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The impacts of public expenditure innovations on real exchange rate volatility in South Africa

Naser Yenus Nuru and Hayelom Yrgaw Gereziher*

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Abstract: This study investigates the impacts of public expenditure innovations on exchange rate volatility in South Africa using quarterly data for the period 1970–2019. To achieve this objective, a version of the vector autoregressive impulse response model proposed by Jordà is employed and the innovations are identified recursively. The impulse response functions indicate that public expenditure innovation has a significant depreciating trend impact on exchange rate volatility, and its impact relies on the type of fiscal expenditure innovation. While the impact of public expenditure innovation on exchange rate volatility does not rely on the direction of the innovation, it varies according to the state of the economy. Public expenditure innovation has a depreciating trend impact on exchange rate volatility in the upturn state, and mostly an appreciating trend impact in the downturn state. The impact is greater in the upturn than the downturn state.

Key words: public expenditure, impulse response, exchange rate volatility, South Africa

JEL classification: C32, E62, F31, F41

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*Adigrat University, Adigrat, Ethiopia; corresponding author: nyenus23@gmail.com

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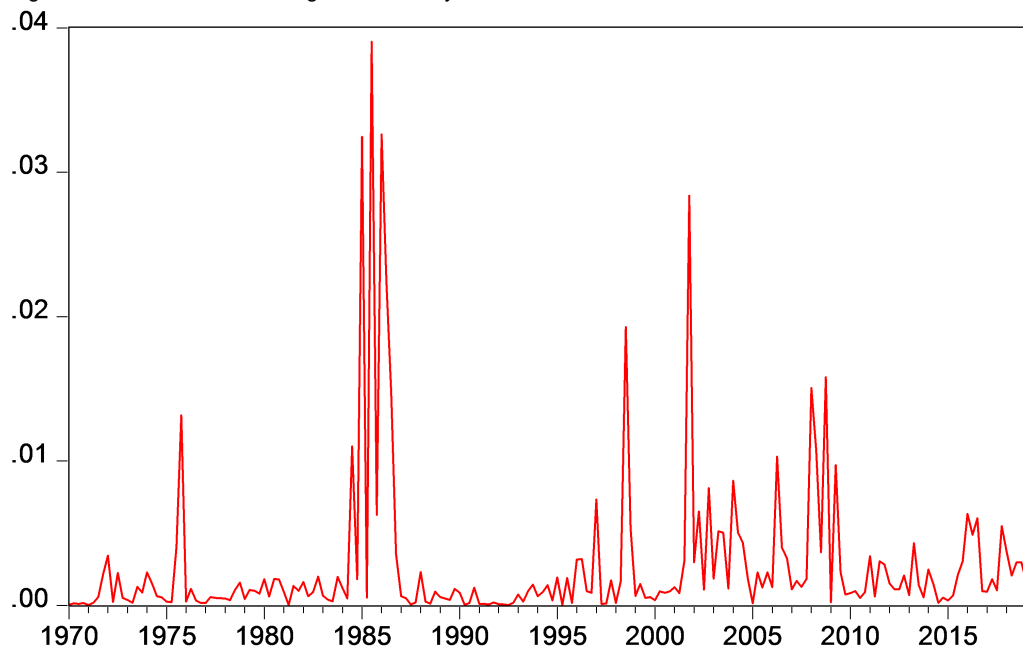
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1 Introduction

The end of the Bretton Woods system of fixed exchange rates in the 1970s marked a rise in financial liberalization leading to exchange rate uncertainty in both developed and developing countries. When the dual exchange rate system that was in effect from the mid-1980s had been abandoned, South Africa liberalized its capital account, in March 1995. Since this time, and following the lifting of economic sanctions due to apartheid, South Africa has been reintegrated into the global economy. The South African exchange rate policy has passed through various structural modifications over the previous few decades. The exchange rate used the fixed exchange rate system before 1970; during 1970–2000 it was a managed floating exchange rate regime; and after 2000 the exchange rate system became a free-floating exchange rate regime, with its value determined by market forces under the inflation-targeting framework of the South African Reserve Bank (SARB) since 2001 (Khomo 2018; Reinhart and Rogoff 2002; Rossi and Galbraith 2016). Such a foreign exchange policy may cause excessive short-term volatility in exchange rates and currency misalignments (Lafrance and Tessier 2001).

The Central Bank triennial survey (2013) of the Bank for International Settlements (BIS) shows that the South African rand is one of the most exchanged currencies in the world. Compared to the currencies of other emerging economies, the rand is more volatile as there is a highly developed foreign exchange market and high participation of foreigners in local markets. The country's good integration into the global economy could also be a factor in the volatility of the rand relative to other emerging economy currencies (Aye et al. 2015; Hassan 2016; Khomo 2018; Mpofu 2016). This volatility of the exchange rate may have an effect on macroeconomic stability. A stable exchange rate may be preferred by policy-makers and investors as this minimizes uncertainty and assists in conducting sound planning activities. This is of paramount significance for the South African rand, which exhibits cyclical appreciation and depreciation trends that accord with high levels of uncertainty (see Figure 1). Such uncertainties may create a challenge for policy-makers, investors, consumers, and others, and they may undermine economic performance (Aye and Harris 2019).

Figure 1: Real effective exchange rate volatility



Source: authors' illustration based on SARB data.

Exchange rate volatility may also be linked with higher macroeconomic volatility in terms of international trade, investment, and economic growth; on the other hand, volatility may be considered as a

shock-absorber, and seems to be more relevant for economies facing frequent real shocks (Barguelli et al. 2018). In economies in which the exchange rate serves as a shock absorber in the face of asymmetric shocks, fluctuations in the nominal exchange rate might be anticipated, and hence short-term real exchange rate volatility may result from such nominal volatility (Aye and Harris 2019).

Public expenditure is one instrument of fiscal policy utilized by a number of countries. Governments may use this expenditure in periods of uncertainty for stimulus or austerity purposes. Countries encountering difficulties in achieving sustained growth may stabilize their economies with suitable combinations of public expenditure. This expenditure may come from borrowing, taxes, or seigniorage (Oyakhilome 2017). In periods of economic contraction in South Africa or other corners of the world, public expenditure may play a role as a stimulus, and so is a significant tool for policy-makers. For example, during the global financial crisis of 2008, South Africa passed an expenditure stimulus measure of around 1.2 per cent of gross domestic product (GDP) (Khatiwada 2009). In the mean time, to keep its fiscal sustainability position, South Africa has also gone through expenditure consolidation measures (Jooste and Marinkov 2012). In this regard, then, it is crucial to examine the impacts of exogenous public expenditure innovations on economic variables, including exchange rate volatility.

A number of studies have examined the nexus between public expenditure and the level of the real exchange rate, including a recent study by Nuru (2020) which investigates the effects of exogenous public expenditure shocks on the level of the real exchange rate for the South African economy. To the best of the knowledge of the authors, there is no single study that clearly examines the relationship between public expenditure and real effective exchange rate volatility. The present study on South Africa fills this important knowledge gap in the literature and raises the following important research questions. First, do public expenditure innovations exert significant influence on exchange rate volatility? If yes, in what manner (depreciating or appreciating trend)? Second, do the impacts of the exogenous public expenditure innovations on exchange rate volatility vary across the economic cycle (economic upturn vs downturn) or the direction of the innovation (positive vs negative)?

The study is structured as follows. The literature review is presented in Section 2. Section 3 discusses the data type and source, as well as the methodology. The results are presented in Section 4, while conclusions and policy implications are drawn in Section 5.

2 Literature review

An extensive literature has investigated the nexus between public expenditure and the level of the exchange rate, but not its volatility. Hence, we review the existing literature with an emphasis on the relation of the former to the latter.

While a number of papers have shown exchange rate depreciation in response to a positive public expenditure innovation (Corsetti et al. 2012; Enders et al. 2011; Kim and Roubini 2008; Monacelli and Perotti 2010; Müller 2008), others (Beetsma et al. 2008; de Castro and Fernández 2013) found real exchange rate appreciation. Kim (2015) found depreciation of the real exchange rate alongside positive public consumption innovations for 18 developed countries; similar findings are also reported by Ravn et al. (2012), using panel structural vector autoregression (SVAR) for other four developed countries, including the United States. Bouakez et al. (2014) and Corsetti and Müller (2006) revealed that a rise in public expenditure led to depreciation in the real exchange rate in four developed countries. Different from these findings, Gidey and Nuru (2021) examined the impact of public expenditure innovation on the real exchange rate for Ethiopia and found exchange rate appreciation in response to the innovation. Olasunkanmi and Babatunde (2013), using the SVAR approach of Blanchard-Perotti (2002), also docu-

mented appreciation of the real exchange rate in response to positive public expenditure innovation over the sample period 1980Q1–2010Q4.

Alves da Silva et al. (2015) demonstrated that the impacts of expansionary public expenditure innovations are not the same among all countries, with a rise in public expenditure causing real exchange rate appreciation in Mexico but depreciation in Brazil and Chile. de Castro and Garrote (2015) found that an increase in public expenditure caused real exchange rate appreciation in the euro area but real depreciation in the USA. Miyamoto et al. (2019), using exogenous military expenditure panel data, also showed that expansionary public expenditure innovation leads to real exchange rate depreciation in developed countries while it causes real exchange rates to appreciate in developing countries. Ilzetzi et al. (2013), using a panel of developed and developing countries, documented that while positive public expenditure innovation leads to depreciation of the real exchange rate in developed countries, it causes appreciation of the real exchange rate in developing countries.

Galstyan and Lane (2009a, 2009b) examined the impacts of the components of public expenditure innovations and found that while public consumption appreciates the exchange rate, public investment depreciates it. Similarly, Bénétrix and Lane (2009) confirmed that for Ireland the impacts of public expenditure innovations on the real exchange rate are based on the type of fiscal expenditure innovation. Bénétrix and Lane (2013) showed that public investment innovations have stronger appreciation impacts on the real exchange rate compared to public consumption in the euro area. Additionally, they showed that the wage part of public consumption is more persistent than the non-wage part in euro area countries.

Bajo-Rubio et al. (2020) claimed that not only the type of fiscal expenditure consolidation measures matter for the impact of unanticipated public expenditure innovation on the exchange rate in Spain, but also the definition of the exchange rate. While a reduction in public investment causes appreciation of export price-based and CPI-based exchange rates, a reduction in public consumption leads to depreciation of the CPI-based real exchange rate, but not of export-based exchange rates.

Chen and Liu (2018), for the period 1995Q1–2015Q2, showed that positive public consumption and investment innovations led to appreciation in the exchange rate for China. Çebi and Çulha (2014), using quarterly data for the period 2002–12, also found exchange rate appreciation in response to expansionary public expenditure innovation and showed that the impact relies on the type of public expenditure. Although public non-wage consumption creates exchange rate appreciation, public investment innovations have a negligible impact on the exchange rate.

Oyakhilome (2017), based on a panel VAR model analysis, revealed that public expenditure is associated with real exchange rate appreciation in countries of sub-Saharan Africa (SSA). Furthermore, the study examined the separate impacts of public consumption, public investment, and transfer payments on the real exchange rate and showed that public consumption and transfer payments lead to exchange rate appreciation, while public investment causes real exchange rate depreciation in SSA. Caporale et al. (2011) found that fiscal innovations are mostly the main causes of movements in exchange rates in Latin American countries for the period 1980–2006.

Born et al. (2019) showed that the responses of exchange rates to positive and negative discretionary public expenditure changes are symmetric, and found that expansionary public expenditure appreciates the real exchange rate while contractionary public expenditure depreciates it. Auerbach and Gorodnichenko (2016) also examined the responses of exchange rates to public expenditure innovation based on the state of the economy, and revealed that responses to economic downturn and economic upturn are different, with a weak instantaneous response that gradually appreciates for the USA.

Nuru (2020b) examined the effects of public expenditure innovations on the level of the real exchange rate for the South African economy and found that the exchange rate appreciates in response to inno-

vations, though the effect differs based on the type of fiscal expenditure innovation. Similarly, Nuru (2020a) documented nominal exchange rate appreciation as a result of an increase in public expenditure using quarterly data for the period 1994–2014. Mlilo and Kollamparambi (2016) showed that discretionary public expenditure change caused exchange rate appreciation over their sample period 1994Q1–2008Q4 in South Africa.

As we can easily see from the empirical discussion, there is no consensus on the relationship between discretionary public expenditure changes and the real exchange rate. Additionally, the majority of studies focus on the USA and European countries; there is no clear knowledge on the nexus of discretionary public expenditure changes and exchange rate volatility for South Africa, a gap in the literature that this study fills.

3 Data and methodology

3.1 Data source and description

Quarterly data covering the period 1970–2019 is used in the estimation. The starting period of the sample marks the end of the fixed exchange rate system and the beginning of the managed floating exchange system in South Africa. We chose the study period, however, solely on the basis of the availability of the data. Four variables are incorporated in our parsimonious baseline model. These are public expenditure, real GDP, public revenue, and real effective exchange rate volatility. The sum of general public consumption and investment makes up public expenditure, and general public revenue comprises both direct and indirect tax revenues. Public revenue is deflated by the GDP deflator to obtain the real public revenue, while GDP and public expenditure are found in their real form in the data source.

The real effective exchange rate volatility is calculated from the monthly level real exchange rate data, and this can be considered as a measure of the unobservable uncertainty data. As public expenditure data are available on a quarterly basis, the quarterly realized exchange rate is calculated in a similar fashion as in the study by Aye and Harris (2019), as follows:

$$RVOL_t = \sum_{i=1}^T r_{t,i}^2 \quad (1)$$

where r_t is the monthly return for month i within quarter t , and $i = 1 \dots T$, where T is the total number of monthly observations within a quarter. $RVOL$ is the quarterly exchange rate volatility. The main merit of the realized uncertainty is that it is model-free, and this may discard measurement or specification errors. This means that the generated regressor problem linked with two-step estimation procedures is not an issue in this case (Pagan 1984).

High-frequency data such as the quarterly data helps us to identify SVAR restrictions based on theory, which is not the case for annual data. For annual data, identifying these restrictions becomes difficult as variables are more likely to respond to a shock after a one-quarter time period. In addition to this, it helps us to maximize our degrees of freedom in estimation (Blanchard and Perotti 2002). The impacts of the different types of public expenditure innovations (public consumption and public investment) on exchange rate volatility, substituting public expenditure one by one in our baseline model, are also investigated in this paper. The SARB is the source of the data for this study, and the variables are found originally in their seasonally adjusted form.

Logarithmic transformation is made over all the variables except the realized exchange rate volatility. Unit root tests such as the augmented Dickey–Fuller and Phillips–Perron tests are conducted to check the order of integration of the series, and for the augmented Dickey–Fuller test the number of augmentation

lags are specified based on the Schwarz information criterion (SIC) to account for serial correlation in the Dickey–Fuller regressions. The results show that the variables contain unit roots and accept the null hypothesis of non-stationarity, except for the real exchange rate volatility. After first-differencing the non-stationary variables, however, they are found to be stationary. The variables are plotted in Figure A1 (see in Appendix A).

3.2 Methodology

Baseline local projection model

Jordà’s (2005) local projection (LP) model is used to compute impulse response functions from a VAR model and to examine the impacts of discretionary public expenditure changes on exchange rate volatility for South Africa. Jordà’s LP method entails estimating impulse responses from a set of linear projections of the future value of the variable of interest on the current information set. In this regard, then, the estimation is sequential and the regression coefficients obtained from this set of regressions make up the impulse responses (Aye 2019; Aye and Harris 2019). Hence, using this approach, we can easily see the impact of discretionary public expenditure changes on exchange rate volatility at various horizons, h .

Impulse responses from the LP method have a number of benefits in comparison to those from a standard VAR model (Auerbach and Gorodnichenko 2013; Ramey and Zubairy 2018). To begin with, LPs that rely on linear regressions are simpler to estimate and can easily control for non-linearities, and their estimation results depend on robust standard errors. In addition, joint or point-wise analytic inference is simple, and the impulse responses computed from the LP model are consistent and asymptotically normal. More importantly, when a VAR is mis-specified, we can have robust impulse responses from the LP model. This last point, however, is still debated in the literature. Though some studies (Herbst and Johannsen 2020; Kilian and Kim 2011) have raised doubts about the robustness of LPs, others (Brugnolini 2018; Plagborg-Møller and Wolf 2019) exhibit equal or better performance for LPs than VARs.

The baseline LP model can be specified in the following way:

$$x_{t+h} = \alpha_h + \varphi_h(L)y_{t-1} + \beta_h \text{innovation}_t + \text{linear trend} + \varepsilon_{t+h} \quad (2)$$

where x represents the dependent variable, y denotes a vector of control variables, $\varphi_h(L)$ is a polynomial in the lag operator, and *innovation* is the VAR-based public expenditure innovation. In this study, public expenditure and exchange rate volatility are contained in x , and y comprises lags of the values of public expenditure, exchange rate volatility, real GDP, and public revenue. The coefficient β_h shows response of x at time $t + h$ to the innovation at time t . Therefore, impulse responses can be created by estimating a sequence of regressions for each horizon h . Constant α_h and a linear trend are also incorporated into the model. To account for the trend behaviour of fiscal policy variables in our data, the linear trend is included in the model. The lag length of the polynomial $\varphi(L)$ (one) is decided by corrected Akaike information criterion (AICc). As in Ramey and Zubairy (2018), to avoid serial correlation in the error terms, Newey–West correction for standard errors is employed in this study.

VAR structural parameters

In the literature, various approaches are proposed for identifying discretionary public expenditure changes. The approaches are the VAR-based public expenditure innovation (Blanchard and Perotti 2002; Ilzetzki et al. 2013), the narrative approach based on news about future defence expenditure (Barro 1981; Owyang et al. 2013; Ramey 2011a, 2011b; Ramey and Shapiro 1998), loans from official creditors as exogenous sources of movements in public expenditure (Kraay 2012, 2014), and forecast error for the growth rate of public expenditure (Auerbach and Gorodnichenko 2012, 2013). In this paper, we will

use the VAR-based public expenditure innovation to identify public expenditure innovations in our LP model.

The structural vector autoregressive equation is given by:

$$Ay_t = \beta + \Phi t + B_1 y_{t-1} + B_2 y_{t-2} + \dots + B_p y_{t-p} + B e_t$$

where y_t is an $n \times 1$ vector of macroeconomic variables at time t ; β is an $n \times 1$ vector of constants; Φt is an $n \times 1$ vector of time trends; A and B_ℓ are each an $n \times n$ matrix of parameters for $\ell = 1, \dots, p$; and e_t is an $n \times 1$ vector of structural innovations with $e_t \sim \mathcal{N}(0, BE(e_t e_t' B')$.

The exogenous innovations are identified by a recursive identification scheme that restricts A to a lower triangular matrix and B to a k -dimensional identity matrix. This identification scheme depends on the causal ordering of the variables in our model. As in Fatás and Mihov (2001), public expenditure is ordered first, followed by output, public revenue, and exchange rate volatility, respectively. The subsequent instantaneous zero-value restrictions are made for $Au_t = Be_t$:

$$\begin{bmatrix} -\alpha_{expen,expen} & 0 & 0 & 0 \\ -\alpha_{GDP,expen} & -\alpha_{GDP,GDP} & 0 & 0 \\ -\alpha_{rev,expen} & -\alpha_{rev,GDP} & -\alpha_{rev,rev} & 0 \\ -\alpha_{REXV,expen} & -\alpha_{REXV,GDP} & -\alpha_{REXV,rev} & -\alpha_{REXV,REXV} \end{bmatrix} \begin{bmatrix} u_t^{expen} \\ u_t^{GDP} \\ u_t^{rev} \\ u_t^{REXV} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_t^{expen} \\ e_t^{GDP} \\ e_t^{rev} \\ e_t^{REXV} \end{bmatrix}$$

The most exogenous variable, public expenditure, is ordered first based on the assumption that it does not respond instantaneously to innovation to the other variables; the second-ordered variable, output, responds instantaneously to public expenditure innovation but not to public revenue and exchange rate volatility innovations. Public revenue innovation is affected instantaneously by public expenditure and output innovations, while it does not respond to exchange rate volatility innovation; lastly, the exchange rate responds instantaneously to innovations in the other variables. All the variables, however, are allowed to interact freely after the first period.

The instantaneous relations between the variables are made based on the following assumptions. Fluctuations in public expenditure are independent of the state of the economy. Hence, we can consider that public expenditure is not affected by innovations in the private sector. Output is ordered before public revenue on the assumption that it has an instantaneous impact on tax revenue. The ordering of output before public revenue enables us to see the impacts of automatic stabilizers on public revenue while neglecting the instantaneous impacts of discretionary public revenue changes on output. Exchange rate volatility reacts quickly to innovations in all the other variables as it is a fast-moving financial variable.

We construct the different types of public expenditure innovations (public consumption and public investment innovations) the same as public expenditure innovation and examine their impacts on exchange rate volatility by replacing public expenditure innovation in equation (2) with these innovations, one at a time.

Asymmetric impacts of public expenditure innovations

The asymmetric impacts of discretionary public expenditure changes on exchange rate volatility based on the direction of the innovation (positive vs negative) and business cycle (economic upturn vs economic downturn) are also investigated in this study. To examine the impacts from the direction of the

innovation, we make the following changes to our baseline LP model (equation (2)):

$$x_{t+h} = \alpha_h + \varphi_h(L)y_{t-1} + \beta_h D_{it} innovation_t + \beta_h(1 - D_{it}) innovation_t + linear\ trend + \varepsilon_{t+h} \quad (3)$$

where D is a dummy variable with value 1 for positive or negative differences in public expenditure and 0 otherwise. These dummies are incorporated into the model one at a time.

Similarly, the impacts of discretionary public expenditure changes on exchange rate volatility across the economic cycle can be examined by taking the lag of the growth in real GDP as a threshold variable. Economic upturn periods include those with positive differences in GDP, while those with negative differences in GDP are taken as economic downturn periods. Therefore, 153 data points are categorized under periods of economic upturn and the other 45 data points are categorized under economic downturn. Lastly, a version of equation (3) is estimated where D is a dummy variable with value 1 for economic upturn and 0 otherwise.

4 Results

We compute impulse response functions from an LP model and the orthogonal innovations are identified in a VAR model. We specify our VAR model in levels relying on the Monte Carlo results of Lin and Tsay (1996). They do not support testing co-integration in the absence of information about the number of co-integrating vectors. Sims et al. (1990) also argued that we can obtain consistent parameter estimates when we run least square regressions to VARs in levels.

The impacts of discretionary public expenditure changes on exchange rate volatility are given in Figures A2–A10 in Appendix A. The impulse response functions are drawn over ten horizons and the magnitude of the innovations is one standard deviation with 68 per cent confidence bands. The point estimates of the mean of the impulse responses are denoted by the dark thick lines, while the confidence bands are shown by the light black lines. The horizontal axis depicts the horizon for the impulse responses and the vertical axis represents the variations in the response variable due to an exogenous innovation. For brevity, we only show the impacts of public expenditure innovations on the endogenous variables.

Figure A2 shows the impact of public expenditure innovation on the endogenous variables. Public expenditure innovation is persistent in the full horizon taken. GDP responds positively and significantly after the second quarter in response to public expenditure innovation. This finding is in line with the results of Nuru (2020) and Jooste et al. (2013). Public revenue falls significantly after the second quarter, except in the fifth quarter in response to the public expenditure innovation. Lastly, public expenditure innovation has a statistically significant depreciating trend impact on exchange rate volatility up to the second quarter. One standard deviation public expenditure innovation leads to around 0.2 per cent depreciating trend impact on exchange rate volatility up to the second quarter.

The impacts of the different types of public expenditure (i.e. public consumption and public investment) are also examined. Figure A3 indicates that public consumption innovation is persistent in the full horizon taken. Public consumption innovation has a positive and significant impact after the second quarter, and its impact on public revenue is negative and significant in the third quarter. Similar to public expenditure, public consumption innovation also has a statistically significant depreciating trend impact on exchange rate volatility up to the second quarter. One standard deviation public consumption innovation causes around 0.4 per cent depreciating trend impact on exchange rate volatility up to the second quarter.

The impact of public investment innovation on exchange rate volatility is also presented in Figure A4. The findings exhibit that public investment innovation is persistent up to the ninth quarter. Output responds positively and significantly to public investment innovation over the full horizon taken. Its

impact on public revenue is negative and significant in the fifth and after the eighth quarter, however. The decline in taxation may have a positive impact on the economy. Public investment innovation has a significant appreciating trend impact on exchange rate volatility up to the fifth quarter. One standard deviation public investment innovation leads to about 1 per cent appreciating trend impact on exchange rate volatility in the fourth quarter.

The non-linear impacts of public expenditure innovations on exchange rate volatility relying on the direction of the innovation (positive vs negative) and across the economic cycle (economic upturn vs economic downturn) are presented in Figures A5–A10. In these figures, the blue lines indicate the expansion state and the brown lines show the recession state.

Figure A5 reports that positive public expenditure innovation has a significant depreciating trend impact on exchange rate volatility at the time the shock arrives, and negative public expenditure innovation has a significant appreciating trend impact on exchange rate volatility at the time the shock arrives. The size of the impacts of both innovations is identical. Non-linear impacts of the innovations are not observed on the basis of the direction of the innovation. In unreported results, similar evidence is also obtained for the other endogenous variables in response to positive and negative public expenditure innovations. The results for the components of public expenditure are also symmetric based on the direction of the innovation (Figures A6 and A7).

Figure A8 exhibits that public expenditure innovation is persistent in economic downturns, while it is short-lived in economic upturns. GDP responds positively and significantly in both regimes in response to public expenditure innovation, though the impact is larger in the economic downturn regime than the economic upturn regime. This evidence backs up the old Keynesian argument that fiscal stimulus packages are essential to lift an economy from recession. A rise in public expenditure stimulates idle factors of production, leading to a rise in output in response to public expenditure innovation. A similar finding is obtained by Nuru (2019). In both regimes, public revenue responds negatively and significantly. Lastly, public expenditure innovation has a significant depreciating trend impact on exchange rate volatility in the economic upturn regime, while it has mostly an appreciating trend impact on exchange rate volatility in the economic downturn regime. The size of the impact is larger in the economic upturn than economic downturn. One standard deviation public expenditure innovation causes around 0.75 per cent depreciating trend impact on exchange rate volatility up to the second quarter in the economic upturn regime, while it has only around 0.4 per cent appreciating trend impact on exchange rate volatility up to the fourth quarter in the economic downturn regime.

Figure A9 shows that public consumption innovation is persistent over the full horizon taken in both states. The impact of public consumption innovation on output is positive in both regimes, while it shows a significant decline in the seventh quarter in the economic upturn regime. Public revenue falls significantly in the first four quarters and in the seventh quarter in the economic upturn regime, and it falls significantly in the third quarter and rises after the fourth quarter in the economic downturn regime in response to public consumption innovation. Public consumption innovation has a significant depreciating trend impact on exchange rate volatility in the economic upturn regime, while it has a significant appreciating trend impact on exchange rate volatility in the economic downturn regime. The size of the impact varies across both regimes.

Figure A10 shows that public investment innovation dies quickly within the second quarter in the economic upturn regime, while it continues over the full horizon taken in the economic downturn regime. The impact of public investment innovation on GDP is negative and significant in the third quarter, then it turns positive and significant in the fourth quarter in the economic upturn regime, and is positive and significant over the full horizon taken in the economic downturn regime. Public revenue increases in the third quarter and later on it falls significantly after the ninth quarter in the economic upturn regime, and declines insignificantly in the first five quarters in the economic downturn regime. Public investment in-

novation has a significant appreciating trend impact on exchange rate volatility in both regimes, though the size of the impact is greater in the first six quarters in the economic downturn regime.

5 Conclusion and policy implications

This paper investigates the impacts of exogenous public expenditure innovations on exchange rate volatility in South Africa over quarterly data that spans from 1970 to 2019. To address this point, Jordà's (2005) LP model is used to compute impulse response functions from a VAR model and the innovations in the VAR model are identified recursively.

The findings of this paper show that expansionary public expenditure innovation leads to depreciating trend impact on exchange rate volatility, and its impact relies on the type of fiscal expenditure shock. Although exchange rate volatility responds in a depreciating trend manner to public consumption innovation, public investment innovation has an appreciating trend impact on exchange rate volatility.

The non-linear impacts of discretionary public expenditure changes on exchange rate volatility are also examined, relying on the direction of the innovation (positive vs negative) and the business cycle (economic upturn vs economic downturn). We show that the findings do not rely on the direction of the innovation. An increase in public expenditure leads to a depreciating trend impact on exchange rate volatility at the time the shock arrives, and a decrease in public expenditure causes an appreciating trend impact on exchange rate volatility at the time the shock arrives. In terms of the size of the innovations, the impacts of public consumption and investment innovations on exchange rate volatility are identical.

The impacts of the innovations, however, vary across the business cycle. While discretionary public expenditure change has a depreciating trend impact in the economic upturn regime, it has overwhelmingly an appreciating trend impact on exchange rate volatility in the economic downturn regime. The size of the impact is greater in the economic upturn regime than in the economic downturn regime. While one standard deviation public expenditure innovation causes around 0.75 per cent depreciating trend impact on exchange rate volatility up to the second quarter in the economic upturn regime, it has only around 0.4 per cent appreciating trend impact up to the fourth quarter in the economic downturn regime. Non-linear impacts of public expenditure innovations on exchange rate volatility are also evidenced for the different types of public expenditure.

These results have important implications. While exogenous public expenditure innovations encourage short-term volatility in the competitiveness of the economy, this is not the case for public investment. Additionally, stimulus packages released at the time of downturns do not dampen the external competitiveness of the economy; this is especially the case for public investment.

Finally, it might be essential to use the forecast error for growth rate of public expenditure, as an exogenous public expenditure innovation identified through the VAR approach may not actually be unexpected innovation. It would be appropriate to control for monetary policy when studying the nexus between public expenditure and exchange rate volatility, and we leave these points for future research.

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Appendix A

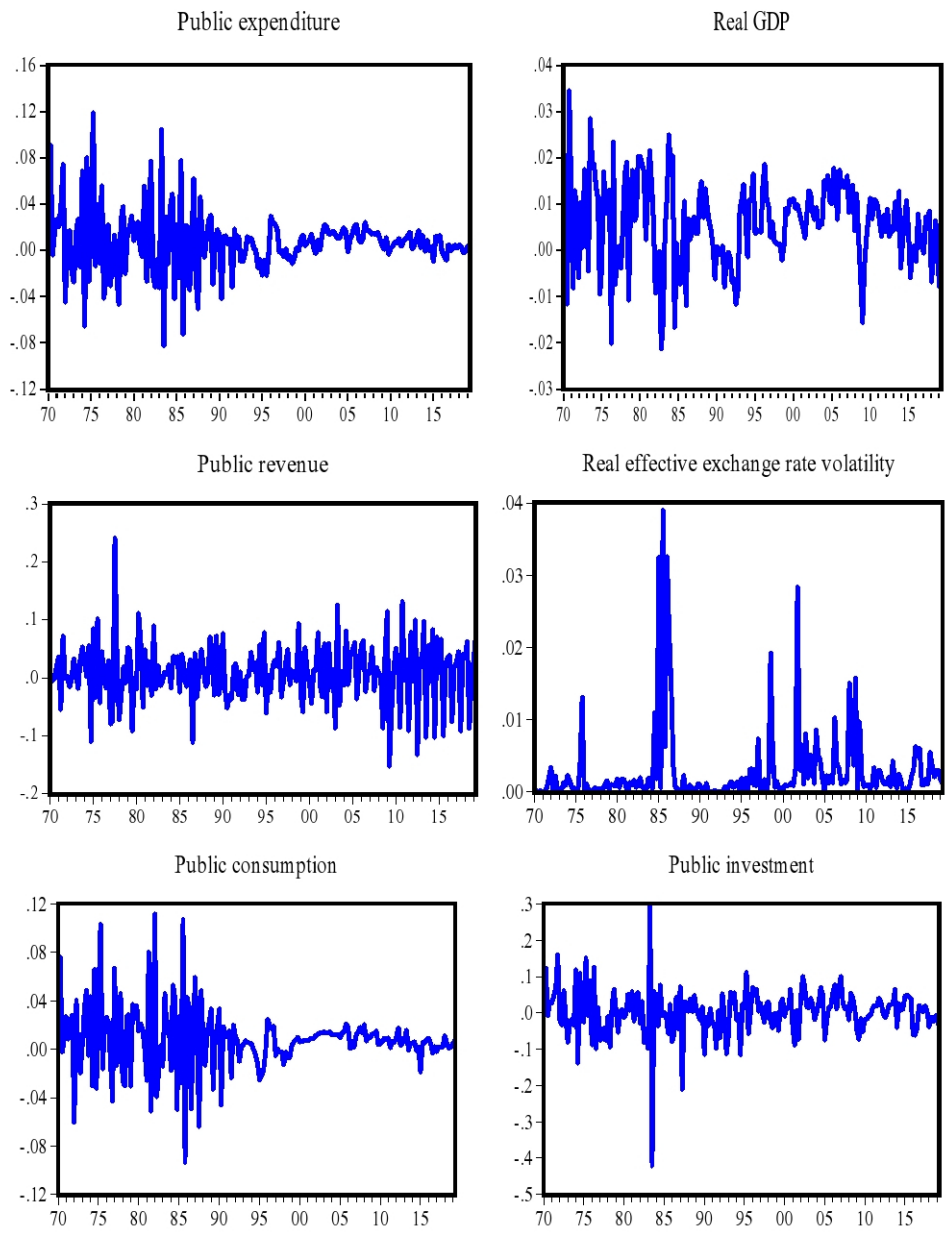
Table A1: Unit root tests

	ADF			Phillips–Perron	
	Lags (SIC)	<i>t</i> -statistic	<i>p</i> -value	<i>t</i> -statistic	<i>p</i> -value
Public expenditure	1	-0.690434	0.9718	-0.907127	0.9521
Real GDP	1	-1.118471	0.9224	-1.102623	0.9251
Public revenue	4	-1.407170	0.8561	-3.622138	0.0304
Real exchange rate volatility	1	-4.781389	0.0001	-12.50158	0.0000
Public consumption	1	-0.944970	0.9477	-1.092139	0.9268
Public investment	1	-1.091553	0.9269	-1.462332	0.8392

Note: the null hypothesis is that the variable has a unit root.

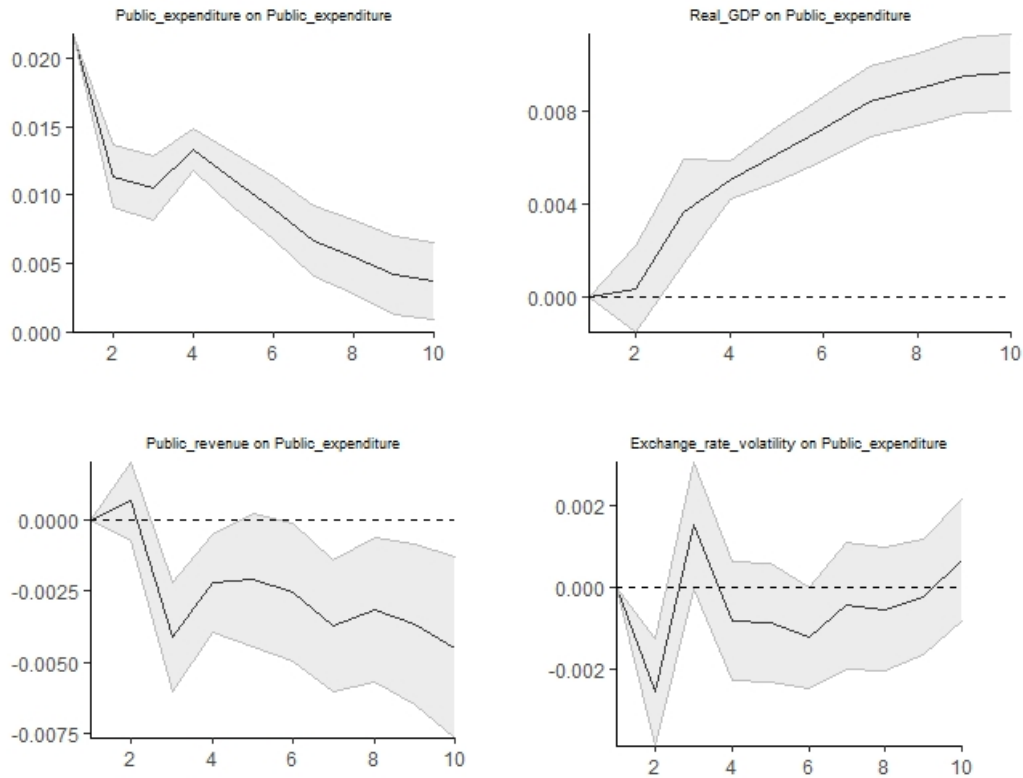
Source: authors' calculations based on SARB data.

Figure A1: Fiscal policy variables, real effective exchange rate volatility, and economic activity



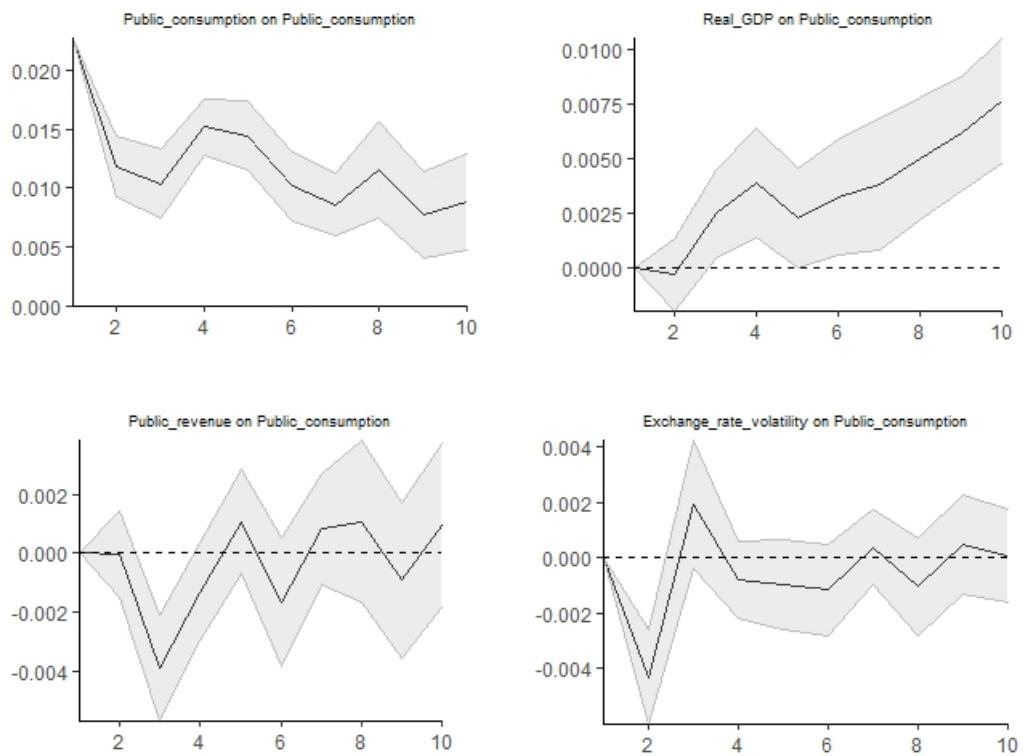
Source: authors' illustration based on SARB data.

Figure A2: Impulse response functions to public expenditure innovation



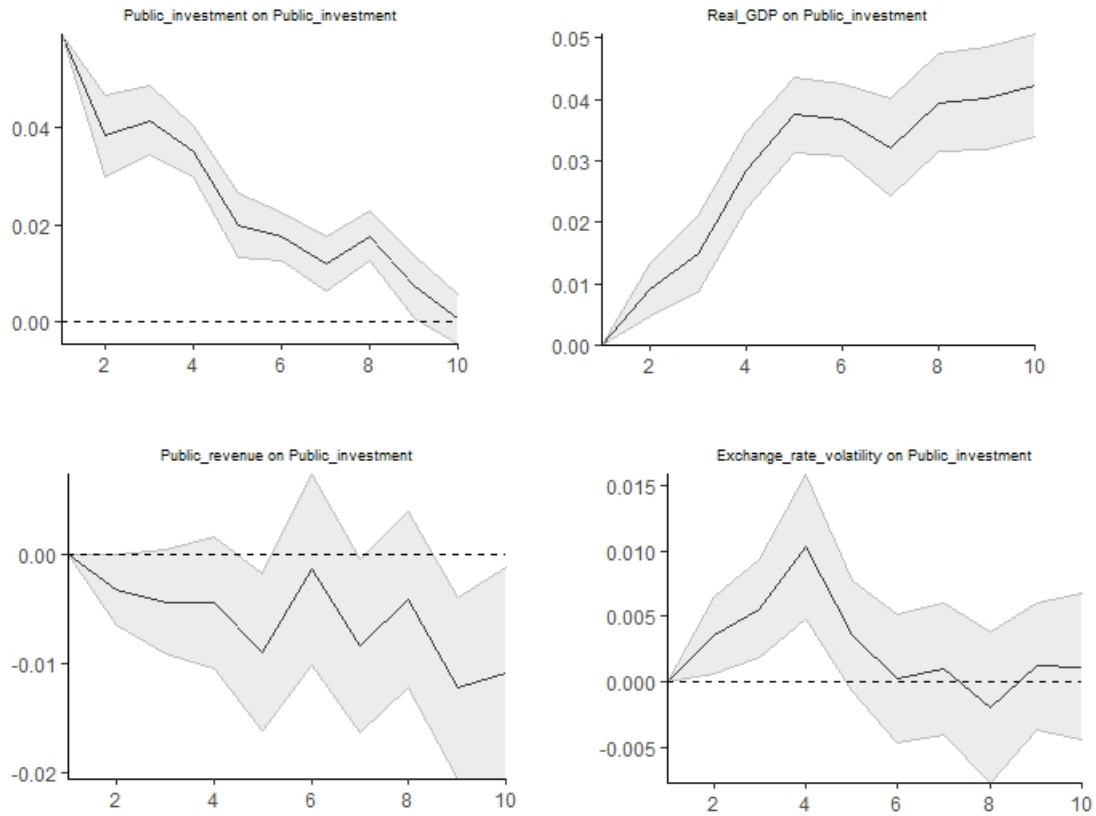
Source: authors' illustration based on SARB data.

Figure A3: Impulse response functions to public consumption innovation



Source: authors' illustration based on SARB data.

Figure A4: Impulse response functions to public investment innovation

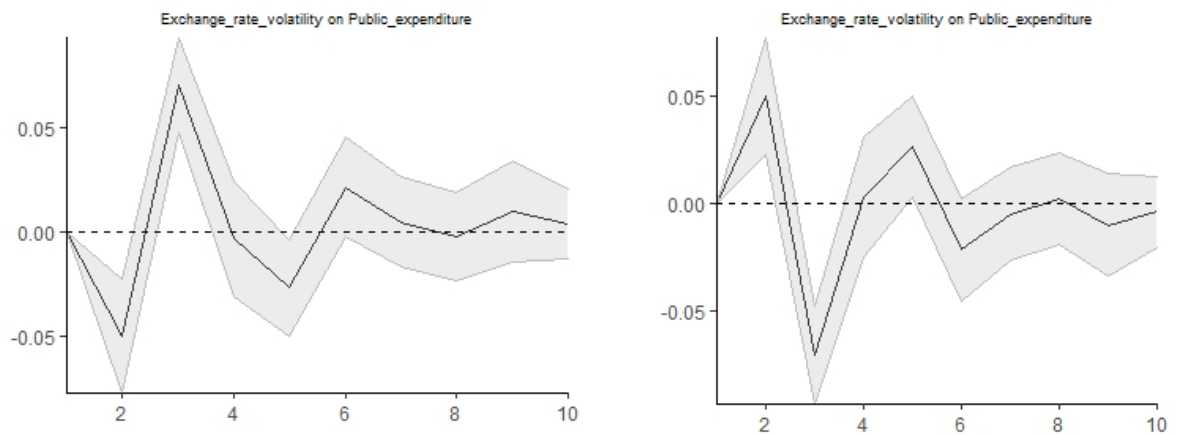


Source: authors' illustration based on SARB data.

Figure A5: Impulse response functions to positive and negative public expenditure innovations

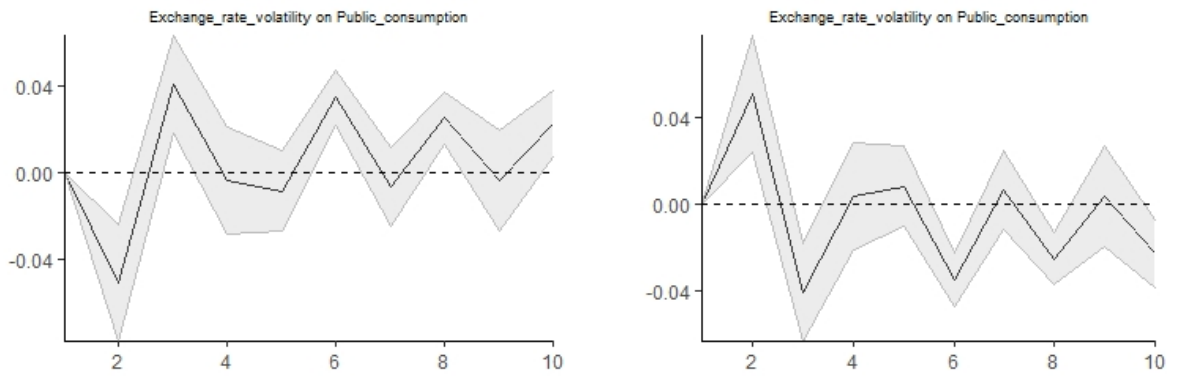
(a) Positive

(b) Negative



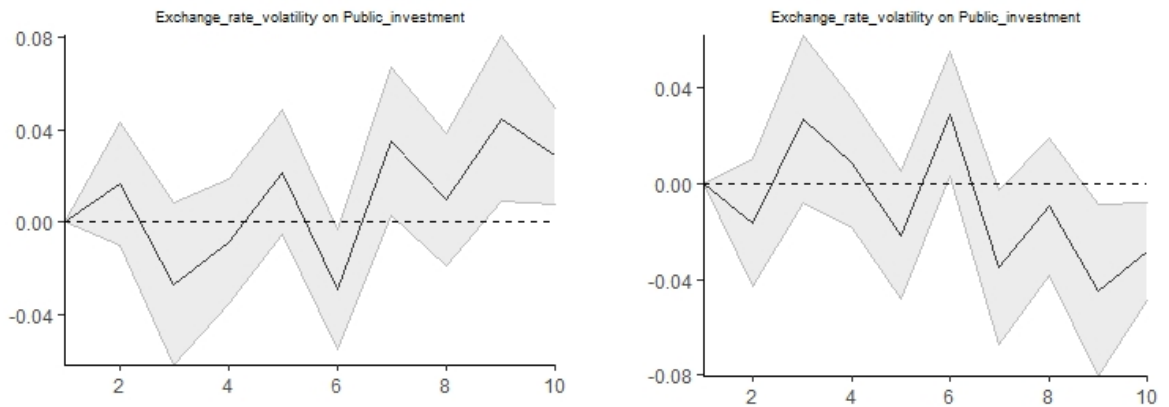
Source: authors' illustration based on SARB data.

Figure A6: Impulse response functions to positive and negative public consumption innovations



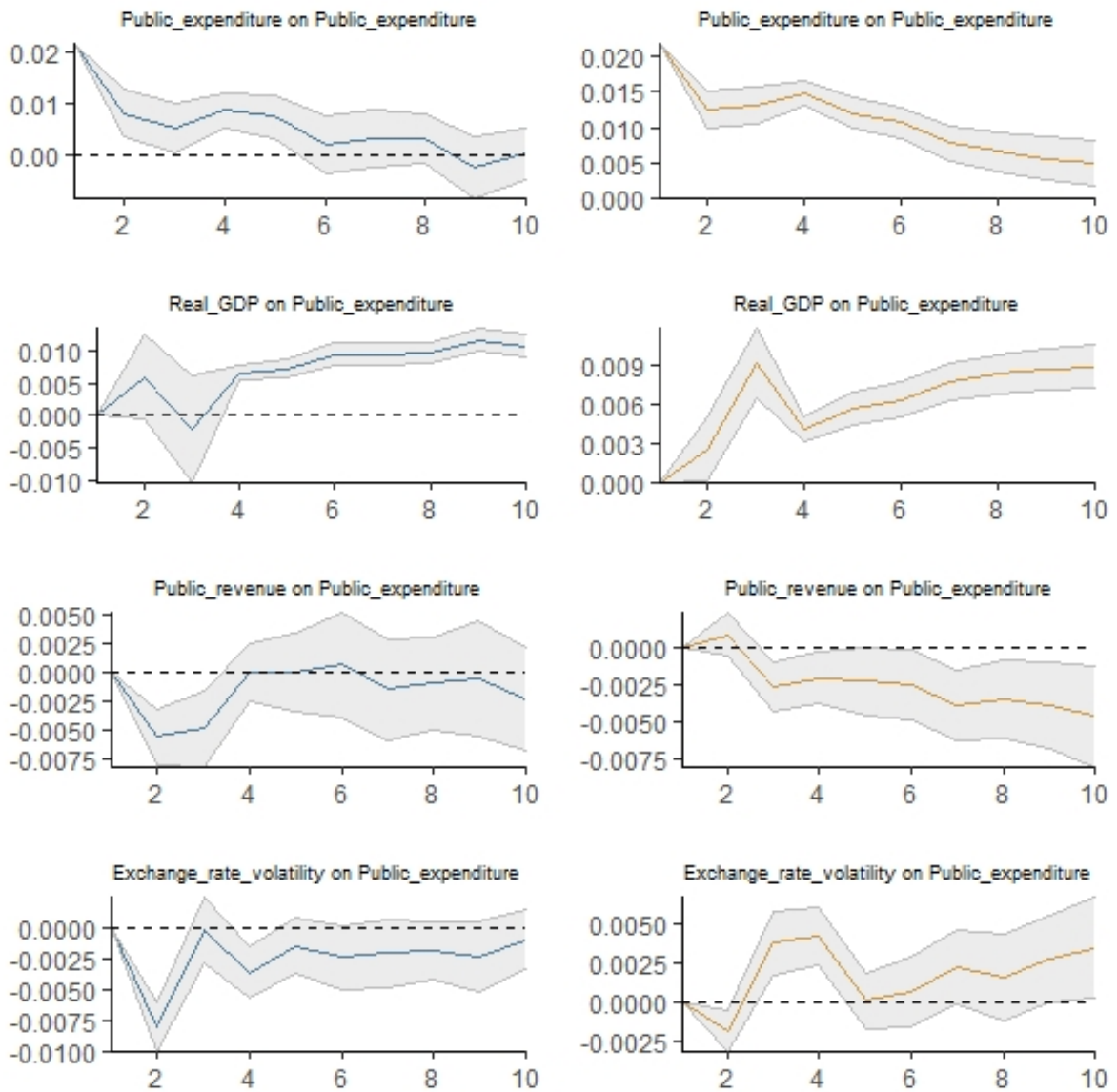
Source: authors' illustration based on SARB data.

Figure A7: Impulse response functions to positive and negative public investment innovations



Source: authors' illustration based on SARB data.

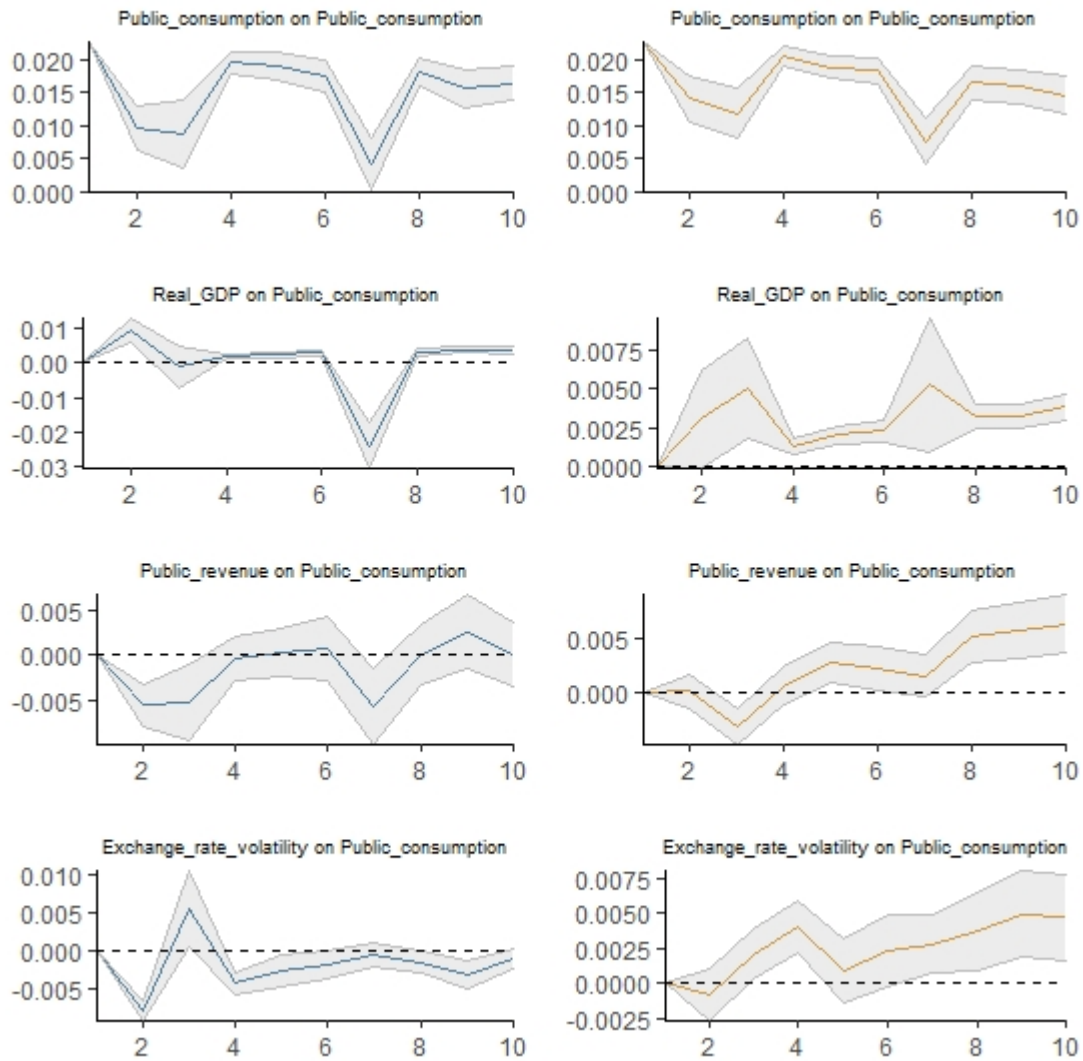
Figure A8: Impulse response functions to public expenditure innovation over the state of the economy



Note: the left column contains impulse responses for the expansionary state and the right column is for the recession state.

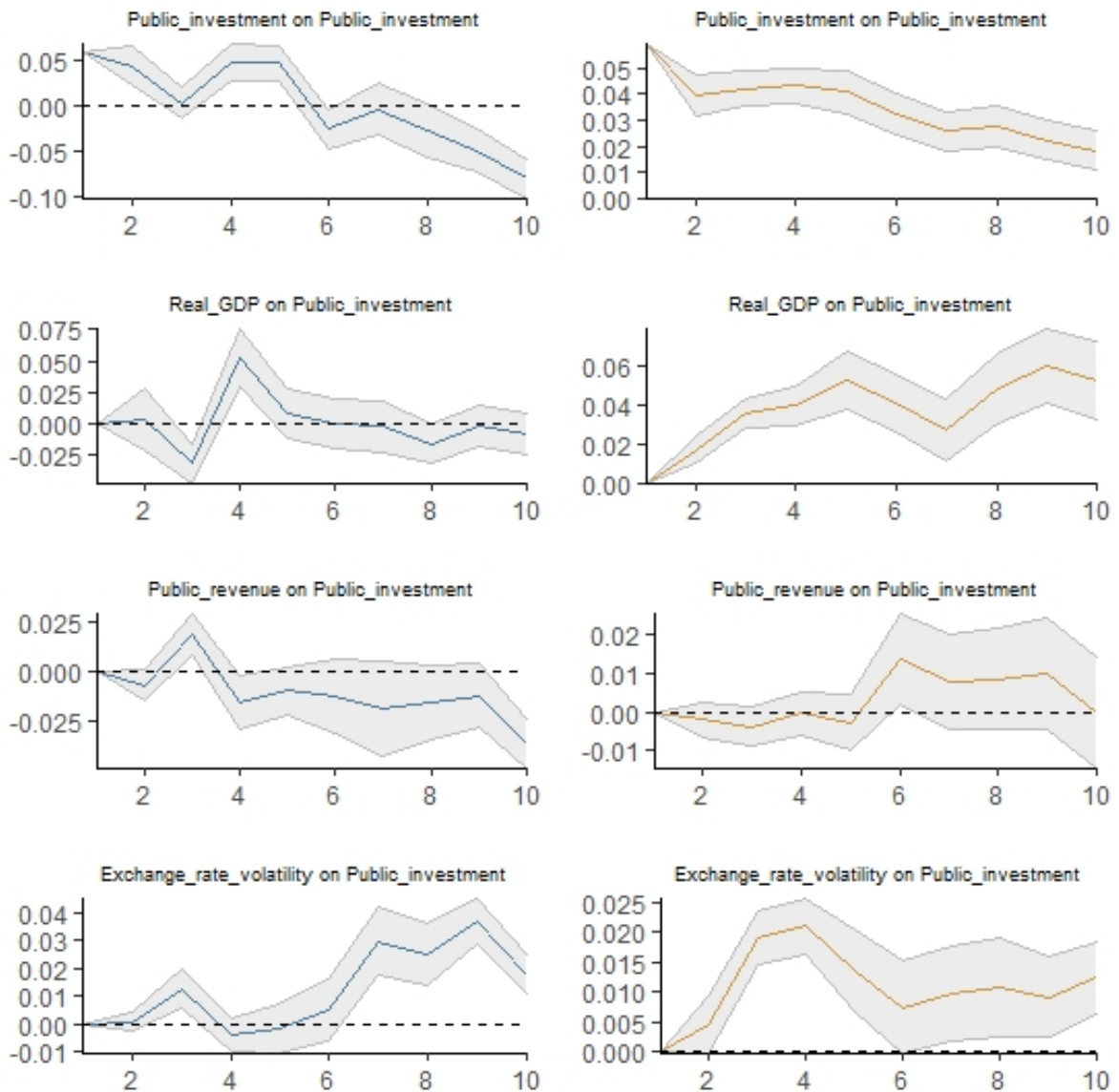
Source: authors' illustration based on SARB data.

Figure A9: Impulse response functions to public consumption innovation over the state of the economy



Note: the left column contains impulse responses for the expansionary state and the right column is for the recession state.
 Source: authors' illustration based on SARB data.

Figure A10: Impulse response functions to public investment innovation over the state of the economy



Note: the left column contains impulse responses for the expansionary state and the right column is for the recession state.

Source: authors' illustration based on SARB data.