School of Economics Macroeconomic Discussion Paper Series

# Fiscal Policy Uncertainty and Economic Activity in South Africa

Kevin Kotzé

Date: 2017 (April)
Number: 2017-02

# FISCAL POLICY UNCERTAINTY AND ECONOMIC ACTIVITY IN SOUTH AFRICA

Kevin Kotzé*

April 2017

**Abstract**

This paper considers the effect of fiscal volatility shocks on key macroeconomic variables. The identification of these shocks is derived from a stochastic volatility model that is applied to policy rules for each fiscal instrument. Thereafter, a vector autoregressive model makes use of these measures in a reduced-form setting to consider the effect of an aggregate fiscal volatility shock on economic output, consumption, investment, prices and interest rates. The final part of the analysis involves the construction of a dynamic stochastic general equilibrium model that may be used to investigate the effects of an unexpected increase in the volatility of each fiscal instrument. The results suggest that fiscal volatility shocks produce prolonged contractions in economic output, consumption and investment. In addition, the labour market is also negatively affected, while gross markups and inflation increase. Hence, it is suggested that fiscal volatility shocks have had an important adverse effect on economic activity in South Africa.

*JEL Classifications*: E32, E62, E63, C11, C32.

*Keywords*: Fiscal policy, emerging market economy, stochastic volatility, vector autoregressive model, dynamic stochastic general equilibrium model.

*School of Economics, University of Cape Town, Rondebosch, 7701, South Africa.

*"... despite the strength of South Africa's institutions, perceptions of weakening governance and of rising uncertainty regarding the direction of policies have been associated with low investment and consumer confidence."*

International Monetary Fund (2016)

# 1 Introduction

Policy uncertainty has the potential to affect economic activity through a number of different channels. For example, the precautionary savings motive of the household may encourage these agents to increase savings and decrease consumption to insure themselves against the effects of future shocks (Carroll *&* Kimball, 2008). Similarly, risk-adverse firms would be more reluctant to commit to investment and hiring decisions under conditions of greater uncertainty.[1] Such firms would also usually choose to make use of larger markups over marginal costs when faced with nominal price rigidities, which would result in a contraction of demand and potential output.[2]

It has also been suggested that higher degrees of uncertainty are associated with an increase in risk premia, which amplifies financial stress and increases the probability of corporate defaults (Christiano *et al.*, 2014). In addition, when this uncertainty relates to the policy of a particular country, this may increase the cost of fiscal debt. For example, Standard and Poor's (2017) noted that one of the reasons for downgrading South Africa's credit rating was "... political and institutional uncertainty, where changes in the executive leadership, including the finance minister, have put policy continuity at risk." Fitch Ratings (2017) made a similar statement shortly thereafter, where it was noted that "... the failure of economic growth to recover is due to the sustained uncertainty relating to economic policy."[3]

The objective of this paper is to consider the quantitative effects of fiscal policy uncertainty on economic activity, where an increase in policy uncertainty is associated with an *unexpected* increase in the volatility of a particular fiscal instrument.[4] Hence, when modelling the time-varying volatility of a fiscal instrument (as an unobserved variable), the expected and unexpected changes in volatility are treated as independent processes, where a probability distribution is used to describe the unexpected changes in volatility.[5]

The initial part of the paper is concerned with the identification of the fiscal volatility shocks. To achieve this objective, policy rules are specified for the individual fiscal instruments, which include capital taxes, consumption taxes, labour income taxes and government

[1] A rationale for this "wait-and-see" behaviour may be derived from the finance literature, where investment choices are regarded as a series of financial options (and an increase in uncertainty would result in an increase in the value of an option). As such, firms would choose to hold onto these options rather than make a physical investment, which would be equivalent to relinquishing the right to such an option (Bernanke, 1983).

[2] When prices are not flexible and the quantity of demand needs to be satisfied, the marginal profit curve becomes convex in relative prices. This is essentially the inverse of the flexible price case that is discussed in Abel (1983), Hartman (1972) and Oi (1961).

[3] These press statements were released on 3 April 2017 and 7 April 2017, respectively.

[4] See, Balcilar *et al.* (2017) for an investigation into the effects of monetary policy uncertainty on economic activity in South Africa, while Jooste *et al.* (2013) considers the effects of fiscal policy shocks on the South African economy. Note that the later of these studies is not concerned with the effects of volatility, uncertainty, or volatility shocks.

[5] To the best of the author's knowledge, this is the first attempt that has been made to describe the effects of an unexpected increase in fiscal policy uncertainty on macroeconomic activity in South Africa. Similar studies have been conducted for the United States economy by Born *&* Pfeifer (2014) and Fernández-Villaverde *et al.* (2015).

expenditure. These models are augmented with a stochastic volatility (SV) specification that allows for the inclusion of independent shocks that pertain to the fiscal rules and the respective fiscal volatility processes. The results from this analysis suggest that there have been a number of relatively large innovations to the volatility that is associated with certain fiscal policy instruments.

The measures for an unexpected increase in fiscal policy uncertainty are then combined with a number of macroeconomic aggregate variables in a vector autoregressive (VAR) model that makes use of the empirical framework of Christiano *et al.* (2005). This data-driven reduced-form model is then used to consider the effect of an aggregate fiscal volatility shock on measures of output, consumption, investment, wages, labour productivity, labour costs, prices and nominal interest rates. The impulse response functions are then used to show that a shock to fiscal policy uncertainty may be associated with persistent reductions in output, consumption and investment, while prices increase.

In the final empirical investigation, a dynamic stochastic general equilibrium (DSGE) model is constructed for the analysis of fiscal policy uncertainty within a theoretically consistent structural framework. The model incorporates a number of nominal and real rigidities that have been popularised in the new Keynesian literature. It also allows for the inclusion of nonlinear features and a nonstationary growth path. To describe the effects of the fiscal volatility shocks on the respective macroeconomic variables, the specification of the fiscal rules (with the augmented SV conditions) have been included in the model. After fitting the model to South African data, the results suggest that an unexpected increase in fiscal policy uncertainty is associated with a protracted decline in economic output, consumption and investment; which is consistent with the evidence from the reduced-form model. In addition, the labour market is also adversely affected over an extended period of time, while gross markups and inflation increase.

The paper is structured as follows: Section 2 describes the data that has been used in the study, while section 3 provides details of the SV models that are used to identify the fiscal volatility shocks. The discussion that relates to both the VAR and DSGE models are contained in sections 4 and 5, respectively. The conclusion is included in section 6.

## 2 Data

All of the models in this paper utilise data that was collected for the period 1990q1 to 2016q2.[6] To describe the evolution of fiscal volatility shocks over time, the SV model is applied to measures of fiscal revenue and expenditure. The three main sources of fiscal revenue are summarised into measures for capital taxes, $\tau_{k_t}$, consumption taxes, $\tau_{c_t}$, and labour income taxes, $\tau_{n_t}$. In addition, data pertaining to government spending as a share of output, $g_t$, is also used to describe the evolution of volatility shocks that are due to fiscal expenditure.

To derive the measure for capital taxes, the sum of the seasonally adjusted taxes on property and taxes on companies are expressed as a percentage of gross fixed capital formation. Similarly, consumption taxes are expressed as the seasonally adjusted domestic taxes on goods and services as a percentage of consumption expenditure. For labour income taxes, the seasonally adjusted income tax as a percentage of compensation to residents is utilised.[7] The fiscal rules incorporate an endogenous feedback mechanism for the current state of the government debt-to-output ratio, $b_t/y_t$, and the output gap, $\tilde{y}_t$. The debt-to-output ra-

[6]Du Plessis *&* Kotzé (2010, 2012) note that many South African macroeconomic variables were subject to at least one significant structural break that arose in the mid-1980s. Hence, data from that period is not included in this study.

[7]The X-13 seasonal filter is applied to the monthly data before it is aggregated to a quarterly frequency.

tio makes use of data for the seasonally adjusted loans that relate to the debt of national government and the output gap makes use of the filter that was developed by Hodrick & Prescott (1980, 1997).

The VAR model in section 4 makes use of the aggregate measure of fiscal volatility shocks that are due to the fiscal revenue (i.e. capital, consumption, and labour income taxes). The values for this measure relate to output of the smoother in the SV model. In addition, the model also makes use of measures for the natural logarithm of real goss domestic product per capita, consumption per capita, gross fixed capital formation per capita, total remuneration per worker, labour productivity, nominal unit labour costs and the price level (which is represented by the output deflator). The nominal short-term interest rate is also included and is expressed in terms of basis points.

The source for all the data is the South African Reserve Bank and additional details relating the respective variables is included in the appendix.

# 3 Stochastic Fiscal Volatility Shocks

It is assumed that fiscal policy is implemented with the aid of an underlying rule, where each instrument may be represented by a linear regression model that includes a SV representation for the identification of the innovations to the fiscal volatility shocks.[8] To characterise the features of the model, the fiscal instruments are stacked in the vector, $\tilde{x}_t$, which incorporates the variables, $x_t \in \{\tau_{k_t}, \tau_{c_t}, \tau_{n_t}, g_t\}$, after they have been demeaned. The specification of the model is then expressed as:

$$\tilde{x}_t = \rho_x \tilde{x}_{t-1} + \phi_{x,y} \tilde{y}_{t-1} + \phi_{x,b} \left( \frac{b_{t-1}}{y_{t-1}} - \frac{b}{y} \right) + \exp(\sigma_{x,t})\, \varepsilon_{x,t}, \quad (1)$$

$$\sigma_{x,t} = \mu_x + \rho_{\sigma,x} \left( \sigma_{x,t-1} - \mu_x \right) + \upsilon_{x,t}, \quad (2)$$

where the fiscal rule for each instrument makes use of information relating to the previous values for the output gap and the demeaned public debt-to-output ratio. The vector of coefficients in equation (1) could then be summarised as $\varphi = \{\rho_x, \phi_{x,y}, \phi_{x,b}\}$, which relate to the degree of smoothing in the fiscal rule, as well as the responses to the output gap and the public debt-to-output ratio, respectively. The shocks to the fiscal instrument would then be captured by the $\varepsilon_{x,t}$ process, which would incorporate unanticipated fiscal actions that are distributed $\varepsilon_{x,t} \sim \mathcal{N}(0,1)$.

Fiscal volatility is described by the time-varying $\sigma_{x,t}$ process, which takes the form of an autoregressive representation that is presented in equation (2). In this case, $\mu_x$ represents the average volatility that influences innovations to the fiscal shock, while $\rho_{\sigma,x}$ relates to the persistence in volatility. The innovations to fiscal volatility are captured by the $\upsilon_{x,t}$ term that is distributed, $\upsilon_{x,t} \sim \mathcal{N}(0,1)$.[9]

All the parameters in the model are estimated with the aid of Bayesian techniques that make use of Markov chain Monte Carlo (MCMC) methods and Gibbs sampling.[10]

[8] Redl (2015) makes use of an alternative methodology to generate a broad estimate for macroeconomic uncertainty, where he combines measures that are derived for macroeconomic forecasting uncertainty with an index that counts the number of times that "economic uncertainty" is mentioned in newspapers and official central bank publications.

[9] In this case the second-order moments of the fiscal instrument are described by the volatility of the process, while the third-order moments pertain to the innovations to the volatility process.

[10] The sampling procedure makes use of 100,000 draws, where the first 1,000 iterations are discarded and only every tenth draw is stored.

| | Capital Taxes | Consumption Taxes | Labour Taxes | Government Spending |
|---|---|---|---|---|
| $\rho_x$ | 0.97 | 0.629 | 0.871 | 0.957 |
| | [0.932, 1.002] | [0.467, 0.785] | [0.766, 0.965] | [0.902, 1.003] |
| $\mu_x$ | -5.014 | -12.565 | -12.093 | -10.696 |
| | [-13.09, 2.183] | [-13.01, -11.589] | [-12.68, -2.432] | [-11.944, 0.006] |
| $\phi_{x,y}$ | -0.014 | -0.011 | 0.053 | -0.005 |
| | [-0.028, -0.001] | [-0.035, 0.015] | [0.02, 0.088] | [-0.049, 0.04] |
| $\phi_{x,b}$ | 0.0 | -0.002 | -0.001 | -0.003 |
| | [-0.001, 0.002] | [-0.004, -0.001] | [-0.004, 0.001] | [-0.005, -0.001] |
| $\rho_{\sigma,x}$ | 0.994 | 0.661 | 0.863 | 0.938 |
| | [0.858, 0.999] | [0.155, 0.957] | [0.451, 0.998] | [0.731, 0.998] |
| $\upsilon_x$ | 0.651 | 0.602 | 0.466 | 0.587 |
| | [0.452, 0.921] | [0.283, 1.011] | [0.236, 0.841] | [0.362, 0.906] |

Table 1: Posterior Median Estimates

This implies that the parameter estimates and unobserved processes may all be treated as random variables that require prior distributions. Hence, the coefficients in the $\varphi$ vector take on conjugate prior values that have a mean value of zero.

With regards to the parameters in the volatility equation, the prior for $\mu_x$ is relatively uninformative and follows Kim *et al.* (1998), with a distribution of $\mu_{x,t} \sim \mathcal{N}\left(0, \sqrt{10}\right)$. The distribution of the persistence parameter $\rho_{\sigma,x}$ takes the form of a beta distribution, $\mathcal{B}_{\varsigma_a,\varsigma_b} = \int_0^1 t^{\varsigma_a - 1}(1-t)^{\varsigma_b - 1}\,\boldsymbol{dt}$, with positive hyperparameters $\varsigma_a$ and $\varsigma_b$. Since the support for this distribution is within the interval $(-1, 1)$, the autoregressive volatility process will be stationary. The values for these parameters are then selected to be consistent with those of Kim *et al.* (1998), such that $\varsigma_a = 5$ and $\varsigma_b = 1.5$, which provides a prior mean of 0.54.

Table 2 provides the median estimates for the posterior parameter values along with the 95% probability intervals. These results suggest that the standard deviation pertaining to some of the shocks of the fiscal instruments are relatively large. For example, the standard deviation for taxes on capital is almost equal to 66%.[11] In addition, it is also worth noting that the persistence in the effect of an innovation to the volatility of this fiscal instrument is relatively high. This would imply that shocks to the volatility that are associated with taxes on capital are large and long-lasting. These results also suggest that the volatility in the government spending process is relatively high and that the innovations to this fiscal instrument are fairly persistent. Note also that the feedback mechanism for the debt-to-output ratio is relatively small in all instances and that the sign of the coefficient suggests that government spending is slightly countercyclical.

Figure 1 displays the smoothed values of the volatility shocks that relate to each fiscal instrument, along with the 95% posterior probability intervals. All these graphs make use of a common vertical axis to facilitate comparability. The results suggest that innovations to fiscal volatility, stemming from capital taxes and government spending, have resulted in relatively large changes in these fiscal instruments.[12] In addition, it is worth noting that there are a total of twenty-one instances where the cumulative fiscal volatility shock is

[11] Since the traditional SV model makes use of a logarithmic form, the standard deviation is derived from $(100 \times e^{\mu_x})$.

[12] The large spike in the volatility of capital taxes corresponds to the introduction of capital gains tax in South Africa, which has been in existence since 1 October 2001.

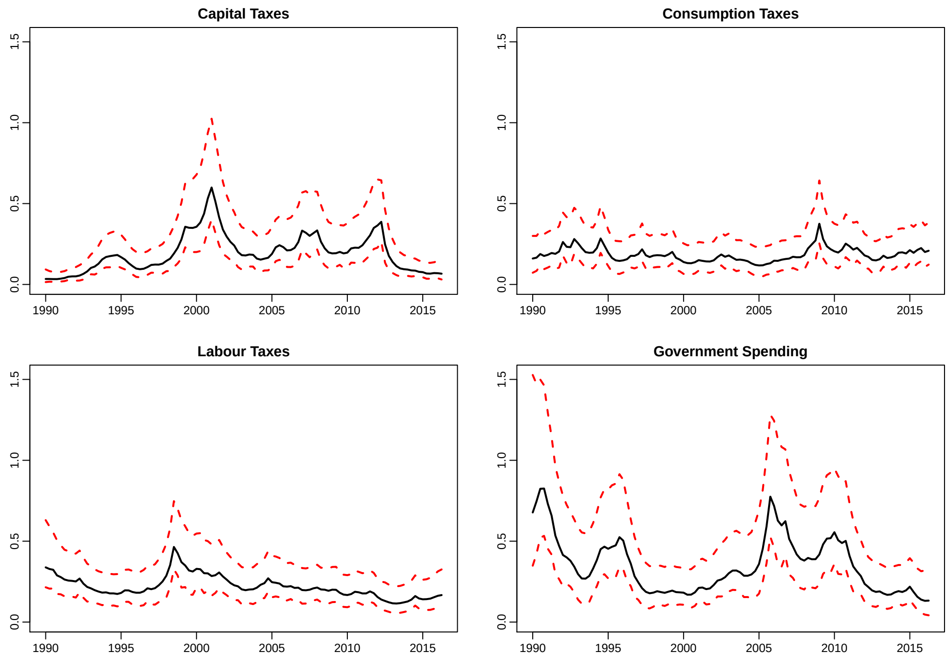



Figure 1: Fiscal Volatility: 1990q1 - 2016q2

greater than two standard deviations, when using the 95% intervals. For the given sample length, this is equivalent to almost 20% of the time span.

# 4 Vector Autoregressive Analysis

To describe possible interactions between the volatility shocks and key macroeconomic variables, this section makes use of a data-driven VAR methodology. This specific model follows the reduced-form structure of Christiano *et al.* (2005), which includes a constant and a deterministic time trend. It may be expressed as

$$X_t = \sum_{i=1}^{4} \Phi_i X_{t-i} + \Upsilon \Xi_t \tag{3}$$

where the $X_t$ vector includes measures for the aggregate volatility in the fiscal taxation instruments, output, consumption, gross fixed capital formation, remuneration, labour productivity, labour costs, the price level and interest rates.[13] $\Upsilon$ is a lower triangular matrix with diagonal terms equal to unity and $\Xi_t$ is a vector of zero-mean serially uncorrelated shocks that take on a diagonal variance-covariance matrix. The parameters in the model are estimated with the least-squares technique before the impulse response functions are derived, following a two standard deviation shock to the aggregate fiscal volatility instrument. The 95% confidence intervals that are provided around the dynamic paths for each of the respective variables make use of the approach that is described in Sims & Zha (1999).

[13] The ordering of the variables, which follows sequence that they have been listed, does not appear to have a significant effect on the results, where it is assumed that the fiscal volatility shocks are exogenous.

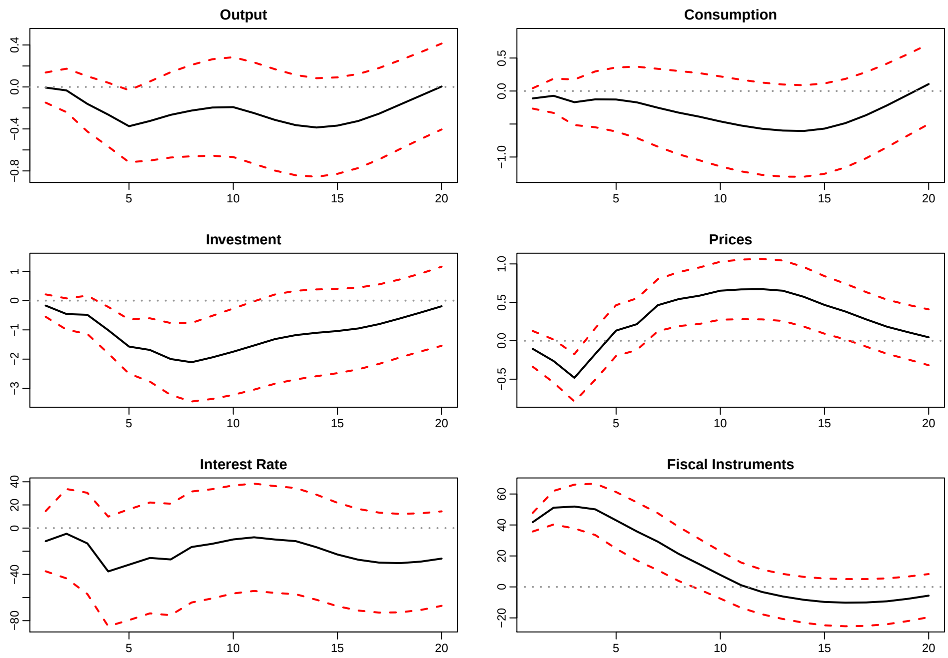



Figure 2: Impulse Response Functions - Fiscal Volatility Shock

Figure 2 contains the impulse response functions, where the graphs for output, consumption, investment and prices reflect percentage points on the vertical scale, while the nominal interest rate reflects annualised basis points. To interpret these results, it may be suggested that following a positive innovation to the fiscal volatility process, the values for consumption, investment and output decrease, while prices initially start to fall. This allows for a reduction in the nominal interest rate, which gives rise to inflationary pressure that starts to increase after a period of a year. This has a negative impact on the real wage and despite the relatively low interest rates, measures of output, consumption and investment remain depressed for close to twenty quarters. In addition, given the relatively poor economic conditions, the response of the central bank to the increase in the price level is somewhat muted. Note that the loss in output could exceed $-0.4\%$ per annum during certain quarters.

To investigate the robustness of these stylised facts for each of the separate fiscal instruments that are used to raise taxes, it is noted that a positive fiscal volatility shock gives rise to an initial decrease in economic activity for each of the three individual cases.[14] In addition, these findings are also largely consistent with those of Redl (2015), who considers the aggregate effect of macroeconomic uncertainty (from any source) on South African economic activity.

[14] As most of the fiscal volatility shocks that are due to government spending are usually associated with increases in expenditure, these shocks usually give rise to an initial increase in economic activity.

# 5 Macroeconomic Analysis

To preserve the effects of the innovations that relate to the fiscal volatility shocks, the following macroeconomic model is solved around a balanced growth path that is characterised by a unit root process, with the aid of a nonlinear third-order perturbation technique. The application of this particular approach, which employs a pruned state-space representation of the model, is described in Andreasen *et al.* (2013).[15] The nonstationarity in the model is introduced through a labour-augmenting productivity shock, which was found to contain useful information in the reduced-form analysis that is contained in section 4.

The model includes several new Keynesian features, where nominal rigidities are introduced through quadratic price adjustment costs for wages and prices that relate to the monopolistically competitive intermediate goods producers, as in Rotemberg (1982).[16] It has been suggested that these rigidities have the ability to improve the fit of the model when applied to South African data (Gupta *&* Steinbach, 2013). The rest of the model largely follows that of Fernández-Villaverde *et al.* (2015), Born *&* Pfeifer (2014) and Christiano *et al.* (2011), which have been used to investigate various effects of fiscal policy.

## 5.1 Households

It is assumed that the economy is populated by a single representative agent for the infinitely lived household that has separable preferences for consumption, $c_t$, government expenditure, $g_t$, and differentiated labour, $n_{j,t}$, where $j \in (0, 1)$. This gives rise to the utility function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ \Theta_t \left\{ \frac{(c_t - \zeta c_{t-1})^{1-\sigma}}{1-\sigma} + \mathrm{f}(g_t) - \psi \Psi_t^{1-\sigma} \int_0^1 \frac{n_{j,t}^{1+\gamma}}{1+\gamma} \; \boldsymbol{dj} \right\} \right]$$

where $\beta$ is the time-discount factor, $1/\sigma$ is the intertemporal-elasticity of substitution and $1/\gamma$ is the Frisch-elasticity of labour supply. Habits in consumption are represented by $\zeta$ and $g_t$ refers to the fraction of output that is attributed to government spending over the sample period. Hence, utility is a function of government spending, where $\mathrm{f}(\cdot)$ is an increasing concave function that is bounded from above. The demand shock, $\Theta_t$, takes the form of an autoregressive process, $\log \Theta_t = \rho_\Theta \log \Theta_{t-1} + \sigma_\Theta \varepsilon_{\Theta,t}$, where $\varepsilon_{\Theta,t} \sim \mathcal{N}(0, 1)$ and $\sigma_\Theta$ represents the volatility in this particular shock. Similarly, the nonstationary labour-augmenting productivity shock is represented by $\Psi_t$ and takes the form of a random walk plus drift, $\log \Psi_t = g_\Psi + \log \Psi_{t-1} + \sigma_\Psi \varepsilon_{\Psi,t}$, where $\varepsilon_{\Psi,t} \sim \mathcal{N}(0, 1)$ and the drift term represents the steady-state growth rate of the economy.

The budget constraint for the household may then be expressed as

$$(1 + \tau_{c,t})\, c_t + i_t + b_t + \Omega_t + \int_0^1 \frac{\phi_w}{2} \left( \frac{w_{j,t}}{w_{j,t-1}} - g_\Psi \right)^2 y_t \;\; \boldsymbol{dj} = \ldots$$

$$(1 - \tau_{n,t}) \int_0^1 w_{j,t} n_{j,t} \;\; \boldsymbol{dj} + (1 - \tau_{k,t})\, r_{k,t} u_t k_{t-1} + \tau_{k,t} \delta k_{t-1} + b_{t-1} \frac{r_{t-1}}{\pi_t} + \Pi_t$$

where the left-hand side includes the expenditure items for consumption, capital investment, $i_t$, government bonds, $b_t$, lump-sum taxes, $\Omega_t$, and real wages $w_{j,t}$ for the $j$ different

[15]This approach differs to that of other models that have been applied to South African data, such as Alpanda *et al.* (2010*a*,*b*, 2011) and Steinbach *et al.* (2009), which focus on the effects of a transitory monetary policy shock in a model that reflects the stationary moments of the data.

[16]Balcilar *et al.* (2015) also make use of the quadratic cost adjustment mechanism when fitting a nonlinear DSGE model to South African data.

types of labour. In this case, $\tau_{c,t}$ represents taxes on consumption expenditure and real wages are subject to a quadratic adjustment cost that is scaled by the steady-state growth rate of the economy, $g_{\Psi}$, and aggregate output, $y_t$. The income items on the right-hand side include after tax income from wages, where $\tau_{n,t}$ is the tax on labour income. The after-tax rental income that is earned on capital is then given by $(1-\tau_{k,t})\, r_{k,t} u_t k_{t-1}$, where $\tau_{k,t}$ is the tax on rental income, $r_{k,t}$ is the rental rate for capital, and $u_t$ is the capital utilisation rate. The taxable depreciation allowance on capital is $\tau_{k,t}\delta k_{t-1}$, where $\delta$ is the rate of depreciation. The real interest rate that is earned on government bond instruments is denoted, $r_{t-1}/\pi_t$, where $\pi_t$ is a measure of inflationary pressure. The profits of firms that are earned by the household are summarised by $\Pi_t$ and the aggregate homogeneous labour function may be expressed as,

$$n_t = \left[ \int_0^1 n_{j,t}^{\frac{\theta_w - 1}{\theta_w}} \, \boldsymbol{dj} \right]^{\frac{\theta_w}{\theta_w - 1}}$$

where $\theta_w$ is the elasticity of substitution for the different labour types. To maximise the expected utility of the household, one is then able to derive the first-order conditions with respect to $w_{j,t}$, $c_t$, $b_t$, $u_t$, $k_t$, and $i_t$.

## 5.2 Capital and Investment

The law of motion for capital incorporates a quadratic investment adjustment cost and a variable depreciation rate that depends on the capital utilisation rate, which may be expressed as

$$k_t = (1 - \delta u_t)\, k_{t-1} + \left[ 1 - \frac{\kappa}{2} \left( \frac{i_t}{i_{t-1}} - g_{\Psi} \right)^2 \right] i_t$$

where the depreciation rate is influenced by capital utilisation, such that the following quadratic expression may be used to describe this relationship, $\delta u_t = \delta + \phi_{u,1}(u_t - 1) + \frac{1}{2}\phi_{u,2}(u_t - 1)^2$.

## 5.3 Production

Domestic production is undertaken by two types of firms: final-goods producers and intermediate-goods producers. The final-goods producing firms are perfectly competitive, as is customary in most new Keynesian models (Galí, 2015). They are responsible for aggregating over the continuum of intermediate goods, $\iota \in [0,1]$, such that the final goods $y_t$ may be represented by

$$y_t = \left[ \int_0^1 y_{\iota,t}^{\frac{\theta - 1}{\theta}} \, \boldsymbol{d\iota} \right]^{\frac{\theta}{\theta - 1}}$$

where $\theta$ is the steady-state elasticity of substitution between the intermediate goods, such that $\theta/(\theta-1)$ is the gross mark-up over marginal costs that intermediate firms charge when they make their pricing decisions.

The intermediate-goods producing firms are monopolistically competitive. They hire differentiated labour to produce the differentiated goods, $y_{\iota,t}$, with the aid of a Cobb-Douglas production function,

$$y_{\iota,t} = k_{\iota,t}^{\alpha} \left[ \Psi_t n_{\iota,t} \right]^{1-\alpha}$$

where $k_{\iota,t}$ and $n_{\iota,t}$ are the capital and labour that are rented by the firm. The monopolistically competitive firms seek to manage the cost of production that is influenced by the real price of labour, $w_t$, and capital, $r_{k,t}$. At a point of equilibrium, all these firms will have identical marginal cost functions that may satisfy the expression

$$mc_t = \left[\frac{1}{1-\alpha}\right]^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha} \left[\frac{w_t^{1-\alpha} r_{k,t}^{\alpha}}{\Psi_t^{1-\alpha}}\right]$$

For the given demand function, intermediate-goods producing firms seek to maximise profits by setting prices subject to the quadratic cost adjustment function of Rotemberg (1982), which in this case is expressed in terms of deviations from the inflationary target, $\pi^{\star}$, of the central bank. Hence, these firms face the following optimisation problem:

$$\begin{aligned} \max_{p_{\iota,t+s}} \quad & \mathbb{E}_0 \sum_{s=0}^{\infty} \beta^s \frac{\lambda_{t+s}}{\lambda_t} \left[\frac{p_{\iota,t+s}}{p_{t+s}} y_{\iota,t+s} - mc_{t+s} y_{\iota,t+s} - \frac{\phi_p}{2} \left(\pi_{\iota,t+s} - \pi^{\star}\right)^2 y_{\iota,t+s}\right] \\ \text{s.t.} \quad & y_{i,t} = \left(\frac{p_{\iota,t}}{p_t}\right)^{-\theta} y_t \end{aligned}$$

where the term $\beta^s \frac{\lambda_{t+s}}{\lambda_t}$ is used to discount future cash flows and $p_{\iota,t}/p_t$ is the relative price index. These expressions may then be used to derive the Phillips curve for the evolution of prices in the economy.

## 5.4 Government

The central bank is assumed to conduct monetary policy according to Taylor's (1993) rule, which may be expressed in terms of deviations from steady-state values,

$$\tilde{r}_t = \left[\tilde{r}_{t-1}\right]^{\varrho_r} \left[\tilde{\pi}_t\right]^{(1-\varrho_r)\varrho_\pi} \left[\hat{y}_t\right]^{(1-\varrho_r)\varrho_y} \exp\left(\sigma_m\right) \xi_t$$

where $\tilde{r}_t = r_t/\bar{r}$ and $\bar{r}$ is the steady-state value for the nominal interest rate. Similarly, $\tilde{\pi}_t$ represents the deviations from the inflation target and the expression for deviations in output, $\hat{y}_t = y_t/\left(y\ \Psi_t\right)$, incorporates an adjustment for the steady-state growth rate in the economy. In this case the monetary policy shock is represented by, $\xi_t \sim \mathcal{N}(0,1)$.

As described in section 3, it is assumed that the fiscal authority makes use of the rules that were defined in equations (1) and (2) when setting taxes on capital, consumption and labour income. In addition, a similar rule is also used to describe the government spending process. These rules are subjected to the fiscal budget constraint that takes the form,

$$b_t = b_{t-1}\frac{r_{t-1}}{\pi_t} + g_t - \Big(c_t\tau_{c,t} + w_t n_t \tau_{n,t} + r_{k,t} u_t k_{t-1}\tau_{k,t} - \delta k_{t-1}\tau_{k,t} + \Omega_t\Big)$$

To ensure that monetary policy is more active than fiscal policy, the following condition that was proposed by Leeper (1991), has been imposed

$$\Omega_t = \Psi_t \left[\Omega + \phi_{\Omega,b}\left(\frac{b_{t-1}}{\Psi_{t-1}y} - \frac{b}{y}\right)\right]$$

where aggregate lump-sum taxes take the form of a relatively persistent process.

## 5.5 Parameterisation

The model is parameterised to match the annualised steady-state values of several South African macroeconomic variables and the specific features of the economy that are described in Alpanda *et al.* (2010*a*,*b*, 2011), Steinbach *et al.* (2009) and Du Plessis *et al.* (2014).[17] In this regard, the parameter for the steady-state growth rate of the South African economy is derived from the data sample over the period 1990q1 to 2016q2, which is equal to 2.4% per annum. The time-discount factor takes on a value of $\beta = 0.99$, which is consistent with most of the models that have been applied to South African data. Consumer preferences take on the posterior parameter estimate of Alpanda *et al.* (2011), which is $\sigma = 1.178$, while habits in consumption follow Du Plessis *et al.* (2014), where $\zeta = 0.808$. The inverse of the Frisch elasticity for labour supply follows Alpanda *et al.* (2010*b*) with $\gamma = 1.478$. The elasticity of substitution for demand and different labour types are set to $\theta = \theta_w = 6$, as in Alpanda *et al.* (2010*b*). The parameter for the persistence in the aggregate demand shock is also consistent with this study, where $\rho_\Theta = 0.812$.

The nominal rigidities utilise the equivalent parameter values that would have been derived from a Calvo (1983) measure in a linearised model. Hence the model makes use of the nominal wage rigidity in Du Plessis *et al.* (2014), who use a value of 0.69, while Alpanda *et al.* (2010*a*) generate a posterior parameter estimate of 0.459 for price rigidities. The utilisation rate is partially derived from the average ratio of investment to output over the sample period 1990q1 to 2016q2. It is normalised to a value of unity in the steady-state. The parameter value for the government spending to output ratio is also derived from the data over this sample period and takes on a value of 0.193. The quarterly rate of capital depreciation follows Du Plessis *et al.* (2014), where $\delta = 0.025$, and the share of capital in the production process follows Alpanda *et al.* (2010*b*), where $\alpha = 0.28$.

The parameter values for the monetary policy rule correspond to the values in Alpanda *et al.* (2010*a*), where $\varrho_r = 0.73$, $\varrho_\pi = 1.476$, and $\varrho_y = 0.476$. For the fiscal policy rule, the response of lump-sum taxes to debt is set to 0.0005, as the results from section 3 suggest that the aggregate reaction of the fiscal authority to debt is extremely low. All of the other parameter values for the fiscal policy rules are equivalent to those that are contained in Table 2, while the steady-state values for the fiscal instruments are derived from the data.

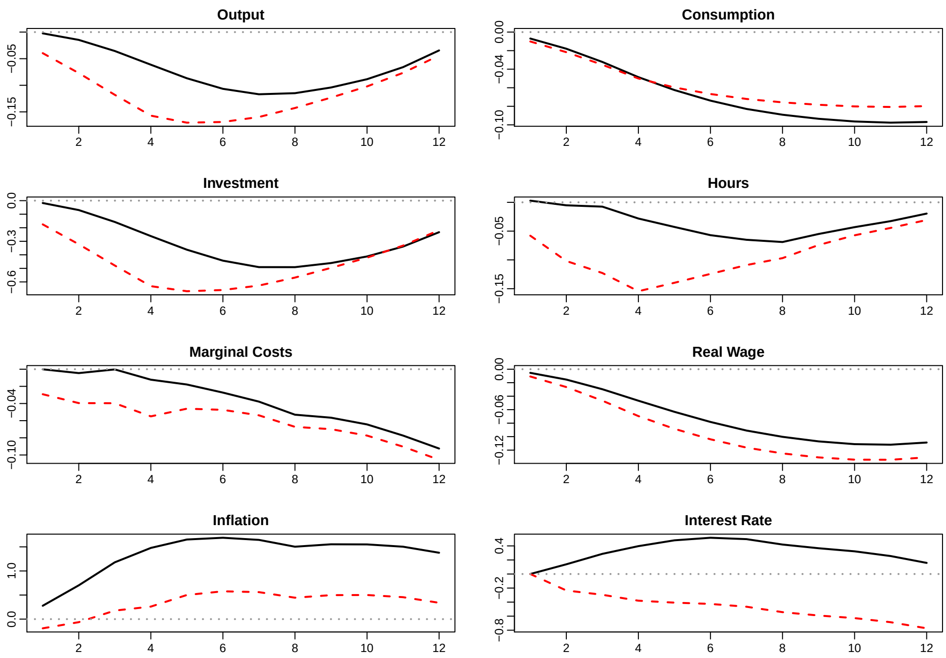
### 5.6 Results

The results of the model, as described by the impulse response functions that pertain to a positive innovation of two standard deviations to the fiscal volatility shock, are contained in Figure 3. In this case, the impulse response functions that are displayed only consider the effect of a shock to the taxes on capital, as each of the fiscal instruments are modelled individually in this framework and the effect of shocks to other instruments are very small. All of the results reflect the quarterly percentage change from the trend.

These results are largely consistent with the VAR evidence, where an innovation to the volatility that relates to taxes on capital produces a prolonged decline in output consumption and investment. In addition, the labour market is also adversely affected as working hours and the real wage decline over an extended period of time. With the reduction in demand, firms are able to decrease their marginal costs after a period of time, while households encounter an increase in inflationary pressure. In this case the central bank imposes a slight upward adjustment on the nominal interest rate, as the response to an increase in inflation is offset by the decline in output.

To interpret these results, it could be suggested that with an increase in the probability of a rise in the taxes on capital, households would choose to reduce their investment. In addition, the output contraction would give rise to a reduction in production as a result of a decline in demand. This would imply that firms would require less capital and the

[17] In most instances the parameter values that do not directly relate to the steady-state values of macroeconomic variables, correspond to the values that are closest to the median of the calibrated or posterior values that have been derived in these studies.




*Note:* Solid line - original monetary policy rule. Dashed line - alternative monetary policy rule.

Figure 3: Impulse Response Functions - Fiscal Volatility Shock to Taxes on Capital

cost of capital would subsequently decline. Given the nominal rigidities that have been introduced into the model, the gross markup is the inverse of real marginal costs, where a rise in marginal costs reduces the labour supply. Similarly, the decline in consumption may be due to the household's motive to increase precautionary savings in the interests of optimal consumption smoothing behaviour. The increase in savings and the decline in investment would result in a decline in the *real* interest rate, where in this case the rise in *nominal* interest rates is less than the rise in inflation. With the passage of time, the households and firms would expect that government will be able to increase spending and reduce future taxes, which would draw output and investment back to the steady-state trend. Therefore, these results are largely consistent with the work Bachmann *et al.* (2013), Jurado *et al.* (2015) and Fernández-Villaverde *et al.* (2015), which considers the role of uncertainty in developed world economies. In addition, these findings also support the work of Fernández-Villaverde *et al.* (2011), which suggests that uncertainty has an important effect on measures of economic activity in other emerging market economies.

Although the model would appear to replicate most of the stylised features of the VAR model, it is worth noting that the behaviour of the nominal interest rate differs. To reconcile this evidence with that of the reduced-form model, a slight amendment to the monetary policy rule may be imposed, where the central bank reacts (by a small degree) to the fiscal volatility shocks. This modification may be supported by the suggestion that since fiscal volatility shocks affect gross markups and inflation during subsequent periods of time, an increase in the nominal interest rate in response to a fiscal volatility shock may subdue the effects of future increases in price indices. Hence, the amended monetary policy rule could be specified as,

$$\tilde{r}_t = [\tilde{r}_{t-1}]^{\varrho_r} \ [\tilde{\pi}_t]^{(1-\varrho_r)\varrho_\pi} \ [\hat{y}_t]^{(1-\varrho_r)\varrho_y} \ [\tilde{\sigma}_{\tau k,t}]^{(1-\varrho_r)\varrho_\sigma} \ \exp(\sigma_m)\, \xi_t$$

where $\tilde{\sigma}_{\tau k,t} = e^{\sigma_{\tau k,t}} / e^{\sigma_{\tau k}}$. To ensure that the effects of this reaction are very small the parameter value for $\varrho_{\sigma}$ is set to 0.001. Note that this modification does not have a dramatic effect on the direction of the other impulse response functions, although the rise in inflation is relatively subdued. In addition, as a result of the larger decline in marginal costs and the higher *real* interest rate, the contraction in output is greater than what was previous obtained with the original monetary policy rule.

# 6 Conclusion

South African fiscal policy has been subject to varying degrees of uncertainty, where there have been long periods of stability and a few large shocks. This paper considers the effect of the shocks that influence the volatility of the fiscal instruments using data-driven reduced-form models and dynamic structural macroeconomic models. The results suggest that an unexpected increase in the volatility of a particular fiscal instrument reduces economic output by close to a half a percentage point per annum and that the effects of such shocks last for almost three years. Such a large single shock also has a persistent adverse influence over consumption, investment, hours worked, real wages, marginal costs and inflation; which makes them particularly debilitating as the possible influence of other policy interventions would be constrained.

Extensions to the model in the form of financial frictions, household heterogeneity and non-convexities in investment may increase the effects of any innovation to fiscal volatility. In addition, it should also be noted that these results pertain to the effects of a single shock and do not account for the impact of cumulative shocks that arise in successive quarters, which could have a much larger potential effect. In addition, accounting for asymmetric responses and distinguishing between the effects of positive and negative volatility shocks may also provide interesting results, particularly when applied to the fiscal instrument for government expenditure. The findings in this paper also suggest that while there is a large literature on the management of monetary policy expectations, it may be worthwhile to consider similar interventions that relate to fiscal policy. These are topics for future research.

# References


Abel, A.B. 1983. Optimal investment under uncertainty. *American Economic Review*, 73(1):228–233.

Alpanda, S., Kotzé, K. & Woglom, G. 2010*a*. The role of the exchange rate in a new Keynesian DSGE model for the South African economy. *South African Journal of Economics*, 78(2):170–191.

Alpanda, S., Kotzé, K. & Woglom, G. 2010*b*. Should central banks of small open economies respond to exchange rate fluctuations? The case of South Africa. *ERSA Working Paper*, No. 174.

Alpanda, S., Kotzé, K. & Woglom, G. 2011. Forecasting performance of an estimated DSGE model for the South African economy. *South African Journal of Economics*, 79(1):50–67.

Andreasen, M.M., Fernández-Villaverde, J. & Rubio-Ramìrez, J.F. 2013. The pruned state-space system for non-linear DSGE models: Theory and emprical applications. Technical Report NBER Working Papers 18983, National Bureau of Economic Research.

Bachmann, R., Elstner, S. & Sims, E.R. 2013. Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics*, 5(2):217–49.

Balcilar, M., Gupta, R. & Jooste, C. 2017. South Africa's economic response to monetary policy uncertainty. *Journal of Economic Studies*, 44(2).

Balcilar, M., Gupta, R. & Kotzé, K. 2015. Forecasting macroeconomic data for an emerging market with a nonlinear DSGE model. *Economic Modelling*, 44:215–228.

Bernanke, B.S. 1983. Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, 98(1):85–106.

Born, B. & Pfeifer, J. 2014. Policy risk and the business cycle. *Journal of Monetary Economics*, 68(C):68–85.

Calvo, G. 1983. Staggered prices in a utility maximizing framework. *Journal of Monetary Economics*, 12:383–398.

Carroll, C.D. & Kimball, M.S. 2008. Precautionary saving and precautionary wealth. In S.N. Durlauf & L.E. Blume (eds.), *The New Palgrave Dictionary of Economics*. Basingstoke: Palgrave Macmillan.

Christiano, L.J., Eichenbaum, M. & Evans, C.L. 2005. Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113:1–45.

Christiano, L.J., Eichenbaum, M. & Rebelo, S. 2011. When is the government spending multiplier large? *Journal of Political Economy*, 119(1):78–121.

Christiano, L.J., Motto, R. & Rostagno, M. 2014. Risk shocks. *American Economic Review*, 104(1):27–65.

Du Plessis, S. & Kotzé, K. 2010. The Great Moderation of the South African business cycle. *Economic History of Developing Regions*, 25(1):105–125.

Du Plessis, S. & Kotzé, K. 2012. Trends and structural changes in South African macroeconomic volatility. Working Paper 297, Economic Research Southern Africa.

Du Plessis, S., Smit, B. & Steinbach, R. 2014. A medium-sized open economy DSGE model of South Africa. Working Paper 14/04, South African Reserve Bank.

Fernández-Villaverde, J., Guerrón-Quintana, P., Kuester, K. & Rubio-Ramìrez, J.F. 2015. Fiscal volatility shocks and economic activity. *American Economic Review*, 105(11):3352–84.

Fernández-Villaverde, J., Guerrón-Quintana, P., Rubio-Ramìrez, J.F. & Uribe, M. 2011. Risk matters: The real effects of volatility shocks. *American Economic Review*, 101:2530–2561.

Fitch Ratings. 2017. Fitch downgrades South Africa to 'BB+'; outlook stable. Available at: `https://www.fitchratings.com/site/pr/1021851`

Galí, J. 2015. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*. 2nd edition. Princeton: Princeton University Press.

Gupta, R. & Steinbach, R. 2013. A DSGE-VAR model for forecasting key South African macroeconomic variables. *Economic Modelling*, 33:19–33.

Hartman, R. 1972. The effects of price and cost uncertainty on investment. *Journal of Economic Theory*, 5(2):258–266.

Hodrick, R.J. & Prescott, E.C. 1980. Postwar U.S. business cycles: an empirical investigation. *Carnegie Mellon University Discussion Paper*, page no. 451.

Hodrick, R.J. & Prescott, E.C. 1997. Postwar U.S. business cycles: an empirical investigation. *Journal of Money, Credit and Banking*, 29(1):1–16.

International Monetary Fund. 2016. South Africa: Concluding statement of an IMF staff visit. Available at: `http://www.imf.org/en/News/Articles/2016/12/13/MS121316-South-Africa-Concluding-Statement-of-an-IMF-Staff-Visit`

Jooste, C., Liu, G.D. & Naraidoo, R. 2013. Analysing the effects of fiscal policy shocks in the South African economy. *Economic Modelling*, 32(C):215–224.

Jurado, K., Ludvigson, S.C. & Ng, S. 2015. Measuring uncertainty. *American Economic Review*, 105(3):1177–1216.

Kim, S., Shephard, N. & Chib, S. 1998. Stochastic volatility: Likelihood inference and comparison with ARCH models. *Review of Economic Studies*, 65(3):361–393.

Leeper, E.M. 1991. Equilibria under 'active' and 'passive' monetary and fiscal policies. *Journal of Monetary Economics*, 27(1):129–147.

Oi, W.Y. 1961. The desirability of price instability under perfect competition. *Econometrica*, 29(1):58–64.

Redl, C. 2015. Macroeconomic uncertainty in South Africa. Working Papers 509, Economic Research Southern Africa.

Rotemberg, J.J. 1982. Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, 49:517–31.

Sims, C.A. & Zha, T. 1999. Error bands for impulse responses. *Econometrica*, 67(5):1113–1156.

Standard and Poor's. 2017. South Africa long-term foreign currency rating cut to 'BB+' on political and institutional uncertainty; outlook negative.
Available at: `https://www.standardandpoors.com/en_US/web/guest/article/-/view/type/HTML/id/1825424`

Steinbach, R., Mathuloe, P. & Smit, B.W. 2009. An open economy new Keynesian DSGE model of the South African economy. *South African Journal of Economics*, 77(2):207–227.

Taylor, J.B. 1993. Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39(1):195–214.

| Number | Description |
|---|---|
| KBP1405 | Discount rates on 91-day Treasury Bills |
| KBP4109 | National government debt: Gold and Forex Contingency Reserve |
| KBP4113 | Total loan debt of national government |
| KBP4570 | National government revenue: Taxes on income, profits and capital gains |
| KBP4571 | National government tax revenue: Taxes on income, profits and capital gains |
| KBP4577 | National government tax revenue: Total taxes on property |
| KBP4582 | National government tax revenue: Total taxes on goods and services |
| KBP6006 | Gross domestic product at market prices (GDP) |
| KBP6007 | Final consumption expenditure by households: Total (PCE) |
| KBP6008 | Final consumption expenditure by general government |
| KBP6009 | Gross fixed capital formation (Investment) |
| KBP6240 | Compensation of residents |
| KBP6270 | Gross domestic product (GDP) per capita |
| KBP7009 | Total employment in the non-agricultural sectors |
| KBP7013 | Total remuneration per worker in the non-agricultural sector |
| KBP7014 | Labour productivity in the non-agricultural sectors |
| KBP7015 | Nominal unit labour costs in the non-agricultural sectors |

Table 2: South African Reserve Bank Data