (3), and $\tilde{t}$ is obtained from (2).

$\alpha = \frac{G(0)}{Y(0)}$ is the share of the government expenditure in real GDP at time 0. Real GDP grows at the rate $g+\rho$, on the other hand the government expenditure grows at the rate $g+\gamma$, and $\gamma > \rho$. The larger the values of ρ and γ are, the smaller the time necessary for realization of full employment is. The value of α at $\tilde{t}$ is denoted by

$$\alpha(\tilde{t}) = \frac{G(\tilde{t})}{Y(\tilde{t})} = \frac{e^{(g+\gamma)\tilde{t}}}{e^{(g+\rho)\tilde{t}}}\alpha = e^{(\gamma-\rho)\tilde{t}}\alpha.$$

From (2) and (3), we get

$$\alpha(\tilde{t}) = e^{\left(\frac{\ln\left[\frac{\beta}{\alpha}(\zeta-1)+1\right]}{\ln\zeta}-1\right)\rho\frac{\ln\zeta}{\rho}}\alpha = \frac{\beta(\zeta-1)+\alpha}{\zeta}.$$

This is constant, that is, it does not depend on ρ and γ. We have shown the following result.

Proposition 1 *The share of the government expenditure in real GDP at the time when full employment is realized does not depend on the values of ρ and γ.*

If $d(0)$ and $b(0)$ have the steady state values, that is, $b(0) = (r-g)d(0)$, then (6) is rewritten as

$$d(\tilde{t}) - d(0)|_{b(0)=(r-g)d(0)} = \frac{1}{\zeta}\{(1-\zeta)d(0)$$
$$\left. -\tau\left[\frac{\zeta-e^{(r-g)\tilde{t}}}{g+\rho-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right] + \alpha\left[\frac{e^{\gamma\tilde{t}}-e^{(r-g)\tilde{t}}}{g+\gamma-r} - \frac{1-e^{(r-g)\tilde{t}}}{g-r}\right]\right\}.$$

Suppose $\tilde{t} = 1$, that is, full employment is realized within one year. Then, with $e^{\rho} = \zeta$,

$$d(\tilde{t}) - d(0)|_{b(0)=(r-g)d(0)} = \frac{1}{\zeta}\{(1-\zeta)d(0) - \tau\left[\frac{e^{\rho} - e^{r-g}}{g+\rho-r} - \frac{1-e^{(r-g)}}{g-r}\right] + \alpha\left[\frac{e^{\gamma} - e^{(r-g)}}{g+\gamma-r} - \frac{1-e^{(r-g)}}{g-r}\right]\}.$$

We use the following approximation for exponential functions for small x;

$$e^{x} = 1 + x + \frac{1}{2}x^{2}.$$

Then, we obtain

$$d(\tilde{t}) - d(0)|_{b(0)=(r-g)d(0)} = \frac{1}{\zeta}\{(1-\zeta)d(0) - \frac{1}{2}\tau[(\rho+r-g)-(r-g)] + \frac{1}{2}\alpha[(\gamma+r-g)-(r-g)]\}$$
$$= \frac{1}{\zeta}\left[(1-\zeta)d(0) - \frac{1}{2}(\tau\rho - \alpha\gamma)\right]$$

We apply the following approximation to (3),

$$\ln x = x - 1,$$

and apply the following approximation to $\zeta = e^{\rho}$,

$$e^{\rho} = 1 + \rho.$$

Then, we get

$$\alpha\gamma = \beta\rho = [1 - c(1-\tau)]\rho, \qquad 1 - \zeta = -\rho.$$

Thus,

$$d(\tilde{t}) - d(0)|_{b(0)=(r-g)d(0)} = \frac{\rho}{\zeta}\left[-d(0) + \frac{1}{2}(1-\tau)(1-c)\right]$$

If

$$\frac{1}{2}(1-\tau)(1-c) < d(0),$$

we have $d(\tilde{t}) - d(0) < 0$. This condition is rewritten as

$$c > 1 - \frac{2}{1-\tau}d(0).$$

If $d(0) > 0.5$, this is always satisfied even if $c = 0$. We have shown the following result.

Proposition 2 *If the full employment state is realized within one year,* $d(0)$ *and* $b(0)$ *have the steady state values, and the propensity to consume* c *satisfies the following condition*

$$c > 1 - \frac{2}{1-\tau}d(0),$$

the debt-to-GDP ratio at the time when the full employment state is realized is smaller than that before the fiscal policy. If $d(0) > 0.5$, this condition is always satisfied for even very small (including zero) propensity to consume.

3. Graphical simulations

We present some simulation results. Assume the following values for the variables.

$$c = 0.5,\ \tau = 0.25,\ \alpha = 0.3,\ g = 0.025,\ r = 0.015,\ b(0) = -0.015 \text{ and } \zeta = 1.15.$$

We assume that g and r are constant, and $g > r$[5]. However, in Subsection 3.9 we examine a case where $r > g$. We do not assume that $d(0)$ and $b(0)$ have the steady state values described in (1). But, in Subsection 3.11 we consider a case where $d(0)$ and $b(0)$ have the steady state values.

3.1. Relation between ρ and $\tilde{t}$

In addition to the above assumptions we assume $d(0) = 0.45$, which is the debt-to-GDP ratio at the tome 0. Figure 1 represents the relation between ρ and $\tilde{t}$ which is the time at which full employment is realized. ρ is the extra growth rate of real GDP over g by a fiscal policy. As (2) suggests, the larger the value of ρ is, the smaller the value of $\tilde{t}$ is, that is, the faster the full employment state is realized.

Therefore, the more aggressive the fiscal policy is, the faster full employment is realized. For example, when $\rho = 0.05,\ \tilde{t} \approx 2.7$, when $\rho = 0.1,\ \tilde{t} \approx 1.4$.

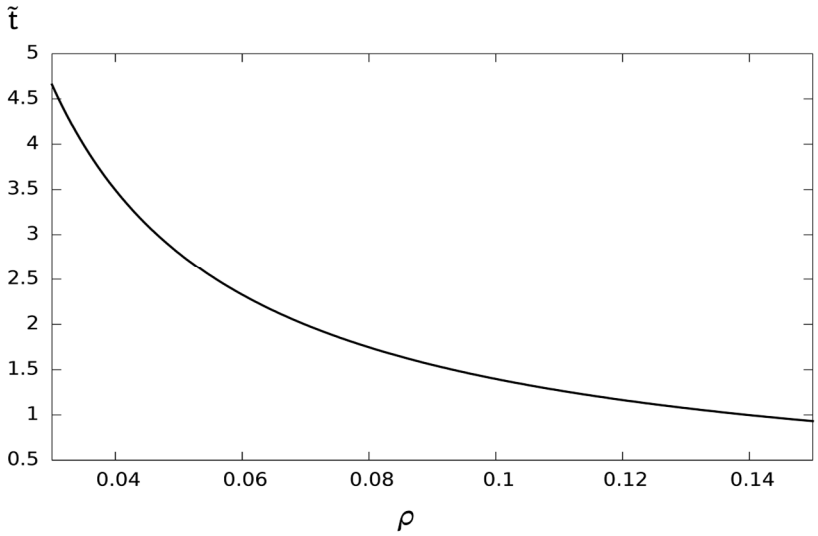

Figure 1: The relation between ρ and $\tilde{t}$

[5] In Mitchell et al. (2019) (pp. 357-358) it is stated that when $g > r$, there exists a stable steady state value of the debt-to-GDP ratio. Also see Wray (2016).

3.2. Relation between ρ and γ

Again we assume $d(0) = 0.45$. Figure 2 represents the relation between the value of ρ and the value of γ, which is the extra growth rate of the government expenditure by a fiscal policy, according to (3). The larger the value of ρ is, the larger the value of γ is. For example, when $\rho = 0.05,\ \gamma \approx 0.1$, when $\rho = 0.1,\ \gamma \approx 0.19$.

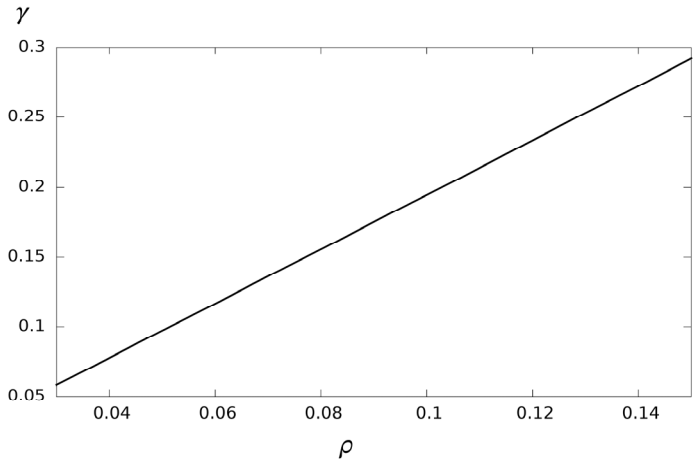

Figure 2: The relation between ρ and γ

3.3. Relation between ρ and $d(\tilde{t})$

We assume $d(0) = 0.45$. Figure 3 represents the relation between ρ and $d(\tilde{t})$, which is the debt-to-GDP ratio at the time when full employment is realized, according to (5). The larger the value of ρ is, the smaller the value of $d(\tilde{t})$ is, that is, the smaller the debt-to-GDP ratio at the time when full employment is realized.

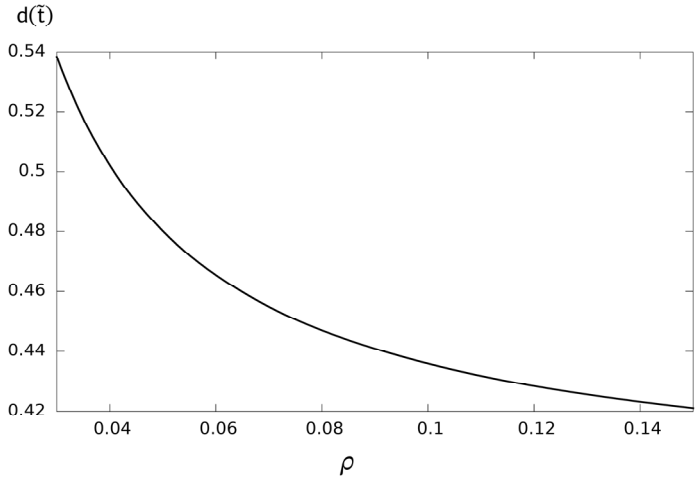

Figure 3: The relation between ρ and $d(\tilde{t})$

3.4. Relation between ρ and $d(\tilde{t}) - d(0)$

We assume $d(0) = 0.45$. Figure 4 represents the relation between ρ and $d(\tilde{t}) - d(0)$, which is the difference between the debt-to-GDP ratio at $\tilde{t}$ and that at $t = 0$, according to (6). The larger the value of ρ is, the smaller the value of $d(\tilde{t}) - d(0)$ is. If ρ is larger than about 0.072, the debt-to-GDP ratio at $t = \tilde{t}$ is smaller than that at $t = 0$, that is, the aggressive fiscal policy to realize full employment reduces the debt-to-GDP ratio.

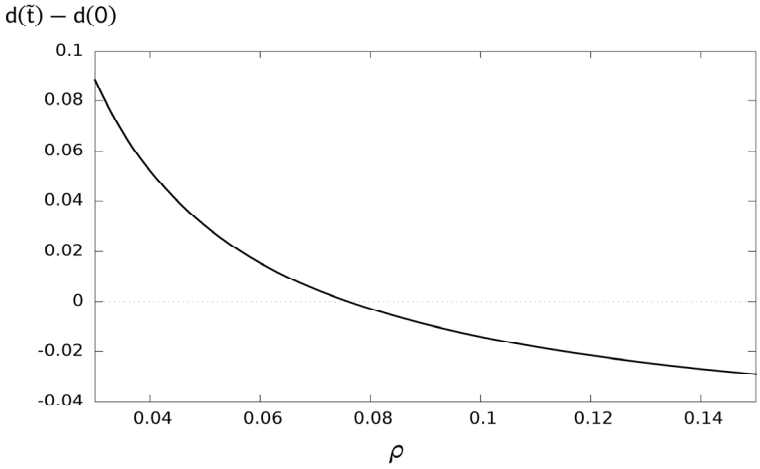

Figure 4: The relation between ρ and $d(\tilde{t}) - d(0)$

3.5. Relation between t and $d(t)$

We assume $d(0) = 0.45$ and $\rho = 0.085$. Figure 5 represents the relation between the time (t) and the value of $d(t)$, which is the debt-to-GDP ratio at the time t, according to (4). First $d(t)$ increases, then it decreases.

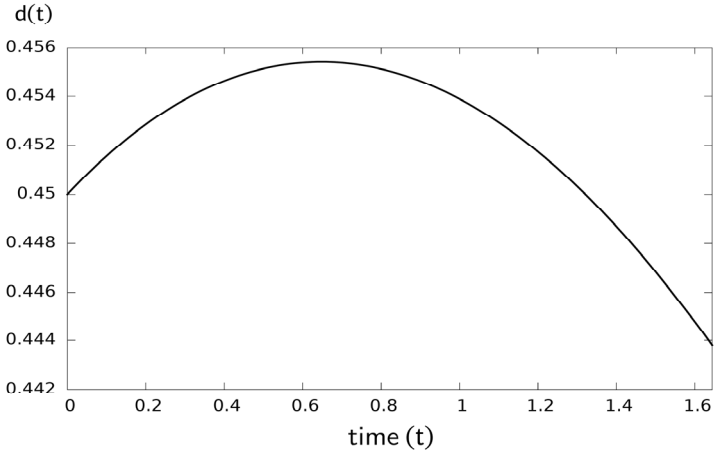

Figure 5: The relation between the time and $d(t)$

3.6. Relation between t and $d(t) - d(0)$

Again we assume $d(0) = 0.45$ and $\rho = 0.085$. Figure 6 represents the relation between the time (t) and the value of $d(t) - d(0)$. First $d(t) - d(0)$ increases, then it decreases.

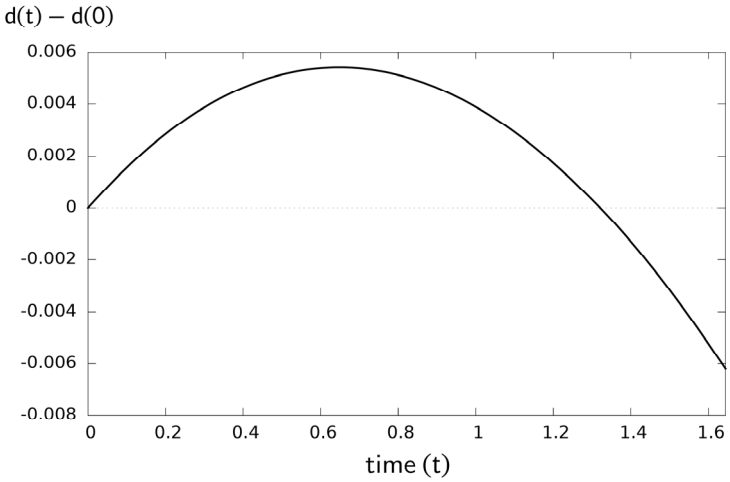

Figure 6: The relation between the time and $d(t) - d(0)$

3.7. Relation between $d(0)$ and $d(\tilde{t})$

We assume $\rho = 0.085$. Figure 7 represents the relation between the value of $d(0)$ and the value of $d(\tilde{t})$ according to (5). By (5) it is a straight line whose slope is smaller then one.

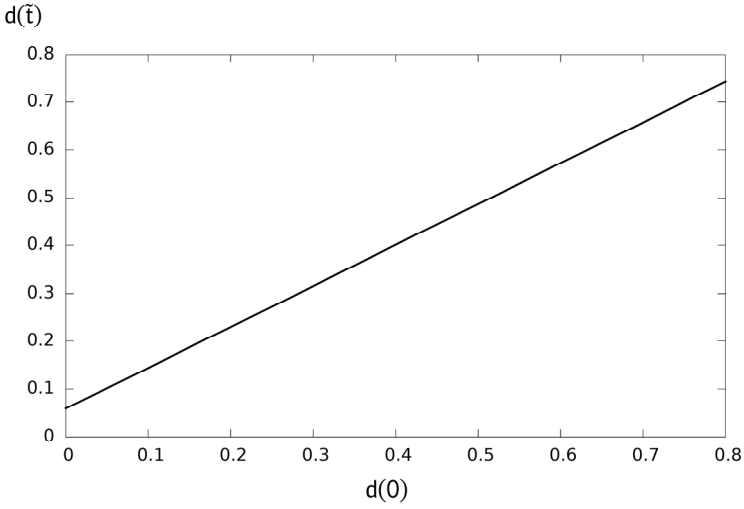

Figure 7: The relation between $d(0)$ and $d(\tilde{t})$

3.8. Relation between $d(0)$ and $d(\tilde{t}) - d(0)$

Again we assume $\rho = 0.085$. Figure 8 represents the relation between the value of $d(0)$ and the value of $d(\tilde{t}) - d(0)$ according to (6). By (6), since $e^{(r-g)\tilde{t}} < \zeta (= e^{\rho \tilde{t}})$, it is a straight line whose slope is negative.

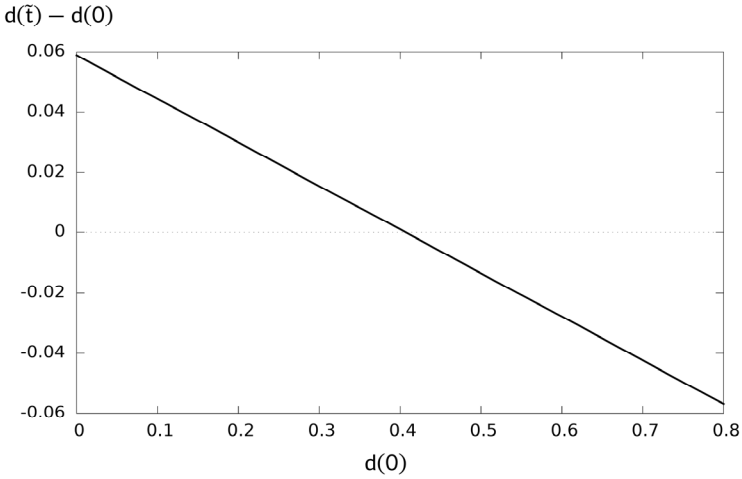

Figure 8: The relation between $d(0)$ and $d(\tilde{t}) - d(0)$

3.9. Relation between ρ and $d(\tilde{t}) - d(0)$ with low and high interest rates

We assume $r = 0.035$. The values of other variables are the same as those in the previous cases. In Figure 9 we compare the relation between ρ and $d(\tilde{t}) - d(0)$ in the case of low interest rate and that in the case of high interest rate.

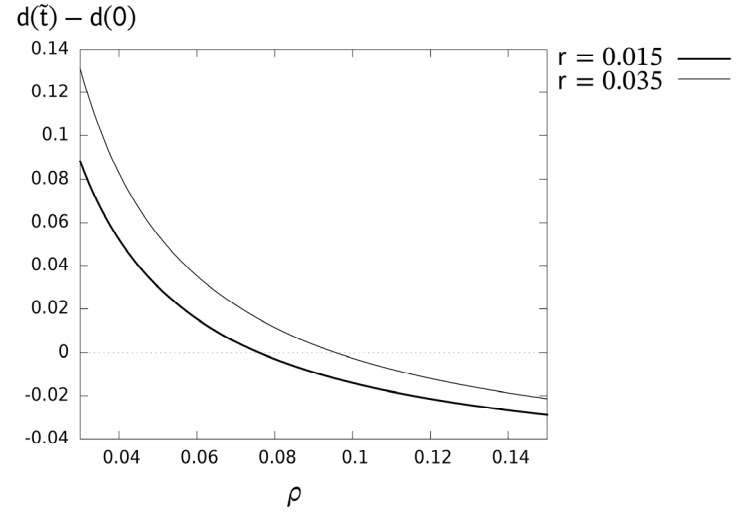

Figure 9: The relation between ρ and $d(\tilde{t}) - d(0)$ with low and high interest rates

With higher interest rate the debt-to-GDP ratio at the time when full employment is realized is less likely smaller than that at time 0 than the case with low interest rate.

3.10. Relation between ρ and $d(\tilde{t}) - d(0)$ with very small marginal propensity to consume

We assume $c = 0$. The values of other variables are the same as those in the previous cases. In Figure 10 we compare the relation between ρ and $d(\tilde{t}) - d(0)$ in this case and that when $c = 0.5$.

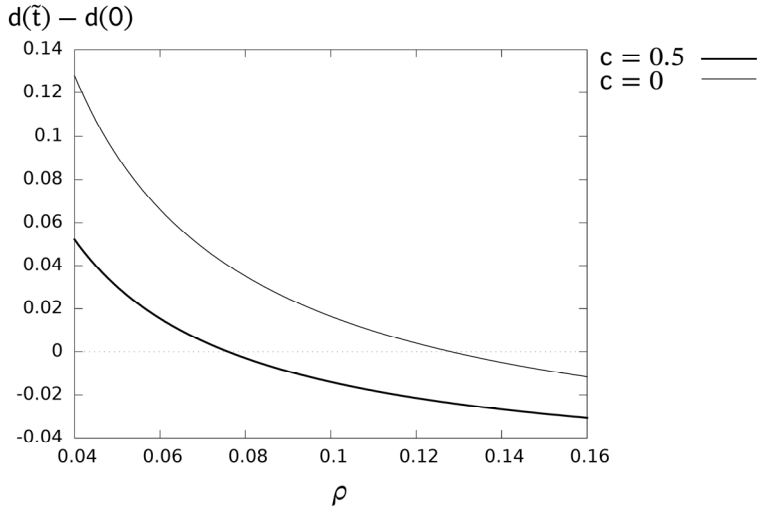

Figure 10: The relation between ρ and $d(\tilde{t}) - d(0)$ in the case where $c = 0$ and the case where $c = 0.5$

Even if marginal propensity to consume is very small, an aggressive fiscal policy can reduce the debt-to-GDP ratio at the time when full employment is realized.

3.11. Relation between ρ and $d(\tilde{t}) - d(0)$ when $d(0)$ and $b(0)$ have the steady state values

We assume $b(0) = (r - g)d(0)$. The values of other variables are the same as those in the previous cases. In Figure 11 we compare the relation between ρ and $d(\tilde{t}) - d(0)$ in this case and that $b(0) = -0.015$.

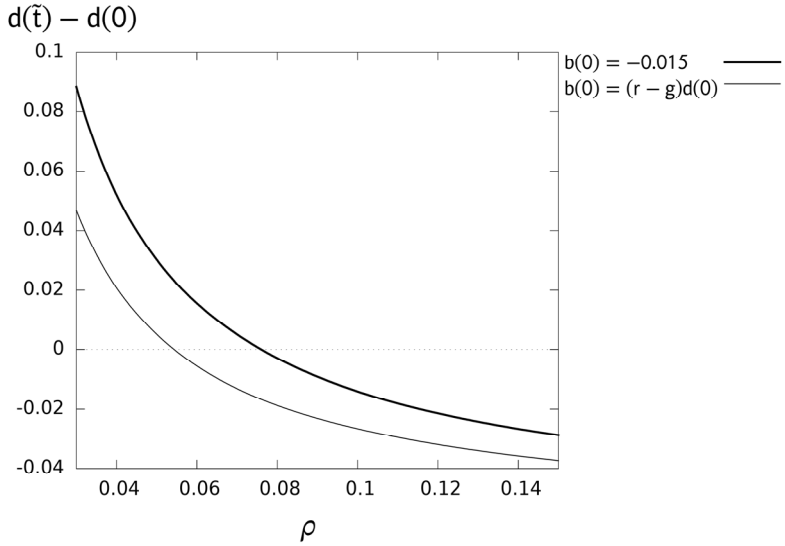

Figure 11: The relation between ρ and $d(\tilde{t}) - d(0)$ in the case where $b(0) = (r-g)d(0)$ and the case where $b(0) = -0.015$

If $d(0)$ and $b(0)$ have the steady state values, the debt-to-GDP ratio at the time when full employment is realized is more likely smaller than that at time 0 than the case where $b(0) = -0.015$. It is because $-0.015 < (r-g)d(0)$.

4. Concluding remarks

We have presented mathematical analyses and simulations of a fiscal policy which realizes full employment from an under-employment state without increasing the debt-to-GDP ratio than before the fiscal policy. We have shown the following results.

1. A fiscal policy to realize full employment from a state of under-employment can reduce the debt-to-GDP ratio.

2. The larger the extra growth rate (increasing rate) of real GDP by a fiscal policy is, the smaller the debt-to-GDP ratio at the time when full employment is realized is.

3. Even if the marginal propensity to consume is very small, by an appropriate fiscal policy we can realize full employment without increasing the debt-to-GDP ratio.

Also we considered a condition to realize full employment from a state of under-employment within one year without increasing debt-to-GDP ratio.

The main conclusion of this paper is that full employment can be realized by an aggressive fiscal policy with smaller debt-to-GDP ratio than before the fiscal policy.

Appendix: Derivation of multiplier by an overlapping generations model

We consider a two-period (young and old) overlapping generations model under monopolistic competition according to Otaki(2007, 2009). There is one factor of production, labor, and there is a continuum of goods indexed by $z \in [0,1]$. Each good is monopolistically produced by Firm z. Consumers are born at continuous density $[0,1] \times [0,1]$ in each period. They can supply only one unit of labor when they are young.

We use the following notations.

$c^i(z)$: consumption of good z at period i, $i = 1,2$.
$p^i(z)$: the price of good z at period i, $i = 1,2$.

$$X^i = \left\{ \int_0^1 c^i(z)^{1-\frac{1}{\eta}} dz \right\}^{\frac{1}{1-\frac{1}{\eta}}}, \qquad i = 1,2, \qquad \eta > 1.$$

ξ: disutility of labor, $\xi > 0$.
$0 < \alpha < 1$.
W: nominal wage rate.
Π: profits of firms which are equally distributed to each consumer.
L: employment of each firm and the total employment.
L_f: population of labor or employment at the full employment state.
y: labor productivity, $y \geq 1$.
δ is the definition function. If a consumer is employed, $\delta = 1$; if he is not employed, $\delta = 0$. The labor productivity is y, that is, y unit of the goods is produced by one unit of labor. The utility of consumers of one generation over two periods is

$$U(X^1, X^2, \delta, \xi) = (X^1)^\alpha (X^2)^{1-\alpha} - \delta\xi, \ 0 < \alpha < 1 \ .$$

With the budget constraint

$$\int_0^1 p^1(z)c^1(z)dz + \int_0^1 p^2(z)c^2(z)dz = \delta W + \Pi.$$

$p^2(z)$ is the expectation of the price of good z at period 2. The Lagrange function is

$$\mathcal{L} = (X^1)^\alpha (X^2)^{1-\alpha} - \delta\xi - \lambda \left(\int_0^1 p^1(z)c^1(z)dz + \int_0^1 p^2(z)c^2(z)dz - \delta W - \Pi \right).$$

λ is the Lagrange multiplier. The first order conditions are

$$\alpha (X^1)^{\alpha-1} (X^2)^{1-\alpha} \left\{ \int_0^1 c^1(z)^{1-\frac{1}{\eta}} dz \right\}^{\frac{\frac{1}{\eta}}{1-\frac{1}{\eta}}} c^1(z)^{-\frac{1}{\eta}} = \lambda p^1(z),$$

and

$$(1-\alpha) (X^1)^\alpha (X^2)^{-\alpha} \left\{ \int_0^1 c^2(z)^{1-\frac{1}{\eta}} dz \right\}^{\frac{\frac{1}{\eta}}{1-\frac{1}{\eta}}} c^2(z)^{-\frac{1}{\eta}} = \lambda p^2(z).$$

They are rewritten as

$$\alpha(X^1)^{\alpha}(X^2)^{1-\alpha}\left\{\int_0^1 c^1(z)^{1-\frac{1}{\eta}}dz\right\}^{-1} c^1(z)^{1-\frac{1}{\eta}} = \lambda p^1(z)c^1(z), \quad (7)$$

and

$$(1-\alpha)(X^1)^{\alpha}(X^2)^{1-\alpha}\left\{\int_0^1 c^2(z)^{1-\frac{1}{\eta}}dz\right\}^{-1} c^2(z)^{1-\frac{1}{\eta}} = \lambda p^2(z)c^2(z). \quad (8)$$

From (7) and (8) we obtain

$$\alpha(X^1)^{\alpha}(X^2)^{1-\alpha}\left\{\int_0^1 c^1(z)^{1-\frac{1}{\eta}}dz\right\}^{-1}\int_0^1 c^1(z)^{1-\frac{1}{\eta}}dz$$
$$= \alpha(X^1)^{\alpha}(X^2)^{1-\alpha} = \lambda\int_0^1 p^1(z)c^1(z)dz,$$

and

$$(1-\alpha)(X^1)^{\alpha}(X^2)^{1-\alpha}\left\{\int_0^1 c^2(z)^{1-\frac{1}{\eta}}dz\right\}^{-1}\int_0^1 c^2(z)^{1-\frac{1}{\eta}}dz$$
$$= (1-\alpha)(X^1)^{\alpha}(X^2)^{1-\alpha} = \lambda\int_0^1 p^2(z)c^2(z)dz.$$

Thus, we get

$$\frac{\int_0^1 p^1(z)c^1(z)dz}{\int_0^1 p^2(z)c^2(z)dz} = \frac{\alpha}{1-\alpha},$$

$$\int_0^1 p^1(z)c^1(z)dz = \alpha(\delta W + \Pi),$$

and

$$\int_0^1 p^2(z)c^2(z)dz = (1-\alpha)(\delta W + \Pi).$$

Therefore, the aggregate demand of the younger generation is

$$\alpha(\delta W + \Pi).$$

The total aggregate demand is

$$\alpha(WL + \Pi) + G + M.$$

G is the government expenditure and M is consumption by the old generation. Since in the model of this appendix the goods are produced by only labor, the investments by firms are zero. The aggregate supply is

$$P^1 Ly = WL + \Pi.$$

The profit of a firm is written as

$$\Pi = P^1 Ly - WL.$$

Since the aggregate demand and supply are equal,

$$P^1 Ly = \alpha P^1 Ly + G + M.$$

In real terms

$$Ly = \frac{1}{1-\alpha}\left(\frac{G}{P^1} + \frac{M}{P^1}\right).$$

Therefore, we get the multiplier $\frac{1}{1-\alpha} > 0$.

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A PANEL ARDL ANALSIS OF THE PRODUCTIVITY OF KEY ECONOMIC SECTORS CONTRIBUTING TO LOCAL ECONOMIC GROWTH IN AN EMERGING COUNTRY

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Abstract: It has become precise and indisputable that the South African economic growth has been stagnant. Despite this stagnant growth, the productivity of key sectors is supposed to alleviate some of the challenges of the South African economy. The aim of this study is to identify the key sectors that may assist in boosting economic growth at a local level. This study employed three estimators (PMG, MG and DFE) of a panel autoregressive distributed lag model (ARDL) to analyse the short- and long-run effects of various sectors' productivity on economic growth in a South African district. By employing annual data from 1996 to 2015, 6 sectors (construction, finance, trade, community service, manufacturing, transport, mining and tourism) from four municipalities in South Africa were analysed. Results show that the productivity of the construction, transport, trade, manufacturing and finance sectors influence economic growth positively in the long-run. However, the productivity of the mining and tourism sectors negatively affect economic growth in the long-run. Short-run results reveal that, in the short-run, the productivity of all sectors, except trade and transport, contribute positively to local economic growth. This study recommends that the government improves the production methods and invests in infrastructure and skills development to advance the productivity of the mining and tourism sectors.

JEL classification: O12, R11;

Keywords: Local economic growth; productivity; economic sectors; Panel ARDL

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1. Introduction

In most emerging economies, the economic activities tend to be concentrated in major cities and urban areas, leaving small towns and rural areas with low economic growth. As a result, there is an unbalanced level of economic development across different regions of developing countries. To address, such disparity in regional development, Local Economic Development (LED) has been identified as one of the strategies that can be implemented to boost economic growth at a local level. One of the LED roles is to promote sustainable growth of the sectors that are considered to be important in contributing to local economic growth in a specific area. Thus, the identification of such key sectors requires a detailed analysis of the productivity of each sector. However, this may not be an easy task due to structural changes that require shifting the factors of production from sectors considered to be traditional to modern sectors that are characterised by high productivity (Todaro and Smith, 2006). Hence, this study aims to identify the effect of sectoral production on local economic growth in a South African district.

For the past few decades, South Africa has been faced with the conundrum of stagnant economic growth. The low average economic growth rate of 2 percent since independence in 1994 illustrates this assertion (Statistics South Africa, 2018). This average economic growth of 2 percent is below South Africa's prescribed economic growth target of 5 percent (Trading Economics, 2018). Thus, this stagnant growth has contributed to low investor confidence, subsequently, hindering the country's economic development. In a bid to solve this problem, the South African government has developed certain policies that seek to address this obstinate problem. These policies include the Reconstruction and Development Programme, the Growth, Employment, and Redistribution strategy and the Accelerated and Shared Growth Initiative (Karriem and Hoskins, 2016). However, these policies have not been effective as expected. Since these policies did not yield favourable results, researchers such as Marwa and Zhanje (2015) and Mongale (2017) were probed to investigate further on the possible causes of stagnant growth. These researchers reached a general consensus that stagnant growth has been mainly caused by the global financial crisis, depreciation of the rand and low productivity of the main economic sectors (National Treasury, 2018). Of particular interest is that policy partners identified the productivity of key economic sectors as one of the major solutions to South Africa's slow economic growth and urged all the stakeholders to take initiatives to improve the productivity of these sectors in the Capricorn District Municipality (Statistics South Africa, 2018). Firstly, the Capricorn District Municipality is one of the district municipalities with the worst economic growth in South Africa. In this light, World Insight (2018) reports an average economic growth of 0.8 percent in the district, which is below other municipalities and with a national average economic growth of 2 percent. Furthermore, there seems to be a lack of studies done in the study area, specifically on this topic. Given the stagnant economic growth in the region and the lack of econometric empirical studies in the region, this study seeks to conduct an econometric empirical analysis to identify the key economic sectors that can assist in boosting local economic growth in the Capricorn District Municipality.

Noteworthy is that the productivity of key sectors is the catalyst for economic growth. This notion is influenced by three main economic theories: the structural change model (Kacar et al., 2016), the neoclassical theory (Todaro and Smith, 2006) and Kaldor's theory (Kaldor, 1966). The aforementioned theories affirm that all the resources should be channelled to modern sectors to improve the productivity of the sectoral output, subsequently, influencing economic growth (Kaldor, 1966). One point to note is that economic growth can be better improved at a micro level as compared to a macroeconomic level. Therefore, municipalities need to identify the key sectors that improve local economic growth so as to channel resources to such key sectors. Furthermore, there are other studies that have investigated the impact of the productivity of the key economic sectors on economic growth at local/micro levels (Rodgerson, 1996; Sol Plaatje, 2008 and Musakwa, 2009). For example, Rogerson (1996) investigated the sectors that improved economic growth using interviews in the Free State province. The participants identified the manufacturing sector as the major contributor to economic growth in Mangaung local municipality. Furthermore, in the Sol Plaatje Local Municipality (2008), a survey was also carried out to identify the major sectors contributing to economic growth. The survey established the agriculture, manufacturing and tourism sectors as the major contributors to economic growth in Sol Plaatje Local Municipality.

Over the past two decades, the productivity of sectors has been fluctuating. Generally, sectors such as the community service sector, construction sector, tourism sector, manufacturing sector and transport sector have constantly shown an upward trend (Statistics South Africa, 2019). The growth in the aforementioned sectors has been attributed to several factors. Among the reasons for this growth are the grants given to firms in these sectors, the relatively lower borrowing rate, the increase in exports that was also used as inputs in other key sectors (National Treasury, 2019; Statistics South Africa, 2019). It is essential to note that these sectors have also experienced some downturn due to the weak demand for local goods and the depreciation of the South African Rand. On the other hand, the mining and tourism sectors have faced a downward trend due to load shedding and political uncertainty. These fluctuations have given researchers the latitude to analyse how productivity growths contribute to economic growth.

Notably, there is no consensus about which sectors should be regarded as important for economic growth. Instead, the studies conducted on the productivity of the key sectors promoting economic growth in South Africa have yielded mixed results (Baur, 2014; Gwenhure and Odhiambo, 2017; Machaka, 2012; Ndabeni et al., 2019). It is also important to note that all these studies employed qualitative research methods such as focus groups and interviews. As such, there is a limited empirical framework, especially one that is based on econometric analysis and the use of focused historical data towards the identification of these sectors. Therefore, this study aims to contribute to this research lacuna by analysing the productivity of key sectors and their contribution to economic growth using the panel analysis and more recent econometric techniques – panel autoregressive distributive lag (ARDL) model. This method of analysis allows researchers to analyse the impact of the productivity of sectors on economic growth both

in the short-run and long-run. The panel ARDL is beneficial because it simultaneously estimates short- and long-run dynamics; it accommodates different orders of integration namely, I(0), I(1) or a or mixture of I(0) and I(1) variables as long as none of the variables are I(2); and it also accommodates a different number of lags on each variable (Duasa, 2007; Pesaran et al., 2001).

The rest of the paper is organised as follows. Section two reviews the literature available in this discipline, and section three explains the methodology. Sections four and five discuss the empirical results and conclusions.

2. Literature review

The accessible writings on economic growth and the productivity of the key economic sectors provide profound insight into local development economics. The theories that link up the local economic growth and the productivity of key economic sectors are the neoclassical theory, structural change model and the Kaldor's theory. The neoclassical theories propose that all the factors of production should be invested in sectoral growth (Kacar et al., 2016). The theory experts propound the argument that labour and capital should be available in every sector to improve both productivity and local economic growth (Kacar et al., 2016). The central aim of this theory is to allow all the factors of production to flow without limitations so that the region's economic systems move to equilibrium. Therefore, growth in the local economy improves as the productivity of each sector in the municipality improves.

Contrary to the neoclassical theory, the structural change model's focal point is on modern sectors (Dang and Pheng, 2015). In other words, it shifts the focus from traditional sectors to modern sectors such as the manufacturing, service, tourism and trade sectors. Therefore, the structural change model calls for labour and capital to be shifted from traditional sectors to modern sectors. Todaro and Smith (2006) reinforce the idea of shifting the factors of production because modern sectors are characterised by high productivity. Thus, these sectors contribute more output to economic growth. It is important to note that the success of this theory depends on the capital accumulation of the modern sector (Todaro and Smith, 2006). In other words, for a municipal area to improve its sectors productivity, the modern sectors should invest in capital accumulation.

On the other hand, Kaldor's approach focuses on the positive relationship between the productivity of the manufacturing sector and economic growth in a region. Such a relationship branches into three laws. The first law pertains to a positive relationship between manufacturing and economic growth (Kaldor, 1966). The second law stipulates that an increase in the productivity of the manufacturing sector increases employment and the third law stipulates that the manufacturing growth positively affect other economic sectors. However, for the purposes of this study, attention will be given to the first and third laws only as these laws are directly linked to economic sectors and economic growth. The first law emphasises that the productivity of the manufacturing sector influences local economic growth positively (Kaldor, 1966). The Kaldor approach has received wide attention from researchers as they share the same sentiments that

manufacturing is the engine for economic growth (Garidzirai et al., 2019 and Zhanje, 2018). Thus, the increase in the productivity of the manufacturing sector also increases local economic growth. The third law outlines that the growth of the manufacturing sector will eventually positively influence other key economic sectors and improve local economic growth. Hence, Kaldor's theory is one of the relevant theories for the region as there are many manufacturing activities in the Capricorn District Municipality.

The effect of the productivity of key economic sectors on economic growth cannot be isolated from the previous empirical literature. It is important to note that there is a scarcity of empirical literature on the subject under investigation. The few studies on this topic include Department of Social Welfare (2003), Stiftung (1999), Rogerson (1996), Musakwa (2009) and Sol Plaatje Local Municipal (2008). For example, a study done in a municipality in Europe investigated the relationship between tourism and local economic growth in Consiglio municipality (Pedrana, 2013). The author used a unique Pike, Pose and Tomaney development model and found that tourism is the major contributor to local economic growth. In South Africa, similar results were found by Stiftung (1999) who conducted a similar study but focused on the Mangaung municipality. The major difference between these studies was the methodology used as the latter used a survey as opposed to the Pike, Pose and Tomaney development model used by the former.

Another study on a local municipality was conducted by Nel and McQuaid (2002). The authors investigated the impact of key economic sectors on economic growth in the Stutternheim local community. They used formal interviews and found that the service and the Small-Medium Micro-Sized Enterprises sectors were the major contributors to local economic growth. Other sectors that contributed to improving economic growth included the trade and tourism sectors. In Mogalakwena Local Municipality (2006), a study was undertaken to investigate sectors that improve the living conditions in the area. The study used a Local and found that the finance sector, trade sector, government sector and mining sector were the major contributors to economic growth. Another study that used the same topic and methodology but found different results was that of the Molemole Local Municipality (2011). This study used a Local Economic Potential Analysis and found that the agriculture sector is the vehicle to local economic growth. The aforementioned studies produced different results due to different sizes of the municipalities and the different economic structures.

A study by Musakwa (2009) employed a questionnaire to identify the key economic sectors contributing to the local economic growth in the Clarens and Smithfield community. The study identified the tourism and agriculture sector as the main contributors to economic growth in those municipal areas. Lastly, Sol Plaatje Local Municipality (2008) used a survey to investigate the major sector contributors to local economic growth. The study found that manufacturing, agriculture and tourism were major contributors to local economic growth.

From the empirical literature, studies conducted on the impact of the productivity of key economic sectors on local economic growth have grown significantly, and the effect tends to differ across the different areas. Despite this growth, all these studies are based on a qualitative technique, which is mainly surveys, focus groups and interviews. It is important to note that the research methods used were subjective and based on

perception rather than reality. To limit the subjectivity, this study introduced a historical data-driven empirical analysis to shed more light on the topic. Specifically, the current study bridges this gap by providing a quantitative approach using a panel ARDL model. Pesaran et al. (1999) mention that the panel ARDL is consistent and produces robust results compared to other research methodologies.

3. Data and Model specification

This study followed a quantitative approach and employed secondary annual data from the Global Insight database. The data was for the Capricorn District Municipality that is composed of four municipalities, namely: Blouberg, Molemole, Lepelle-Nkumpi and Polokwane. This paper used a balanced panel data approach that consisted of two dimensions, namely, four cross-sectional dimension and twenty time-series dimension making a total of eighty observations. Panel data was employed as it gives precise results of the parameters under investigation (Hsiao et al., 2006). In the study, economic growth was used as a dependent variable, while the productivity of key economic sectors were independent variables. Economic growth was measured by GDP per capita, which is the aggregate number of goods and services in each municipality after taking into consideration the population of that municipality (Boulhol, 2008). On the other hand, independent variables include the productivity of community service, trade, manufacturing, construction, transport, finance, mining and the tourism sectors, measured using gross value added. Gross value added is the contribution measure of the economy in a city or region (Frechtling, 2013). This relationship can be expressed mathematically following the economic growth theoretical framework, and the model is specified as follows:

$$lgrowth = f(lcomus, ltrade, lmanuf, lconstr, lfin, ltour, lmin, ltrans) \quad (1)$$

Where *lgrowth* is the natural log of economic growth in the municipality, *lcomus* is the natural log of productivity in the community service in the municipality, *ltrade* is the natural log productivity in trade in the municipality, *lmanuf* is the natural log of productivity in manufacturing in the municipality, *lconstr* is the natural log of productivity in construction in the municipality, *lfin* is the natural log of productivity in finance in the municipality, *ltour* is the natural log of productivity tourism in the municipality, *lmin* is the natural log of productivity mining in the municipality, and *ltrans* is log of productivity in transport. All the variables in this study were expressed in logarithm form in order to estimate growth or elasticities. The next section discusses the method of estimation used in this study.

The method of estimation in this study includes a panel ARDL model. Before other econometric techniques, the unit root should be tested to check if the variables are stationary or not. For panel data, the Levin, Lin and Chu (2002), Breitung (2000), Perasan and Shin (2003), Maddala and Wu (1999) and Hadri (2000) panel unit root tests were recommended by the empirical literature. Noteworthy is that, the panel unit root tests outline the methodology to be used. For example, when one has a mixture of variables that are stationary at level (I(0)) and at the first difference (I(1)),

the panel ARDL is a suitable model to be employed. Three alternative panel ARDL approaches were estimated, namely; the Mean Group (MG), Pooled Mean Group (PMG) and Dynamic Fixed Effects (DFE). For robustness check, these approaches were compared to identify the best panel ARDL that accounts for the efficiency and consistency of the estimators. The best estimator among the three approaches was selected based on Hausman MG test. The estimated panel ARDL model estimation is shown in equation 2:

$$\Delta lgrowth_{i,t} = \emptyset_i\left(lgrowth_{i-t} - \beta_i X_{i,t-j}\right) + \sum_{j=1}^{p-1} \gamma\ {}_j^i\Delta\ (lgrowth_{i,t-j} + \sum_{j=0}^{q-1} \delta\ \Delta(X_i)_{t-j} + \mu_i + \varepsilon_{it} \quad (2)$$

Where *lgrowth* is economic growth in the Capricorn District Municipality Area, *X* denotes all the productivity of the key economic sectors in the Capricorn District Municipality Area while δ and γ represent the short-run coefficients of dependent and independent variables, respectively. The subscripts *i* and *t* stand for cross-section and time respectively, β stands for long-run coefficients while *u* stands for fixed effect and *e* is the error term. The last test to be conducted is the residual diagnostic test. The residual test confirms if the results are not spurious through the cross dependency. To test for cross-dependency, literature has prescribed the Pearson CD, Breusch-Pagan Chi-square and the Pearson LM normal tests (Ertur and Musolesi, 2017; Xu et al., 2016).

4. Results and Discussions

4.1 Panel Unit Root Results

The results of the unit root tests (in Table 1) show that the p-values of *lmin, lgrowth, ltour* and *ltrans* are less than 0.05, indicating that the null hypothesis for non-stationarity is rejected at a 0.05 significance level. Thus, it is concluded that economic growth, mining, tourism and transport sector are integrated of order zero or I(0). Since other variables were not stationary at levels, these variables were first differenced. The results for first difference show that *lcomus, lconstr, lfin, lmanuf* and *ltrade* p-values are less than 0.05, suggesting that these variables are stationary at first difference. The results of the panel unit root tests, therefore, show that there is mixture I(0) and I(1) but none of the variables is I(2). This confirms the use of panel ARDL model which is appropriate for a mixture of I(0) and I(1) variables. Muchapondwa and Pamhidzai (2011) emphasised the panel ARDL model as a new cointegration procedure. This is because, the panel ADRL model allows for the estimation of both the short-run and long-run relationships between the productivity of key economic sectors and local economic growth.

Table 1: Panel Unit Root Tests Results (P-values)

Variables	Level & 1st Diff.	Intercept/trend	LLC	IPS	ADF	Decision
Lcomus	Level	Intercept	0.6830	0.9723	0.8838	I(1)
		Interc. & trend	0.7991	0.3650	0.3627	
	1st diff.	Intercept	0.0000***	0.0000***	0.000***	
		Interc. & trend	0.0000***	0.0000***	0.000***	
Lconstr	Level	Intercept	0.9175	0.9929	0.978	I(1)
		Interc.& trend	0.2618	0.1432	0.2030	
	1st diff.	Intercept	0.0837*	0.0000***	0.000***	
		Interc. & trend	0.7147	0.0003***	0.002***	
Lfin	Level	Intercept	0.6964	0.9596	0.6766	I(1)
		Interc. & trend	0.0549	0.0823*	0.1274	
	1st diff.	Intercept	0.0023***	0.0047***	0.0122**	
		Interc. & trend	0.0149**	0.0571*	0.0996*	
Lmanuf	Level	Intercept	0.2365	0.9129	0.9102	I(1)
		Interc. & trend	0.0219**	0.1659	0.2302	
	1st diff.	Intercept	0.0000***	0.0000***	0.000***	
		Interc. & trend	0.0000***	0.0000***	0.001***	
Ltrade	Level	Intercept	0.1158	0.7332	0.4023	I(1)
		Interc. & trend	0.0044***	0.0423**	0.0510**	
	1st diff.	Intercept	0.0000***	0.0000***	0.000***	
		Interc. & trend	0.0032***	0.0000***	0.000***	
Lgrowth	Level	Intercept	0.070**	0.6443	0.6908	I(0)
		Interc. & trend	0.0000***	0.0000***	0.004***	
Lmin	Level	Intercept	0.0009***	0.0092***	0.0213**	I(0)
Ltour	Level	Intercept	0.0000***	0.0002***	0.000***	I(0)
Ltrans	Level	Intercept	0.0000***	0.000***	0.000***	I(0)

*Note: *, **, *** indicates 10%, 5% and 1% respectively*

4.2 Long-run Analysis

The panel ARDL results were estimated from the best model, ARDL (1, 1, 1, 1, 1, 1, 1, 1, 1), selected based on Akaike info criterion (AIC). Table 2 presents the long-run relationship between the productivity of key economic sectors and

economic growth (lgrowth) as estimated by the three estimators (PMG, MG and DFE). The panel ARDL model was estimated with intercept and trend. The Hausman test was used to test the null hypothesis (H_0) that the PMG estimator is efficient and consistent. The Chi-square p-value (0.326) from the Hausman test is greater than 0.05, meaning the H_0 cannot be rejected; implying that PMG is a more efficient estimator than MG and DFE. However, it should be noted that there seems to be no major difference between the results on these estimators, which confirms the robustness of the estimated results. Thus, the PMG long-run results are interpreted and discussed.

Table 2: Long-run Results

	MG		PMG		DFE	
Variables	**Coefficient**	**P-values**	**Coefficient**	**P-values**	**Coefficient**	**P-values**
Lcomus	0.2762	0.0002*	0.2959	0.0000*	0.1876	0.0016*
Lconstr	0.0629	0.0000*	0.0546	0.0000*	0.0397	0.0101**
Lfin	0.2896	0.00019*	0.3107	0.0000*	0.3107	0.0000*
Lmanuf	0.0731	0.2683	0.0404	0.3379	0.1052	0.1079
Lmin	-0.1503	0.0000*	-0.1314	0.0000*	-0.1293	0.0000*
Ltour	-0.0181	0.0004*	-0.0273	0.0000*	-0.0206	0.0001*
Ltrade	0.1745	0.0019*	0.1890	0.0002*	0.1801	0.0006*
Ltrans	0.2089	0.0028*	0.3160	0.0000*	0.3722	0.0000*
C	-4.26	0.0000*	-5.5	0.0000*	-4.09	0.0000*
Hausman test: Chi-square p-value = 0.326						

*Note: *, **, *** indicates 10%, 5% and 1% respectively*

The PMG results in Table 2 show both a positive and negative relationship between the productivity of the economic sectors and economic growth in the Capricorn District Municipal area. The study found that the productivity of the community service, construction, finance, transport and trade sectors have a positive effect on local economic growth. Thus, a 1 percent increase in the productivity of the community service sector, construction sector, finance sector, transport sector and trade sector leads to a 0.296 percent, 0.055 percent, 0.312 percent, 0.316 percent and 0.189 percent increase in economic growth, respectively. It is important to note that the transport sector and the finance sector were the most contributing sectors in the region. These empirical findings were consistent with the structural change model theory, which stipulates that modern sectors are ideal to economic growth (Todaro and Smith, 2006). Furthermore, the results are in line with the empirical literature by Mogalakwena Local Municipality (2006), which also found all these sectors to be positively related to economic growth.

On the other hand, the productivity of the tourism and mining sector showed an inverse relationship with economic growth. Quantitatively, if the productivity of the tourism sector increases by 1 percent, economic growth will decrease by 0.027

percent. This result was also concluded by Musakwa (2009). In addition, a 1 percent increase in the productivity of the mining sector leads to a 0.131 percent decrease in economic growth. The results show that mining productivity does not translate into local economic growth because such growth may not be reinvested locally. Furthermore, the growth of the mining sector may not lead to local employment as most of the growth may be generated through capital intensive production. In addition, the tourism sector factors of production may not be locally owned; hence any growth in tourism nay have benefited international owners instead of the locals. Noteworthy is that, the result of the manufacturing sector was not statistically significant. This means growth in the manufacturing sector does not contribute to local economic growth in long-run due to the fact that the sector is not well structured and the selected district is not a manufacturing hub. Noteworthy is that this finding is inconsistent with the first law of Kaldor (1966) that the productivity of the manufacturing sector influences local economic growth positively. Therefore, the long-run results support the structural change model (Dang and Pheng, 2015). This suggests that the focal point in the Capricorn District Municipality should be on modern sectors such as trade, transport and financial services.

4.3 Short-run Analysis

Having established the long-run relationship between the productivity of economic sectors and economic growth in the selected District, this section discusses the short-run results of the study. Thus, table 3 illustrates the short-run results of the Error Correction Model, estimated by the PMG, MG and DFE estimators. Following the selection of the PMG estimator in the previous section, the PMG short-run results are discussed and compared to the MG results for robustness check. The PMG results show a significant and negative error correction term (ECT) of -0.4879 and this is confirmed by the MG and DFE results that also report a significant negative ECT. This means that 48.79 percent of disequilibrium in the district municipal area is restored in the upcoming years provided the productivity of sectors respond positively. Thus, it takes 2.05 (1/0.4879) years for economic growth to move back to equilibrium (Bannerjee et al., 1998). This high Error Correction Term (ECT) shows that there is a stable relationship between economic growth and key economic sectors in all the municipalities. In the short-run, the tourism, mining, finance and manufacturing sectors were significant at one percent and positively related to economic growth. Noteworthy is that tourism and mining sector have a positive relationship with economic growth in the short-run but not in the long-run. This means that the two sectors contribute to economic growth in the short-run but not in the long-run. Manufacturing also has a short-run positive effect on economic growth and this result is different from the long-run. On the other hand, trade and transport sectors positively affect the economic growth in the long-run but do not have a significant short-run effect. The short-run results seem to be almost similar across the three estimators (PMG, MG and DFE) and this confirms that the estimated results are robust.

Table 3: Short-run results

	MG		PMG		DFE	
Variable	**Coefficient**	**P-values**	**Coefficient**	**P-values**	**Coefficient**	**P-values**
ECT	-0.3782	0.0401**	-0.4879	0.0330**	-0.4265	0.0372**
Δlcomus	0.0401	0.5112	0.0323	0.7665	0.1069	0.0912***
Δlconstr	0.0563	0.0000*	0.0404	0.0000*	0.0472	0.0000*
Δlfin	0.2019	0.0001*	0.2301	0.0000*	0.2183	0.0000*
Δlmanuf	0.0931	0.0000*	0.0727	0.0000*	0.1028	0.0000*
Δlmin	0.0873	0.0002*	0.0960	0.0000*	0.1102	0.0000*
Δltour	0.0109	0.0000*	0.0117	0.0000*	0.0136	0.0000*
Δltrade	0.2031	0.5213	0.1890	0.8500	0.3704	0.4813
Δlntrans	0.5098	0.2989	0.3160	0.3916	0.4875	0.3074
C	-4.875	0.0451**	-5.4991	0.0434**	-3.9687	0.0481**
@Trend	-0.0081	0.1201	-0.0093	0.1077	-0.0079	0.1232

*Note: *, **, *** indicates 10%, 5% and 1% respectively*

In addition to the comparison of the PMG, MG and DFE results for robustness check, the cross-section dependency test was used to check whether the study did not produce spurious results. This test also examines the presence of serial correlation. The diagnostic tests employed in this study were the Breusch-Pagan Chi-Square, Pearson LM normal and the Pearson CD tests. The results of all the diagnostics tests, in table 4, confirm that the model is stable and has not produce spurious results.

Table 4: Cross-sectional Dependency results

Test	**Probability**
Breusch-Pagan Chi-Square	0.0585*
Pearson LM	0.5328
Pearson CD	0.0772*

Note * represents 1 percent level of significance

5. Conclusion

This study investigated the productivity of key economic sectors as vehicles to local economic growth. The central aim of the study was to identify sectors contributing to local economic growth in the South African District Municipality of Capricorn. This study therefore aims to contribute to the diverse literature of economic growth and productivity of the key economic sectors at a local level and broaden the latitude for policymakers in the region. To achieve this objective, the study employed a panel ARDL model as the variables were integrated at order zero and order one. It is important to note that economic growth was used as a dependent variable while the productivity of the transport, finance, community service, mining, manufacturing, tourism and trade sectors

were used as independent variables. The results of the study showed that the transport sector, finance sector and community service sector contributed significantly to sustainable economic growth in the region. Thus, the region is moving from traditional sectors to modern sectors supporting the structural change model. It is important to note that only few studies found such relationship as many studies still subscribe to traditional theories, which support the traditional sectors. Since the results of the study are more inclined to the traditional sectors, it is important for authorities to adapt to change and focus on modern sectors for better local economic growth. Thus, local authorities should transfer factors of production from traditional sectors to modern sectors.

Conversely, the productivity of the mining and tourism sectors did not positively influence economic growth in the long-run. The study expected these two sectors to contribute to local economic growth significantly since there are some of the stronghold sectors in the region. Surprisingly, these two sectors influenced the economic growth in the short-run. The possible reason is that the mining sector and the tourism sector could have provided employment for a short period of time and failed to sustain employment in the long-run. Since tourism and mining influence economic growth in the short-run, policymakers should come up with the policies that govern the activities of the mining and tourism sectors. For instance, the government can consider subsiding firms in these sectors and also creating policies that encourage the reinvestment of mining proceeds to the local communities in order to promote local economic growth in the long-run. Furthermore, the government should invest in local skills development since economic sectors are constantly changing towards modern sectors that require capital accumulation. Moreover, the fiscal authorities may engage in infrastructure development to capitalise on the contribution of trade, transport and finance sectors, which require infrastructural investment. This is very important as the infrastructural development creates income, employment and improve economic growth through the multiplier process.

Even though the study achieved its aim, it has some limitations that should be noted. The study only focused on four municipalities of one district and this can be extended to more districts. Data availability also limited the sample period. Furthermore, the study did not include the qualitative aspect that can assist in identifying the challenges faced by key sectors in the selected district. Thus, future research can address these limitations in order to shed more light on the effect of sectoral production on local economic growth in South Africa.

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ANALYSIS OF THE FACTORS IMPACTING THE ONLINE SHOPPING DECISION-MAKING PROCESS

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Abstract. Selecting online the most suitable product or service can be a draining process, and the broad diversity of products on retailers' websites is overwhelming. Following this, there has been a high interest in examining buyers' motivations and recognizing the determinant factors that affect the decision-making process in the case of online shopping. Hence, in this article, we carried out an empirical study and we analyzed to what extent certain factors such as product features, confidence in the online shop, product reviews, product price, consumer evaluations, the trust of the sources, usability of the online shop, convictions and commitment to the brand, product notoriety, consumer loyalty programs, WOM, and eWOM influence the purchasing decision. The findings reveal that the most significant variables determining the acquisition decision are product features, confidence in the online shop, reviews of the product, product price, and evaluations of customers from trusted sources. The most relevant information resources are trustworthy websites that offer specialized product reviews and reliable websites that offer customer product reviews.

JEL classification: L81, M31

Keywords: Purchase decision, Online shopping behavior, Consumer decision-making process, E-commerce

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1. Introduction

Online shopping is increasingly being used widely as a way of purchasing products and services, becoming a popular medium in the world of the Internet. With its development, the Internet has begun to provide consumers with a range of information and options for comparing products, features, and prices. Also, it offers several variants of purchasing the desired products from different suppliers. Online shopping satisfies modern consumers looking for convenience and speed (Katawetawaraks and Wang, 2011). In the purchasing process, consumers search for product information online, analyze different assessments, and consider product reviews from other consumers. According to previous studies (Floyd *et al.*, 2014), over 70% of consumers say they trust online product reviews, and the use of online recommendations in decision making is increasing. The opinions posted online influence consumers' choices in a surprising variety of contexts such as airlines, telephony, tourism, movies, restaurants, or food ordering. Choosing the right product or service online can be an exhausting process, and the wide variety of products on retailers' websites is overwhelming. In this context, customer reviews have become a major source of information for online shopping customers, which greatly influences the purchase decision (Kostyra *et al.*, 2016). Also, the use of social media (Goodrich and de Mooij, 2014), word of mouth (WOM), electronic word of mouth (eWOM), and other sources of information have an increasing effect on the purchase decision.

In general, consumers often use the brand name of the product and the name of the store as a substitute for product quality. As a result, they reduce risks and simplify the purchase decision, especially when shopping online, where many product attributes cannot be directly examined. The brand image of the product influences consumers' perceptions of the product attributes, the evaluation of the attributes of a product may be influenced by the consumer's impression of the brand image. As a result, a strong and favorable brand image can positively influence consumers' impressions of product attributes. The image of the online store can have a similar effect, also preserving consumers' perceptions of product attributes (Aghekyan-Simonian *et al.*, 2012).

Consumers are increasingly seeking information, products, ratings, and buying items online through online stores. However, little is known about how these activities affect their level of trust, their attitude towards online selling, and their online shopping behavior. However, it is not clear enough how or to what extent the impact of the brand name or the store affects consumers' purchasing decisions. Recent research (Katawetawaraks and Wang, 2011; Floyd *et al.*, 2014; Kostyra *et al.*, 2016) shows a high interest in investigating consumer motivations and understanding the factors that influence the decision-making process in online shopping. Therefore, in this paper, we want to observe to what extent certain factors such as product characteristics, trust in the online store, reviews of the product by specialists/clients, product price,

opinions of customers, the trust of the sources, usability of the online shop, attitude and brand loyalty, product popularity, customer loyalty programs, WOM, and eWOM affect and influence the purchase decision.

2. Literature review

The online decision-making process for products or service purchase is complex and is influenced by several factors. In the following, we will briefly review the specialized literature that analyzes how different factors contribute to the selection process for different users of online commerce. The impact on which the brand image of the product and the online store on specific types of perceived risks, respectively online purchasing intentions, is studied by Aghekyan-Simonian *et al.(*2012). Thus, the results show that the brand image of the product influences consumers' online purchasing intentions, both directly and indirectly, by reducing various perceptions about risk. On the other hand, the image of the online store indirectly affects the purchase intentions by lowering the perceptions about the risk. Also, the impact of the image of the online store on the intention to buy online is less than that of the image of the physical store on the purchase intention for traditional stores.

The influence of the perceived quality of the product, the price and the risk, on the perceived value of the product, and the consumers' desire to buy products were studied by the existing literature (Kim, Xu and Gupta, 2012; Beneke *et al.*, 2013). The results (Beneke *et al.*, 2013) show that there are strong relationships between perceived relative price and perceived product value, as well as between the perceived product value and the desire to buy. There was a negative relationship between the perceived quality of the product and the perceived risk. The results indicate that establishing a value perception is essential in the buying process and it is suggested that the risk should be minimized through the optimal quality of the retail service. Moreover, according to previous studies (Kim, Xu and Gupta, 2012), the perceived price exerted a stronger influence on the purchasing decisions of loyal customers compared to that of the potential customers. Respectively, in the case of the perceived trust, it was found that it exerted a stronger influence on the purchasing decisions of the potential customers, compared to that of the loyal customers.

Katawetawaraks and Wang (2011) bring evidence that the online shopping decision-making process was offered by comparing offline and online decision making. Thus, the factors that motivate customers to decide whether or not to buy online were identified. It was found that the communication process and marketing strategies must be different in order to influence consumer decisions offline and online. The bottom line is that management needs to channel its resources to develop the online store, improve the website, and develop a different marketing strategy for the two environments. The cultural dimensions are used by Goodrich and de Mooij (2014) to compare the use of social media and other sources of information for consumer decision-making

in 50 countries. The results indicate that the use of information sources that influence online purchasing decisions varies widely by culture. Also, there are major differences in the behavior of online complaints, depending on the countries, due to cultural variations. Moreover, the results (Nadeem *et al.*, 2015) show that the quality of the website's services and the consumers' predisposition to use Facebook for online shopping directly and positively affect the consumer's confidence in an online store. Conversely, peer recommendations affect attitude directly, rather than indirectly through trust. Also, peer recommendations have a significantly stronger influence on female attitudes than on men's attitudes.

Word of mouth (WOM) (Goodrich and de Mooij, 2014) involves communication between family, friends, and different people. This informal communication is directed to other consumers regarding the ownership, use, or characteristics of their goods, services, and sellers. The results showed that it has an effective influence on purchasing decisions. According to existing studies (Wang and Yu, 2017), the positive and negative valence of the WOM, the content of the WOM and the observation of the purchases of other consumers significantly affect the consumers' intention to buy a product, thus increasing the probability of buying and sharing product information with other websites. According to WOM, the concept of electronic word of mouth (eWOM) (Goodrich and de Mooij, 2014) also appeared, which is a form of WOM that has become increasingly popular with the development of social media. It offers opportunities for sending messages that can be directed from an individual to many online consumers and has an increasing influence on the decision-making process.

Chen *et al.* (2016) show that the online information about brands from eWOM, neutral/third parties and manufacturer/retailer has a positive impact on customers' attitudes towards the brand and the purchase intention for that brand. Moreover, the source of eWOM is likely to be perceived as more useful by customers with a high sensitivity to informational influence than neutral/third-party and the manufacturer/retailer sources. In contrast, all three sources of brand information are considered useful by consumers with low susceptibility to informational influence. Moreover, López and Sicilia (2014) find that both the customers that seek opinions and those that provide opinions predict the influence of eWOM on the purchase decision. Thus, the perceived reliability of the source partially mediates the correlation between the customers that seek opinions and the influence of eWOM on decision making. In contrast, the perceived reliability of the source mediates the correlation between customers that give opinions and eWOM influence on decision making. Therefore, the perceived trust of sources appears as an important factor in eWOM's influence on decision making for those who regularly express their opinion.

Motivating satisfied customers to share their experience has proven to be an essential strategy (Kostyra *et al.*, 2016), and customers should be encouraged to do so. Loyalty to the brand appears as a crucial factor that can protect the brands so that they are positively evaluated against others, based on online customer reviews. If loyalty comes from an emotional affinity with the brand and not from a functional belief,

then online customer reviews are more likely to be omitted during purchasing decisions, and social media offers many opportunities to strengthen the relationship between a brand and his audience. Moreover, according to Purnawirawan *et al.* (2015), sets of negative reviews that include few positive reviews have the strongest effect on perceived usefulness, while sets of positive reviews that include few or no negative reviews are most successful in influencing attitudes. Also, review valence has a stronger influence on perceived usefulness when reviews refer to experienced (rather than search) products and have a stronger influence on attitudes to unknown (rather than familiar) brands. Finally, the strongest influence of revision valence refers to recommendation intentions.

3. Data analysis and results

The research methodology is based on an empirical study of data collected using a questionnaire. The questionnaire was filled in via Google Forms and was completed by 140 people. After analyzing the specialized literature we made a series of descriptive statistical analyses. In the following, we will present in detail the results obtained. The respondents are between the ages of 18 and 48, with an average age of 22.7. Their gender distribution is 60.7% women and 39.3% men.

The distribution of preferences by gender for certain types of devices is graphically represented in Fig. 1. Thus, the preferred devices for online shopping are the 76.4% desktop. On the other hand, mobile devices are preferred only in a proportion of 23.6%. Depending on gender, there are significant differences ($p < 0.01$) regarding the devices on which online shopping is made. Consequently, the purchase of products from mobile devices is preferred among women, their percentage is 2.9 higher than that in men.

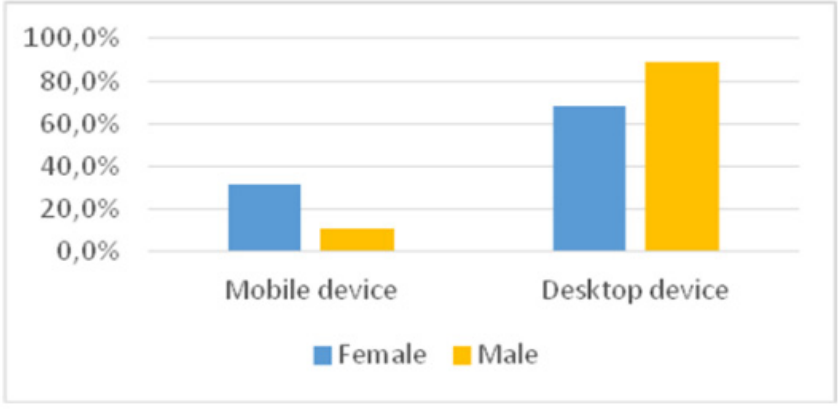

Figure 1: The preferred device for online shopping

In Fig. 2 we can see the distribution of the frequency with which online shopping is carried out. Thus, a percentage of 50.7% orders around 5-6 orders per year, 27.1% make about one order per month, and 13.6% make one order a year. Only 0.7% say they do not shop online. Depending on gender, it was found that there are no significant differences between men and women regarding the frequency with which they order goods and services online.

Information sources that users consult before deciding to purchase a product can be seen in Fig. 3. At the top of the most frequent sources of information is, with 25.7%, the trustworthy websites that offer specialized product reviews, followed by trustworthy websites that offer customer reviews, with 34.3%. On the other hand, the most unpopular sources of information are the official social media page of the brand and any websites that offer specialized product reviews, which are never consulted by 12.1%, respectively 11.4% of visitors.

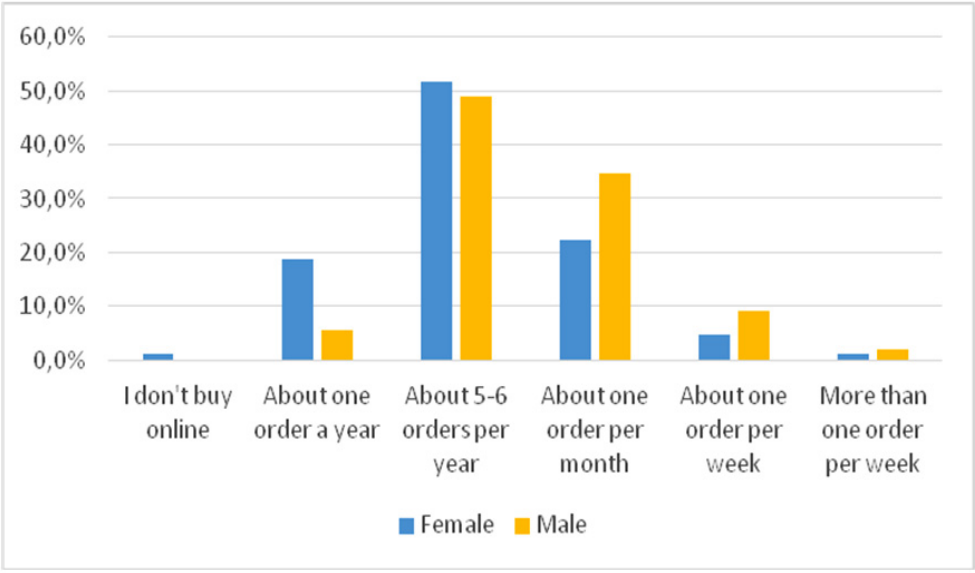

Figure 2: Frequency of ordering goods and services online

Trustworthy websites that offer customer product reviews are visited very often by 34.3% and often by 25.7% of the respondents. Trustworthy websites that offer specialized product reviews are consulted often by 44.3% and very often by 25.7%. The official website of the brand is sometimes accessed by 30.0% and often by 25.7%. The official social media page of the brand is often accessed by 32.1% and rarely by a significant percentage of 25.7%.

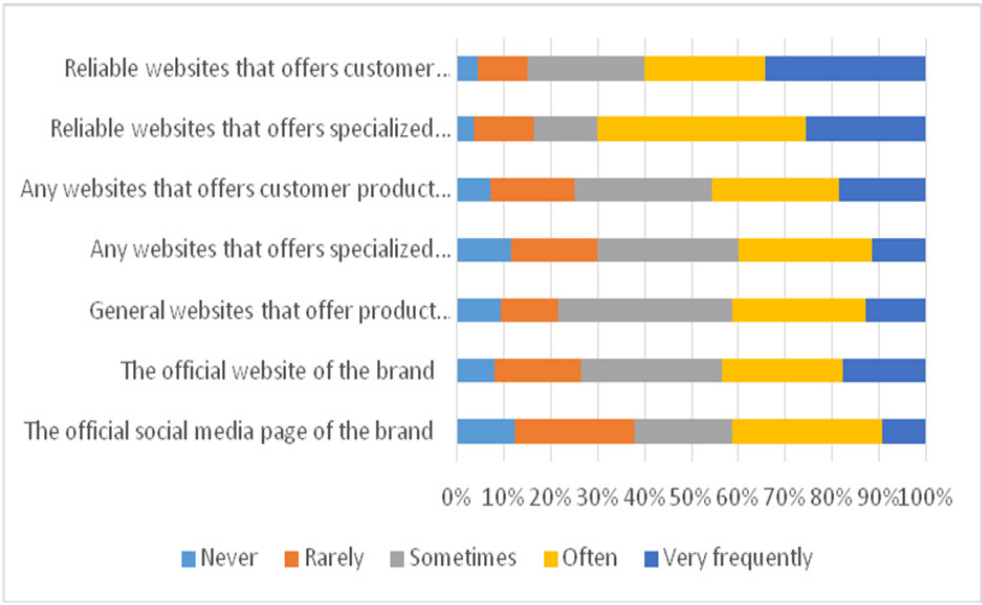

Figure 3: Information sources that users consult before making the decision to purchase a product

The factors influencing the purchase decision can be seen in Fig. 4. Those having the most influence in making the purchase decision are product characteristics, trust in the online store, and product price. They have a great influence on 62.1%, 42.1%, respectively 32.9% of the respondents. The factors with the least influence are WOM, eWOM, and customer loyalty programs. Of the respondents, 18.6%, 16.4%, respectively 14.3% said that they had very little influence in making the purchase decision. In the following, we will analyze each factor and the influence that the respondents consider to have in influencing the purchase decision. Their hierarchy can be seen in Table 1.

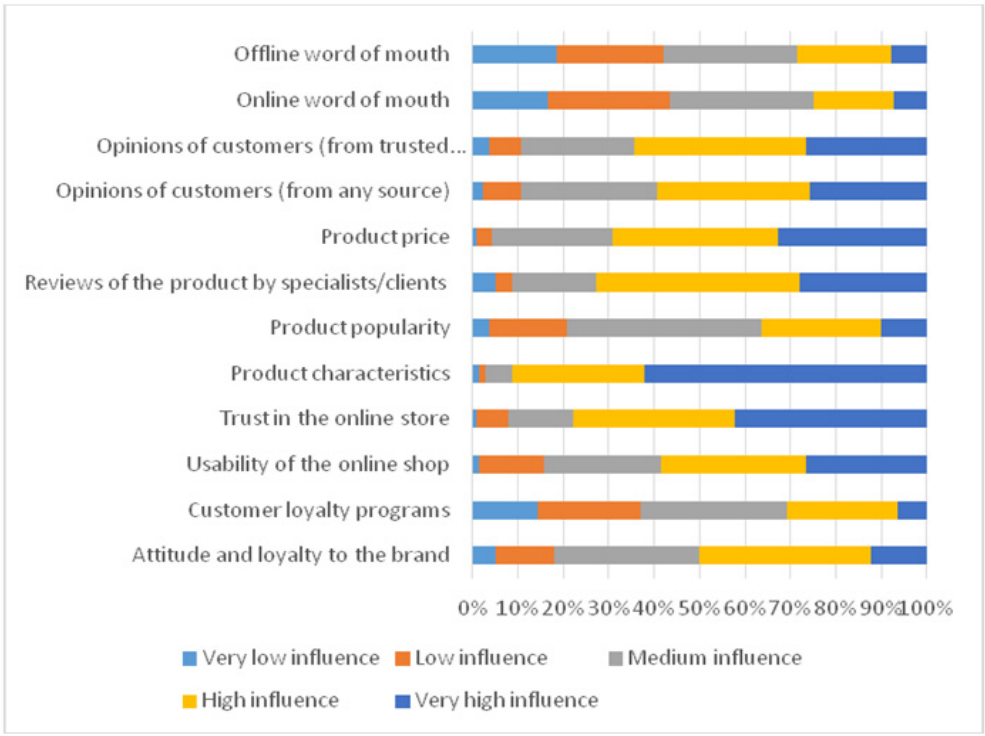

Figure 4: Factors influencing the purchase decision

Product price has a great influence on 36.4% of the respondents and a very great influence on 32.9%, gathered being 69.3%. Opinions of customers (from trusted sources are considered an important and very important factor for 64.3%, and opinions of customers (from any source for 59.3% of the respondents. The usability of the online shop is considered important and very important for 58.6%, attitude, and loyalty to the brand by 50.0% and product popularity by 36.4% of the respondents. The smallest impact in the purchase decision is customer loyalty programs, which are considered important and very important for 30.7%, WOM of 28.6%, and eWOM for only 25.0% of the respondents.

We can see in Fig. 5 the distribution of preferences regarding the store type from which the purchases of goods will be made. Thus, 57.1% from the site you find most reliable, 18.6% from the site that offers most detailed information, 15.7% from the site that offers you the lowest price.

Only 8.6% if possible, will buy the product only from the physical store. Depending on gender, it was found that there are no significant differences between men and women in terms of the store where shopping is made.

Table 1. The ranking according to the importance of the factors that influence the purchase decision

Influence factor	Influence / Importance
Product characteristics	91.4%
Trust in the online store	77.9%
Reviews of the product by specialists/clients	72.9%
Product price	69.3%
Opinions of customers (from trusted sources)	64.3%
Opinions of customers (from any source)	59.3%
Usability of the online shop	58.6%
Attitude and loyalty to the brand	50.0%
Product popularity	36.4%
Customer loyalty programs	30.7%
Offline word of mouth	28.6%
Online word of mouth	25.0%

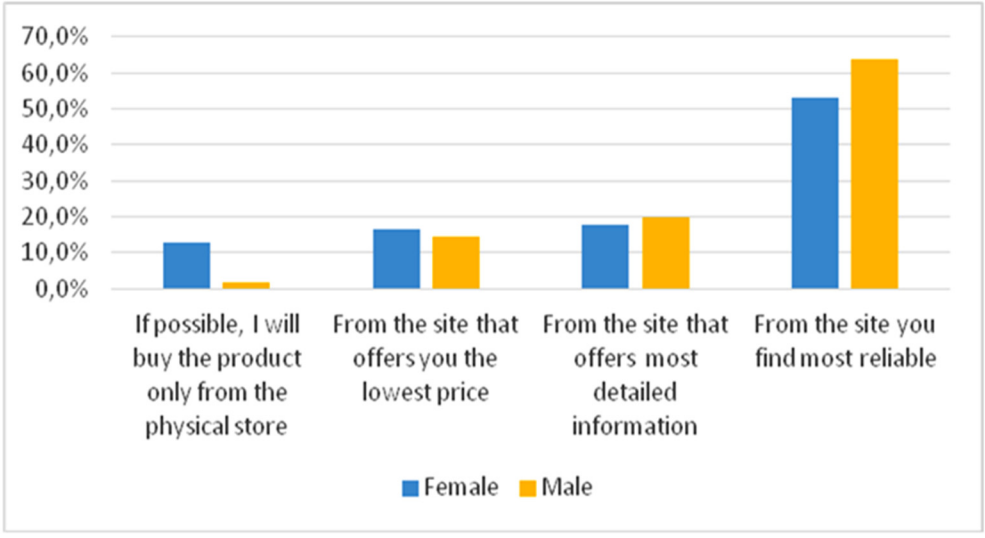

Figure 5: Preferences regarding the store type from which the order will be made

4. Discussions

In online and traditional commerce, demographics like age and gender are considered very important factors in marketing population segmentation (Blanca, 2011) (Meyers-Levy and Sternthal, 1991; Velaudham and Baskar, 2015). This study focuses on young people and explores the influence of gender to differentiate certain behaviors regarding the studied criterion.

The analysis revealed that, in the context of an Eastern-European country, desktop computers are most used as online purchasing tools than mobile devices. Also, on the segment of mobile device usage, women are more "abusive" than men. Similar behavior was found for online Nordic consumers in 2015, where women prefer using smartphones and tablets for shopping more often than men (49 percent of women and 36 percent of men) (Statista, 2020). This can be explained by the fact that being more analytical in online shopping activities than women (Kumaravel, 2017), men require larger screens and office or home comfort to perform various and complex comparisons since mobile devices are a bit limited from this point of view.

The number of annual online purchases increases in the younger population, but for the age range of our sample, there is not a clear distinction in shopping frequency behavior by gender. Our result is also confirmed by (Sramova, Blandina, Pavelka, 2019), that says there are not identified a significant difference in such a habit between men and women. However, this assertion may be applicable only at the global level, significant differences may occur in specific product and service categories (fashion, cosmetics, gadgets, etc).

This study shows that company/site trust and lower prices are the most important variables influencing the purchase decision. To search for a lower price represents a normal behavior for a rational consumer (Moore and Mathews, 2008; Kostyra *et al.*, 2016). The price reference is in many cases that one given by a physical store (Lo, 2014). However, the lowest price for a product cannot guarantee the success of the online purchase process completion. Site reputation contributes significantly to this success (Moore and Mathews, 2008; Aghekyan-Simonian *et al.*, 2012), but many other factors may intervene in this complex equation.

5. Conclusion

Online shopping is widely used as a way of purchasing products and services, becoming an increasingly popular means of everyday life. With its development, the Internet and social media have begun to provide consumers with many opportunities to compare products, features, and suppliers. Besides, it offers several variants of purchasing the desired products from anywhere in the world. Making the purchase decision for a product or service online is a complex process and is influenced by a lot of factors that have been analyzed in this research.

In this paper, we conducted a study in which we analyzed the influence of the main factors on the individual buyers' purchasing decision. The results showed that the preferred devices for online shopping are desktop. On the other hand, mobile devices are preferred among women, their percentage is 2.9 higher than that of men. Therefore, there are significant differences regarding the devices on which online shopping is made according to gender. The vast majority of respondents make online purchases around 5-6 orders per year, with no significant gender differences. The most important information resources are trustworthy websites that offer specialized product reviews and trustworthy websites that offer customer product reviews, without gender differences.

The most important factors influencing the purchase decision are product characteristics, trust in the online store, product reviews by specialists/clients, product price, opinions of customers from trusted sources, and opinions of customers from any source. On the other hand, the factors with the least influence are product popularity, customer loyalty programs, offline word of mouth, and online word of mouth. As for choosing the store from which to make the purchase, the large majority prefer from the site one finds most trustworthy, followed by the site that offers the most detailed information. For further research, given the struggle with the pandemic situation that kills not only people but also businesses, it is critical to continue exploring how buyers' behavior is influenced, including the online purchase.

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MILITARY EXPENDITURE AND MACROECONOMIC PERFROMANCE – THE CASE OF AN EMERGING COUNTRY

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Abstract: The study investigates the nexus between military expenditure and macroeconomic performance in Nigeria between 1980 and 2017. Data on military expenditure and some macroeconomic variables such as output (GDP), exchange rate and inflation rate are used in the study. The Vector Auto-regression technique VAR is applied so as to study the interactions among the variables in the short run. The result shows that military expenditure in Nigeria is significantly influenced by output and exchange rate shocks. It was also revealed that military expenditure does not make significant contributions to the behaviour of output in Nigeria. Military expenditure appears to be insulated against inflation shock since the largest chunk of military expenditure is traded in foreign currency hence less affected by domestic prices.

JEL classification: H19, H50, E00, E02;

Keywords: Output. Military Expenditure, Exchange rate and Inflation rate

1. Introduction

All over the world attention of development economists have been shifting towards researches on military expenditure in the recent years (Abbas & Wizarat, 2018; Odehnal, 2015). The reason behind this might not be unconnected to the fact the expenditure on the military usually constitute the largest chunk of total government expenditure in annual budgets of countries. In the developed countries expenditure on military often vary between 20% to 25% of the total annual budgeted government expenditure while in the developing countries on the average it ranges between 10% and 20% of the annual budget expenditure (UNICEF, 2018). In Nigeria, the percentage of military expenditure in the government budget rose from 12% in 2010 to about

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16% in 2014, the figure jumped to 18% in 2017 at the heat of insurgence attack on the country. However, the current military expenditure to the GD of Nigeria is about 0.43% compared to developed country like US with 4.8% (UNICEF, 2018).

This statistics underscore the importance of military expenditure across the globe and the situation is the same for Nigeria. The rising trend of military expenditure is becoming epidemic as it has spread across various economic blocs across the globe. In BRICS, both Brazil and China committed more money to the military within last one decade and making the percentage to rise by 5% and 4.6% in 2018 respectively for the two countries (Zhang, Liu & Wang, 2017). The issue of the relationship between military expenditure and macroeconomic performance is expected be a symbiotic (Anifowose, Adeleke, & Mukorera, 2019). According to their study, it is expected that a safe country guaranteed by sophisticated military apparatus is important for peaceful co-existence. This, according to them will create an enabling environment for economic activities to thrive and in the long run promote macroeconomic performance of the country.

However, with the rising expenditures on the military year by year in Nigeria and the attendant macroeconomic instability bedevilling the country often questions the role of military expenditure in performing the roles highlighted above.

Furthermore, an important reason for investing in the military is the fact that it will improve security and guarantee peace that will create an investment-friendly enabling environment, which will, in turn, engender sustainable economic growth and improve macroeconomic performance. These hypotheses have been supported by various kinds of literature and theories of economic development. (Keynes, 2016; Zhang, Liu, Xu, & Wang, 2017) from their models concluded that military expenditure might not promote economic growth as expected because an increase in military expenditures will only attract more external aggression that will hinder the growth process. However, countries across the globe appear not to be cognizant of these as military expenditure data show that military spending has been on the rise globally including Nigeria (Farzanegan, 2014).

A major gap in the literature which this paper intends to fill is the fact that previous studies in Nigeria have focused more on the impact of military expenditure on the growth of Nigerian economy alone without considering her macroeconomic performance in general which included growth. The reason behind this is that the linkage between military expenditure and economic growth can further be evident if other macroeconomic variables in the economy are brought into perspective.

Consequently, this study will fill this gap with the main objective of investigating the interactions between military expenditure and some macroeconomic variables such as output GDP, inflation rate and exchange rate. The rest of the paper is divided into the methodology, results and discussions as well as the conclusions.

2. Literature review

Zhao, Zhao, & Chen (2015) examined the military–growth nexus in China for the period of 1952 to 2012.They used an impulse response function based on vector

error correction model and granger causality technique. Their result revealed that there are two long-run relationships and that there exists a negative and unidirectional granger on growth.

Also Furuoka, Oishi, & Karim (2016) explored the impact of military expenditure on growth in China. They confirmed that the increase in military expenditure is mainly driven by Chinese economic development expansion for the period of 1989 to 2011. However, Meng, Lucyshyn, & Li's (2015) findings indicate that an increase in Chinese military expenditure has contributed to the expansion of income disparity in China from 1989 to 2012 using Granger approach.

Obasi, Asogwa and Nwafee (2018) examined the impacts of expenditure on the military on development of human capital in Nigeria. The study covers period spanning through 1970 to 2014. The methodology adopted is Auto-Regressive Distributed Lag ARDL. After some pre estimation and post estimation tests their results showed that military expenditure does not have significant positive impact on education which is one of the proxies of human capital in the study. However, the same military expenditure has significant negative impact on health component of human capital which is infant mortality rate. Based on the results, the study concluded that military expenditure does not have significant positive impact on human capital in Nigeria and it was recommended that government at all levels in Nigeria should improve their efforts on developing human capital in Nigeria.

In another perspective, introducing military expenditure variable as a proxy for capital intensiveness, (Kentor & Kick, 2008) military expenditure-growth debate for both developed and developing countries. Their result indicates that an increase in military expenditure per soldier leads to a significant reduction in gross domestic product per capita, especially in developed countries. Also, Smith and Tuttle (2008) revisit United States of America military expenditure-growth debate by employing Atesoglu's (2002) model. Their outcome indicates negative military expenditure effect on growth.

Applying the Keynesian hypothesis, Shahbaz & Shabbir (2012) revisit the milex-growth nexus using Pakistan as a case study. Their finding suggests that an increase in military expenditure slow-down the economic growth rate.

Wijeweera & Webb (2011) investigated the impact of expenditures on military on the growth of five South Asian Economies. The period covered 1988 to 2007 and the following countries were involved in the study, India, Pakistan, Nepal, Sri Lanka and Bangladesh. Panel cointegration analysis was applied. Findings from the study show that GDP rose by 0.04% after a unit increase in military expenditure. Consequently, it was concluded from the study that military expenditure contributed little to the growth of these economies

Faini, Annez, & Taylor (1984) further examined the impact of military expenditure on investment and growth of 69 countries from 1950 to 1972, employing the fixed effect model. Their result revealed that military expenditure has an adverse impact on economic growth and investment. Thus, military expenditure crowds out investment and retards economic growth for the countries under studied.

Deger (1986) examined military expenditure and investment relationship, where military expenditure was the independent variable and investment equations as the dependable variable. The result revealed the military expenditure coefficients

on investment equations are negative and statistically significant. Thus, military expenditure partly crowds out investment in emerging countries.

Knight, Loayza, & Villanueva (1996) investigated the military expenditure–investment nexus for 79 countries including control variables such as human capital proxy, war proxy and trade. Their result found an inverse relationship between military expenditure and investment, therefore, confirming the crowd out effect.

Feder (1983) re –examined the 3 sectors model on two group of countries (8 Asians and 16 Latin America). The pooled time series, cross sectional techniques was employed. Their result affirmed military expenditure and other expenditure do have direct positive impact on economic growth in Asian countries whereas military expenditure and non-military expenditure have a negative impact on the growth of Latin America countries.

Yildirim, Sezgin, & Öcal (2005) explore the military expenditure –growth relationship for Middle Eastern countries and Turkey, by employing the two-sector model they confirmed the military expenditure stimulate economic growth for the period of 1989-1999 and that military expenditure (industries) were more productive than the civilian sector.

Sezgin (2001) explored the impact of military expenditure, military size on economic growth using Turkey as a case study covering 1950-1993 by utilising the two-sector Feder model. They, however, expanded the two-sector model by incorporating human capital. Their result confirmed that both military size and size of military budgetary allocation does matter and positively impact on growth; however, the externality effect from the military sector was negative.

Reitschuler & Loening (2005) employed two-sector Feder model to empirically analysis the impact of military expenditure on the economic growth of Guatemala for the period of 1951-2001. The empirical analyses indicate that military expenditure threshold of around 0.33% of GDP is preferred and have a positive impact on growth whereas above the threshold of 0.33% military expenditure will have an adverse effect on growth. As regards the externality effect, they assert the military sector has less productivity and externality effects on the civilian sector.

Galvin (2003) investigated the military expenditure and economic growth relationship by employing a panel data analysis framework based on 2 SLS and 3SLS estimation technique. The result shows that military expenditure has a negative effect on the 64 countries economic growth and affirmed that military expenditure adverse impact is greater in middle-income countries and less in low-income countries.

In summary none of the study examined empirically investigated the relationship between military expenditure and macroeconomic performance of Nigeria as a country. this study among others as highlighted in the introduction will be filling these gaps.

3. Methodology

Vector–Autoregression (VAR) Model

Econometrics literature has identified VAR as a veritable means of studying the effect of shocks on economic variable in both short and medium terms (Elborne,

2007; Mordi & Adebiyi, 2010). Formulation of VAR model is strongly dependent on shocks identification in the VAR model and this often depends on the objectives of the researcher as well as literatures.

In this study we are interested in studying macroeconomic shocks effects on military expenditure and vice versa the resultant implication on the macroeconomic performance of Nigeria.

The macroeconomic variables used in these study are GDP, exchange rate and inflation rate. Other variables included in the VAR model are military expenditure and population. VAR models are seen as independent large scale macro econometric model that do not rely on unrealistic assumptions (Elbourne, 2007). The foremost theoretical framework of VAR analysis as proposed by Sims (1980) used Choleski decomposition to get impulse responses.

The construction of our VAR model follows the conventional method where the initial model is specified thus:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} +, \dots \dots \dots . + A_p y_{t-p} + \mu_t \text{ ....(1)}$$

where:

y_t represents an (nx1) vector containing n endogenous variables,

A_i(*i=1, 2,…, p)* are (n x n) matrices coefficients,

and μ_t is an (n x 1) vector containing error terms.

Though the error is $\mu_t \sim iid\ N(0, \Omega)$ but errors do possess tendency of correlating contemporaneously in all the equations.

There exist pn^2 Parameters in the A matrices. Equation 3.9 can be written in other form with the usage of the lag operator L which is selected through $L^k x_t = x_{t-k}$. the equation becomes:

$$A(L) y_t = \mu_t \text{..(2)}$$

where:

$$A(L) = A_0 L^0 - A_1 L^1 - A_2 L^2 - \cdots \dots \dots - A_p L^p \text{................(3)}$$

A_0= I (identity matrix) it is required that *A(L)* lies outside the unit circle for stationarity to be ensured.

The VAR model estimated for the purpose of this study is as follows;

$$GDP_t = [milexp_t, infr_t, exch_t, pop_t] \text{.................................(4)}$$

where GDP is the output, milexp is the military expenditure, infr is the inflation rate; exch is the exchange rate and pop is the population all at period t.

Both the impulse response function and the variance decomposition analysis is done to thoroughly examine the response of the fiscal variables to the identified shocks and also to assess the resultant effect on output growth of Nigeria.

Generalized Impulse Response Function for VAR

Furthermore, the analyses for the nexus between military expenditure and macroeconomic performance in Nigeria will be carried out using the impulse response functions and the variance decomposition of the VAR because of the good economic interpretations attached to the impulse response functions and variance decomposition for all the variables in the model. Both have been proven to be especially useful for describing the dynamic behaviour of economic and financial time series and for forecasting.

The generalized impulse response function refers to the reaction of any dynamic system in response to some shocks or changes. In a VAR framework, the impulse response function traces out the reaction of the endogenous variable to shocks to each of the other individual variables. To assist this study, the impulse response function will be used to investigate the relationship between military expenditure and macroeconomic performance in Nigeria. The process through which the shocks transmit in the economy will be the focus in our context and the cumulative impulse response function to help in the interpretation of the overall effects of shock upon dependent variable in a given period. According to Stock and Watson (2001) the analysis of the impulse response function traced out the effects of a one-unit shock to a variable's error term on the dependent variables that made up the VAR model. Wouter (2011) identifies three types of structural shocks as; productivity shock, preference shock and policy shock. According to his definition, "the impulse response function gives the J^{th}-period response when the system is shocked by a one-standard-deviation shock through a sequence of shock and alternative series of shocks". Impulse response function can be analyzed in different ways but this study follows the multivariate extension of factorization technique of the Cholesky Orthogonalisation approach as it is consistent with previous studies of(Cheng, 2006) that are related to this study.

Variance Decomposition for VAR

This is another application of multivariate time series analysis that will be used in the interpretation of the VAR results. It is known as Forecast error variance decomposition (FEVD). It explains how each variable contribution to other variables in a regression model by determining the rate at which the forecast error variance of each variables is explained by the exogenous shocks to other variables and further consider the portion of the observed variation that is attributed to the orthogonalised shock in a variable. According to (Svensson, 2002) the variance decompositions explain the fraction of the observed variable in the that can either be ascribed to that variables been affected by shock or that of another endogenous variable. The application of this analysis will assist in analysing the behaviour of macroeconomic indicators in the Nigerian economy.

Sources of data

Data on all the variables are sourced from a secondary source specifically from the World Bank database. For instance, the data on the military expenditure are in million US dollars and they are extracted from the World Bank Tables, 2018. The same source is used for extracting data on population. However, data on exchange rate, inflation rate and the GDP were collected from the IFS 2018 edition.

4. Research findings

The interaction and the relationship between military expenditure and some important macroeconomic variables are explained within the Vector Auto regression framework under this section. However, the analysis starts with the unit root test because it is important that all the variables in the VAR model are all stationary.

Unit root test

The study explores the time series properties of the variables for their suitability for the VAR. the augmented dickey fuller until root test is conducted to ascertain the levels of stationarity of the variables that are used in the model.

Table 1: Unit root test results

Variable	T Statistics	Order of Integration
LEXCH	-4.134778	I(0)
GDP	-3.920895	I(1)
LINFLATION	-4.242094	I(1)
LMIL_EXP	-3.111569	I(1)
LPOP	-2.824324	I(1)

Source: Author's Computation

Analysis of the interactions between military expenditure and macroeconomic indicators

The VAR is used to achieve this objective. It is also referred to as the unrestricted VAR where all the variables are allowed to interact with one another within the VAR framework without imposing any restriction. The two major tool used by VAR are the IRFs that is impulse response functions and the Variance decomposition models. Their results are presented as follows;

Impulse response results

The impulse response analysis of the relationship between military expenditure and macroeconomic performance in Nigeria is based on the four identified shocks namely; military expenditure shocks, output shocks, inflation rate shocks and exchange rate. First, we consider the reactions of the variables to shock from each of the identified shocks, in other words the spiral effects of the shocks emanating from some macroeconomic variables such as output, exchange rate and inflation rate is examined as it affects military expenditure. Secondly, in the same perspective we also assess the responses the output, inflation and exchange rate to military expenditure shocks.

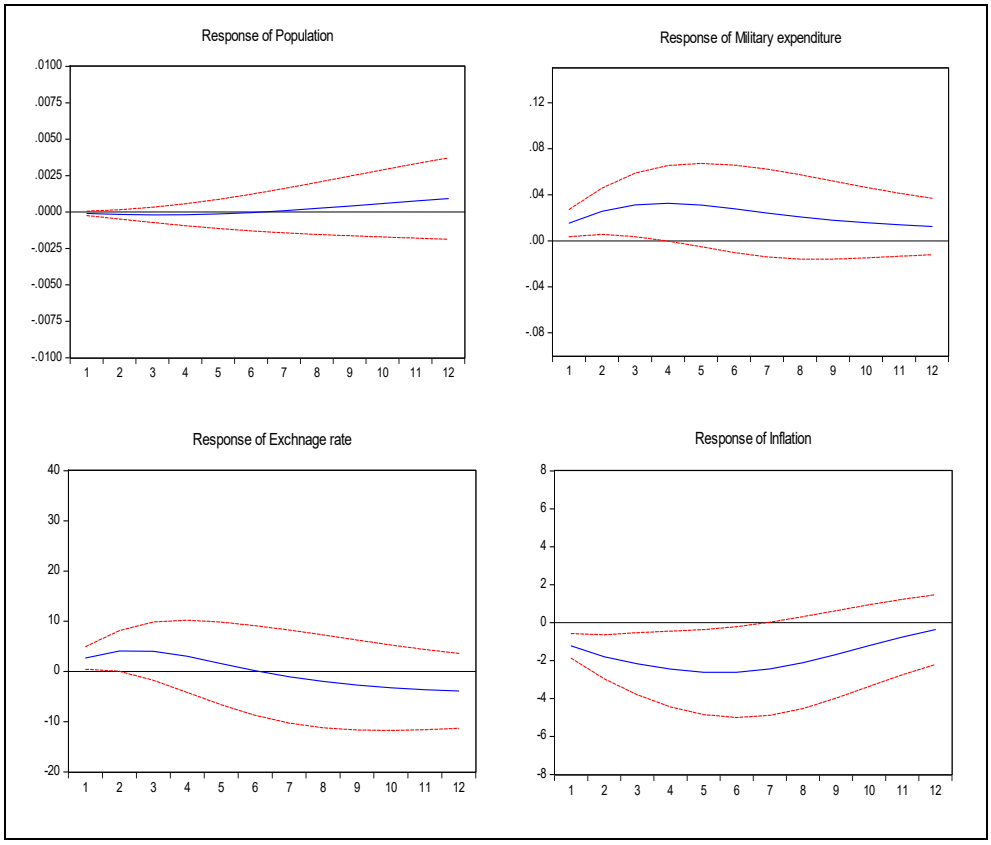

Figure 1: response to output shocks
Source: Author's computation, 2019

The responses of the other variables apart from the output to the output shock is presented in figure 1. In other words the figure shows the responses of population, exchange rate military expenditure and inflation to one percent standard

deviation in output. The results shows that military expenditure rises significantly to output shock, which is an indication that 1% positive innovation in output will bring about increase in military expenditure. This shock also allows exchange rate to appreciate and inflation falls significantly to the same shock. It is obvious form the IRF that the only variable without significant response to output shock is the population.

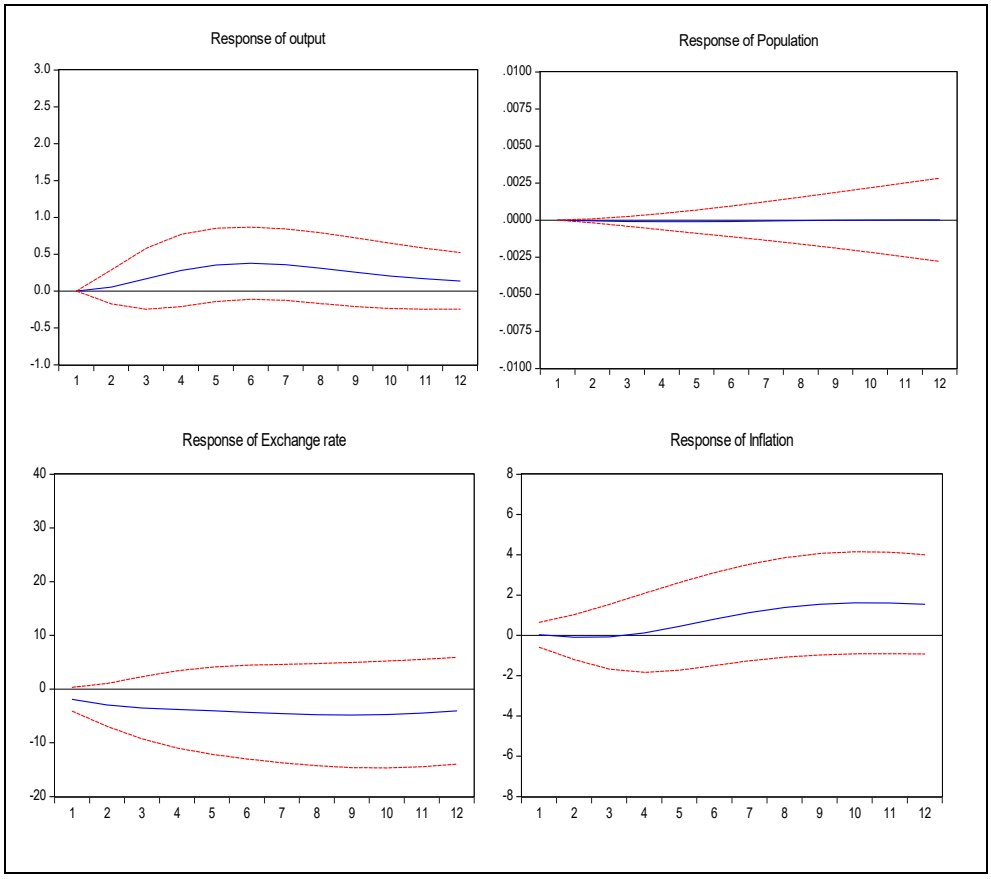

Figure 2: Impulse response to Military expenditure shocks

Figure 2 indicates that all the variables fail to respond to military expenditure significantly during the period under consideration. The output, the population and other macroeconomic variables such as exchange rate and inflation rate do not response significantly to the shocks from military expenditure.

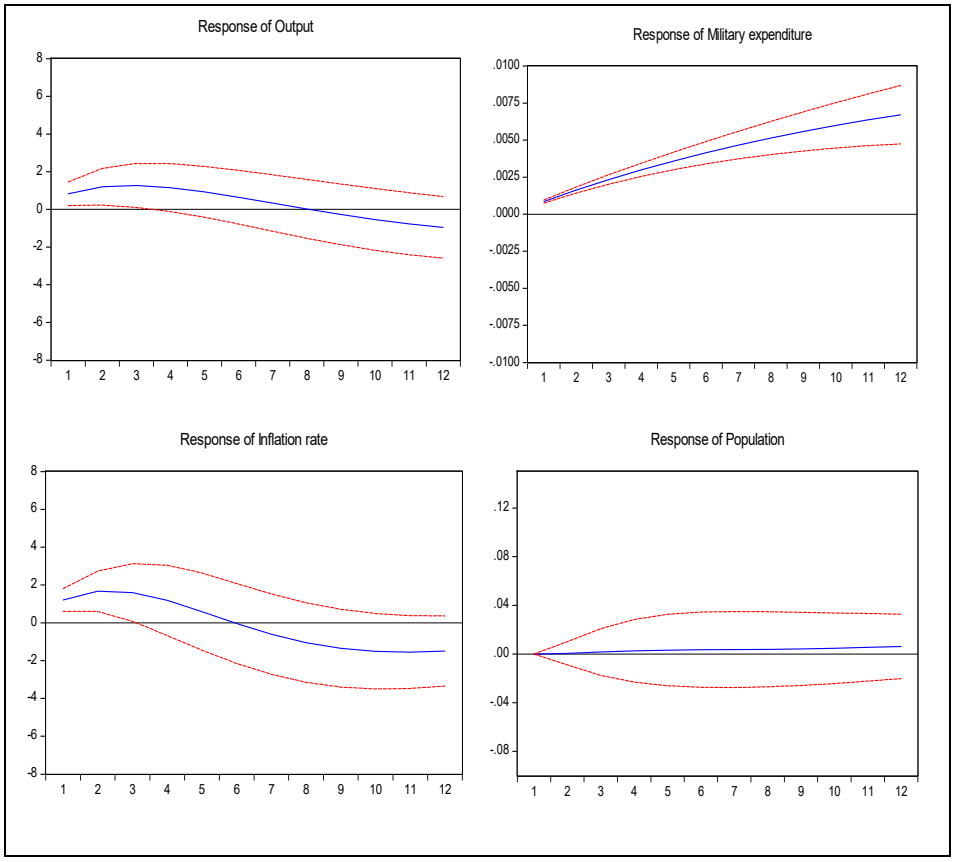

Figure 3: Impulse response to exchange rate shocks

The responses of the variables to one standard deviation in exchange rate is shown in figure 3. Output, military expenditure and inflation rate all respond significantly to the shock except population. The result shows a positive shock to exchange rate which means currency depreciation will cause the output to fall significantly and military expenditure also to rise significantly. Inflation rate is another macroeconomic variable that responds significantly to the shock from the exchange rate as it causes inflation to rise significantly. Population still remains irresponsive to macroeconomic shocks.

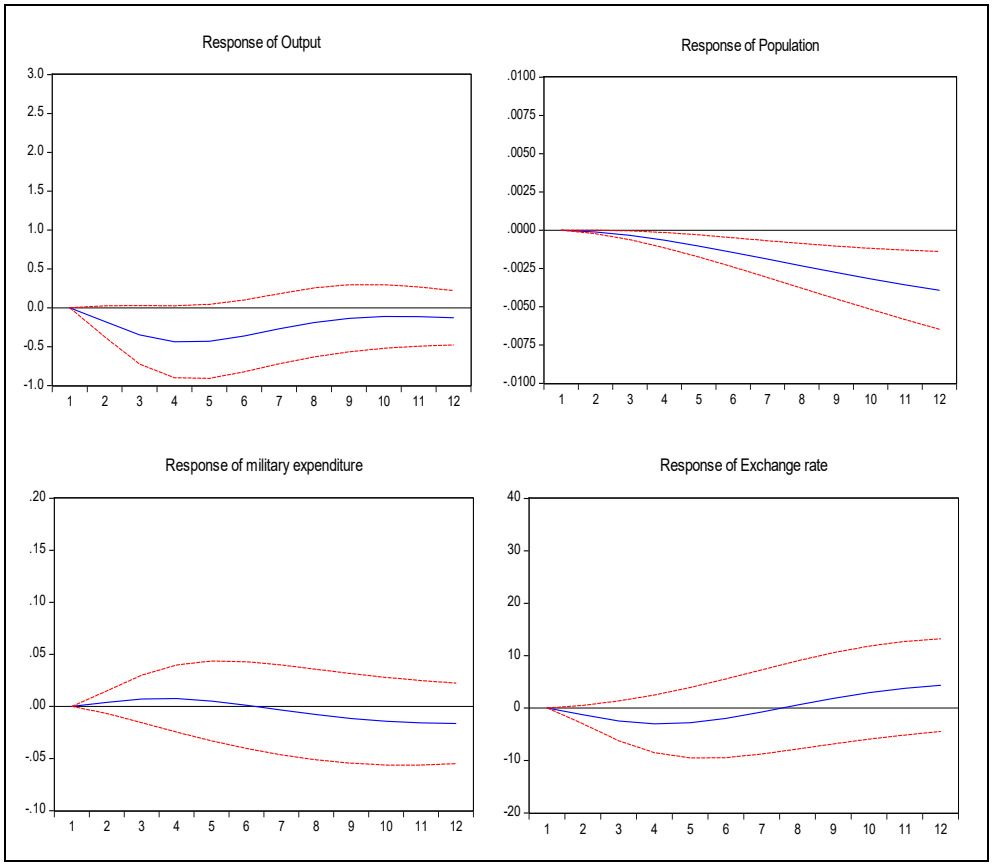

Figure 4: Response to inflation shocks

Responses to one percent positive innovation to inflation is shown in figure 4. The result shows that output, population and military expenditure all respond significantly to the inflation shock. Only exchange rate failed to show a significant response to this shock. A shock to inflation causes the output to fall significantly but the response of military expenditure is not significant Population shows significant response and it indicates that population only respond significantly to inflation rate among the macroeconomic variables. However, exchange rate is the only variable that fail to react significantly to the shock from inflation.

Variance decomposition

Variance decomposition explains the percentage or unit response of each variable in our model to the different structural shocks. In other words we try to explain the contribution of various structural shocks to the behavior of military expenditure and macroeconomic variables.

Table 2: Variance decomposition of military expenditure

Period	Output	Population	Military expenditure	Exchange rate	Inflation
3	1.364685	0.106694	96.92465	0.800747	0.803229
6	7.015666	0.075344	90.55052	2.118957	0.239512
9	13.35770	0.029207	83.39902	2.974041	0.240035
12	18.26971	0.014035	77.45864	3.591742	0.665874

Table 2 shows the contributions of each structural shock to the behaviour of military expenditure in Nigeria. The result shows that output and exchange rate are the two most important macroeconomic variables that affect the behaviour of military expenditure in Nigeria. Apart from its own shock, the output contribute the next shock followed by the exchange rate.

Table 3: Variance decomposition of output

Period	Output	Population	Military expenditure	Exchange rate	Inflation
3	97.76162	0.055857	0.093122	0.357007	1.732393
6	89.60612	0.961428	0.474618	3.279182	5.678655
9	83.41822	2.716925	2.187217	5.385188	6.292450
12	80.37181	4.027492	3.345235	5.877194	6.378270

From table 3 it was shown that the behaviour of output is mostly affected by the macroeconomic variables such as inflation rate and exchange rate. Population is also shown to contribute some shocks to the behaviours output in Nigeria. However, military expenditure again show no significant contributions to the output of Nigeria during the period under consideration as shown from the variance decomposition result on the output.

Table 4: Variance decomposition of exchange rate

Period	Output	Population	Military expenditure	Exchange rate	Inflation
3	2.122749	0.314277	3.474086	93.43044	0.658450
6	2.634247	0.203344	1.856678	94.28399	1.021741
9	3.687355	0.189981	1.683654	93.57577	0.863242
12	4.584314	0.299350	2.359892	91.04132	1.715128

The behaviour of exchange rate in the VAR is mostly affected by the output. The implication is that table 4 which shows the contributions of each of the structural shocks to the behaviour of exchange rate shows that the GDP of Nigeria contributes the highest shock to the behaviour. However, military expenditure has been shown to have high contributions as well to the behaviour of exchange rate. This partly indicates that the weight of military expenditure in our foreign exchange consumption.

Table 5: Variance decomposition of inflation rate

Period	Output	Population	Military expenditure	Exchange rate	Inflation
3	10.10051	3.990966	0.015575	7.259306	78.63364
6	14.05639	3.066197	0.424674	4.136905	78.31583
9	15.94911	2.464454	2.442620	4.466057	74.67776
12	15.27414	2.862739	4.822587	6.439575	70.60096

The behaviour inflation rate is mostly affected by output and exchange rate. Table 4 shows the contributions of each of the structural shocks to the behaviour of inflation rate. These two are followed by the population as the next contributor to the behaviours of inflation rate. However, military expenditure shows little contribution to the behaviour of inflation rate

5. Discussion of results

The findings show a positive and significant relationship between output and military expenditure in Nigeria. This is evident from the history of the two variables in Nigeria. In the year 2013 and 2014 when the oil price rose to about 100 USD, the GDP of Nigeria rose by about 4% during this period and within the last decade that period was when the highest expenditure was recorded for military expenditures in Nigeria (Nnanna, 2002) The implication of this result is that military expenditure is highly susceptible to output shocks in Nigeria. The same conclusion was obtained in the study of Anifowose, Adeleke, & Mukorera, 2019) who established a significant relationship between output growth and military spending.

Again, the VAR result shows that military expenditure shocks does not affect macroeconomic variables in Nigeria significantly. This findings support the conclusions form (Yildirim & Öcal, 2016) which confirmed a unidirectional relationship between Nigerian economic growth and military expenditure and that it output that affect military expenditure and not otherwise. It is important to note here that this explains why rich countries with huge national income have large volume money to spend on their military. For instance the expenditure on the military in the US alone is more than the entire budget expenditure in Nigeria and similar story goes for other advanced or rich countries. The higher a country's output the more money is available to spend on the military.

Furthermore, the analysis has also revealed that exchange rate shocks affect military expenditure in Nigeria significantly. The same position was held by (Saba & Ngepah, 2019) who identified foreign exchange as a major factor affecting military spending mostly in the developing countries. Their study pointed out that expenditure on the military are denominated in foreign currency especially the US dollars. This has been identified as the main reason whily there is a strong linkage between military expenditure and exchange rate in most developing countries who develop majorly on importation to equip their military. Moreover, continuous increase in military spending despite currency depreciation might not be wise enough since it has been confirmed from this study that military expenditure has not been contributing significantly to the output of the country.

6. Conclusions

The findings reveal different forms of relationship among military expenditures and macroeconomic indicators in Nigeria that might lead to some important policy decisions. However, the following conclusions arise from the findings of this study.

Firstly, it can be concluded that output shock is an important shock affecting military expenditure in Nigeria. An upsurge in output of the country will simultaneously lead to significant increase in the military expenditure in Nigeria.

Secondly, the findings establish the fact that macroeconomic variables are not significantly responsive to military expenditure shocks. For instance, the results shows that output is not affected by military expenditure shocks in other words expenditure on military does not have any significant positive influence on output in Nigeria.

Thirdly, the study shows that apart from output shocks, military expenditure also responds significantly to exchange rate shocks. However, the study indicates that when the Naira falls in value, the Nigerian government increases expenditure on the military because of the priority given to it and the fact that costs of military apparatus rise during this period since they are traded in foreign currency. The implication is that even when the domestic currency is weak government of Nigeria still increase funding of the military significantly. However, this might not be a good line of action on the part of the government as it piles more pressure on the domestic currency.

In addition this study shows the inflation shock does not constitute problem to military expenditure in Nigeria. The reason for this might not be unconnected with the fact that military expenditure which the largest percentage is on capital goods are bought from foreign countries hence they are not affected by domestic prices.

Finally, the study brings evidence that the chunk of military expenditure on our foreign transactions is very high hence military expenditure has been shown as an important variables affecting Nigeria exchange rate. The findings reveal that the behavior of the naira is significantly affected by military expenditure.

However, the limitation of the study is in the area of proxy used for military expenditure. The study used the total spending on military expenditure in dollars. However, some literatures believe that the percentage of the military expenditure could be a better measure of military expenditure (Ali & Solarin, 2019; Khalid, Okafor, & Aziz, 2019). Although this position is still contentious, further study can be conducted using percentage of the military expenditure of the GDP as a proxy for military expenditure and see if there will be significant difference in the findings compare to the findings in this study. Again, more macroeconomic variables such as unemployment rate might be added to further assess the effect of military expenditure on economic performance of the country rather than using output alone which was used in this study.

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