ASYMMETRIC EFFECTS OF MONETARY POLICY: A MARKOV-SWITCHING SVAR APPROACH

By

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Abstract

This paper examines the effects of monetary policy on macroeconomic variables in Botswana as a developing small macro-economy using the Markov-switching structural vector autoregressive (MS-SVAR) framework, utilising time-series data from 1994: Q1 to 2019: Q4. The study makes use of bank rate (interest rate), inflation and output gap. The first model is a structural vector autoregressive (VAR) model that takes the form employed by Rudebusch and Svensson (1999), whilst the second one makes use of the same structure but includes Markov switching in the policy rule (i.e., Markov switching SVAR). Regime-switching models can effectively describe the data generating process when considering both in-sample and out of sample evaluations compared to the linear models, which submerge the structural changes that have occurred in the economy over the years. The results from the SVAR shows that monetary policy has a symmetric impact on the output gap and inflation. Therefore, it can be noted that non-linearities in the structural model do not necessarily imply asymmetric effects of shocks. Furthermore, the MS-SVAR shows that the Central Bank of Botswana responds differently to policy shocks in different regimes. This underscores the importance of regime-switching features in providing a more accurate description of the economy.

Keywords: Monetary policy, small macro-economy, Markov switching structural vector autoregressive model (MS-SVAR).

1 Introduction

While monetary policy objectives may differ across countries, the central goals of monetary policymaking worldwide invariably include price stability, sustainable external balance, sustainable output growth, and employment. (Adelakun and Yousfi 2020; Kazungu 2019). In economic literature, there is a distinction between expansionary and contractionary monetary policy. Expansionary monetary policy (which refers to a decrease in short-term lending interest rate) leads to increased investment and output. On the other hand, a contractionary monetary policy (i.e., an increase in short-term lending interest rate) aids in fighting high inflation (Pragidis, Gogas and Tabak, 2013; cited in James and Ali 2020). This implies the symmetric relationship between monetary policy and macroeconomic variables.

In the simple monetary policy reaction function, the relationship between monetary policy, output and inflation is assumed to be symmetric (Taylor, 1993). Therefore, monetary authorities must meet negative or positive inflation and output with equally weighted policy responses (Adelakun and Yousfi, 2020). However, there has been increasing empirical evidence that policy goal variables such as output, and inflation respond asymmetrically to monetary policy shocks. For instance, when a contractionary policy has a more substantial effect on output and inflation than an expansionary policy (Ülke and Berument, 2016; Adelakun and Yousfi, 2020).

The idea that monetary policy has asymmetric effects on output and inflation, which is not new and dates to the great depression in the 1930s when the traditional Keynesian economists vigorously discussed it, has profound implications for the efficacy of the policy and its transmission mechanism (Ülke and Berument, 2016). It is therefore not surprising that in the literature, there has been an increasing attempt to understand the asymmetric effects of monetary policy on the target variables (see Weise, 1999; De Grauwe, 2000; De Grauwe and Senegas, 2006; Karras, 2013; Mertens and Ravn, 2014; Santoro et al., 2014; Georgiadis, 2015; Lee and Yoon, 2016; Kilinc and Tunc, 2017; Fang, 2018).

The literature on the asymmetric monetary policy effect on economic aggregates falls broadly into two strands (Ülke and Berument, 2016). The first empirical strand studies asymmetries arising from the direction of the monetary policy action. The other strand studies asymmetries related to the business cycle phase at the time of policy implementation. According to a Markov process, the regimes are typically assumed to shift (see Garcia and Schaller 2002; Kaufmann, 2002; Chen 2007; and Chen et al., 2013). A common discovery that emerges from this latter strand of studies is that during periods of an economic downturn (recession), a monetary policy shock seems to have more significant effects than in the periods of an economic boom.

This paper investigates the effects of monetary policy on output and inflation in a small developing economy of Botswana. Specifically, the study empirically examines whether the impact of monetary policy in Botswana is asymmetric in terms of the phase of the business cycle when the policy was implemented, thus contributing to the limited existing body of literature in Botswana. The significance of this study emanates from the fact that the case of Botswana reflects a contradictory experience to the theoretical IS-LM model of monetary policy transmission through interest rates, where the tight monetary policy does not decrease inflation (Munyengwa, 2012). During the global financial crisis of 2007/2008, for instance, the adoption of a tight monetary stance by the Central Bank of Botswana was followed by an increased annual inflation rate, alongside the bank rate, far above the set 3-6 per cent objective range (Bank of Botswana, 2008).

Given that the effectiveness of monetary policy as a stabilisation policy instrument hinges greatly on an accurate calculation of the timing and effect on policy goal variables, the above observation motivates an investigation of whether key macroeconomic variables respond asymmetrically to monetary policy shocks. Yet, relatively little empirical work has been done in Botswana, even though it is pertinent for the conduct of monetary policy (see Kganetsano, 2007; Munyengwa, 2012). These studies were mainly restricted to exploring channels of the transmission mechanism of monetary policy and their effectiveness.

The empirical strategy employed consist of a two-step estimation procedure that involves an SVAR that takes the form of Rudebusch and Svensson (1999), whilst the second one makes use of the same structure but includes Markov switching in the policy rule - an extension of the model proposed by Hamilton (1989). In effect, this study will be the first application of the Markov-Switching SVAR model for Botswana, offering a novel approach to analysing and providing insights into monetary policy decisions of the Central Bank. The framework adopted in this study contributes to enhancing knowledge and analytical capacity on the subject matter in Botswana and Africa in general. Furthermore, since developing countries are moving towards evolving monetary policy frameworks, it is hoped that this study shall inspire other researchers to bridge the empirical literature gap in the context of Africa.

The contribution of this study to the existing empirical literature is therefore twofold. First, the paper assesses the co-movements among the economic variables through the business cycle and non-linearities in the evolution of the cycle (during expansions and recessions). Other studies, such as Kganetsano (2007) and Munyengwa (2012), explored the monetary policy transmission mechanism channels and supplied evidence that monetary policy affects the Botswana economy's real side. Still, none of the above studies examined whether such effects were likely to be asymmetric in terms of economic conditions and the nature of the policy action. The distinctive advantage of Markov switching processes, concerning the business cycle evolution analysis often supported by the literature, is their ability to account for the asymmetry of a time series and features such as non-linearity and the persistence of extreme observations (Anas et al., 2004). The Markov switching model, according to Krolzig (1997), shows a link between changes in cyclical phases and changes in regimes. The MS-SVAR method allows data to be used to characterize the features of different economic stages. This approach could be useful even if there is no precise correlation between cyclical phases and observed regimes, especially when detected regimes have a high level of persistence. In this respect, Markov switching models could provide valuable information to improve the perception of the current state of the economy.

The rest of the paper is organised into five sections. Section 2 provides an overview of the evolution of the monetary policy framework in Botswana, while section 3 explains the methodology and data used in the analysis. Finally, section 4 discusses the empirical results, and Section 5 summarises this study's findings and suggests policy recommendations.

2 Background

In many countries, monetary policy frameworks have evolved in response to the changing economic environment and institutional developments, and Botswana is no exception. From this perspective, this section attempts an analysis of the evolution of Botswana's monetary policy regimes, highlighting the volatility of the main macroeconomic variables targeted by monetary policy and underscoring the relevance of the methodology adopted in this study.

From the mid-1970s to the early 1980s, the objective of monetary policy was to promote domestic price stability and encourage domestic investment through low interest rates. However, to address the challenges posed by low levels of industrialisation, there were occasional increases in interest rates to boost capital flows. In addition, exchange rates were also used as a monetary policy instrument to mitigate imported inflation (Bank of Botswana, 2007).

Subsequently, in the 1990s, the critical instruments of monetary policy were interest rates, exchange rates, exchange controls, and commercial banks' liquidity position. The objective, however, remained unchanged until 1997, when it was directed towards promoting price stability (low and stable rate of inflation). The Central Bank of Botswana introduced in 2002 the decision to announce the inflation objective range for the subsequent year, which relied on the trading partner countries' inflation forecasts (Bank of Botswana, 2007).

In 2006, however, the Central Bank introduced a three-year medium-term inflation objective of 3% to 6%, which constituted a shift from the one previously adopted. This was an effort to consider a more realistic time horizon for policy to affect market changes without unduly compromising output growth (Bank of Botswana 2007).

Considering the lag in effects of policy changes on inflation, the Bank in 2006 introduced a rolling medium-term inflation objective set at 3% to 6%. The Bank uses the bank rate (interest rates) as the primary monetary policy instrument for achieving price stability. Figure 1 below depicts the movement of the variables under consideration. A detailed discussion of the trend in the variables, their nature and cyclical movements also follows.

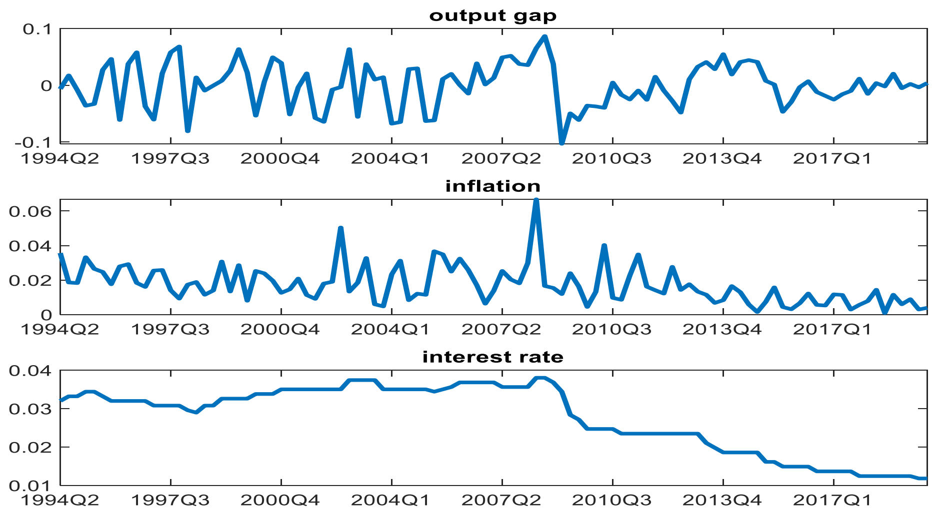


Figure 1: Transformed variables

A glance at the evolution of inflation and bank rate in figure 1 above suggests some co-movements. Overall, the dynamics of inflation, the output gap and the bank rate are consistent with global shocks and how the Central Bank managed the domestic economy in response to these external shocks. For inflation, the plot suggests a downward trend between 1994 and 1998 in line with the Asian financial crisis of 1998. Subsequently, inflation climbed sharply in late 2001, peaked in 2002 and then declined to an all-time low in the last quarter of 2003. Over the entire period of the study, the inflation trajectory peaked in 2008. The high inflation rate could be attributed to exogenous factors, especially fuel and food import prices (African Economic Outlook, 2012).

Considering output, the policy environment in the 1990s marked great emphasis on boosting private sector development through diversification and privatisation. However, as Maipose (2008) notes, the period was initially characterised by sluggish economic growth, high levels of unemployment, and poverty. This led to policy negotiations that targeted foreign investment in the mining industry. Consequently, there was substantial structural transformation with diversification from an agriculture-based economic focus to one where more attention was directed towards mining and manufacturing. As a result, the rate of economic growth improved as the economy benefitted from natural resource exports.

From the above trend analysis, it can therefore be concluded that in line with economic theory, the output was low in periods of tight monetary conditions, and it improved with the accommodative stance. However, inflation, on the other hand, suggests that the situation of Botswana could be diverting from traditional economic theory.

3 Methodology

This study investigates the asymmetric effects of monetary policy on the output gap and inflation in Botswana using the Markov Switching Structural Vector Autoregressive (MS-SVAR) model. The first model is a structural vector autoregressive (SVAR) model that takes the form employed by Rudebusch and Svensson (1999), whilst the second one makes use of the same structure but includes Markov switching in the policy rule (i.e., Markov switching SVAR).

SVAR models are used in economics to analyse the transmission mechanism of monetary policy. Once the monetary policy shock has been established, the monetary transmission mechanism can be observed from the way non-policy variables respond to the monetary impulse (Bagliano and Favero, 1998).

The use of the Markov-switching approach when investigating the effects of monetary policy has become popular. Initially appearing in switching regressions in Golfeld and Quandt (1973), the methodology has several extensions and refinements. For example, Hamilton (1989) and Krolzig (1997) combined switching models with vector autoregression to develop an MS-VAR, which is well equipped to characterise macroeconomic fluctuations in the presence of structural breaks or shifts (Simo-Kengne et al. 2013).

In most cases, macroeconomic data display structural breaks due to cyclical phases or economic crises. This motivates the employment of regime-switching models by central banks to identify these changes. According to Balcilar, Gupta and Kotzé (2017), the regime-switching models can effectively describe the data generating process when considering both in-sample and out of sample evaluations compared to the linear models that submerge the structural changes that have occurred in the economy over the years. Moreover, in the business cycle analysis literature, the Markov-switching models are well known for their ability to account for time series asymmetries or other forms of non-linearity. Therefore, this study employs the Markov switching vector autoregressive model to capture possible structural shifts and account for the asymmetries in different regimes.

3.1 Econometric Model

To begin with, the structural vector autoregressive framework (SVAR) formulated is specified as follows:

$$A_0 z_t = A(L) z_{t-1} + \varepsilon_{it} \qquad (1)$$

Where z_t represents the variables of interest and ε_{it} is a vector of structural innovations. The study considered three main shocks, the Taylor rule shock, aggregate supply shock and the aggregate demand shock.

The innovations in equation (1) are obtained by applying unique restrictions on A_0^{-1} in the vector of the errors of the VAR, $e_t = A_0^{-1} * \varepsilon_{it}$ (Kilian and Park, 2009). Hence equation (2) is a modification of equation (1)

$$y_t = A_0^{-1} A(L) y_{t-1} + A_0^{-1} * \varepsilon_{it} \qquad (2)$$

To identify A_0^{-1} in equation (2), the following restrictions are imposed

$$e_t = \begin{pmatrix} e_{1t}^{output} \\ e_{2t}^{inflation} \\ e_{3t}^{interest\ rate} \end{pmatrix} = \begin{bmatrix} \alpha_{11} & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix} \begin{pmatrix} e_{1t}^{IS\ curve\ shock} \\ e_{2t}^{Phillips\ curve\ shock} \\ e_{3t}^{Taylor\ rule\ shock} \end{pmatrix} \qquad (3)$$

The model is consistent with the traditional Philips curve (aggregate supply equation) that connects inflation to the output gap and an Investment-Savings (IS) curve that links output to a policy rate. More so, this model captures real-world macroeconomic policy models because it focuses on the output gap from the trend, as opposed to GDP growth. Also, it uses short-term bank rate as the policy instrument. Further, the model considers a Phillips curve with lag values in line with the natural rate hypothesis (Rudebusch and Svensson,1999). Lastly, the backward-looking Phillips curve is adopted because many policymakers have extensively used it (see Blinder, 1998; Fuhrer, 1997), and it is reliable (Rudebusch and Bomfim, 1997). The fundamental three equations for the SVAR models are presented in equations (4), (5) and (6). For comparative purposes, the main interest is in symmetry in the effects of the following:

$$\pi_{t+1} = \alpha_{\pi 1}\pi_t + \sum_{i=2}^{p} \alpha_{\pi 2}\, \pi_{t-1} + \alpha_y y_t + \varepsilon_{t+1} \quad (4)$$

$$y_{t+1} = \delta_{y1} y + \delta_{y2} y_{t-1} - \delta_r(\bar{i}_t - \bar{\pi}_t) + \mu_{t+1} \quad (5)$$

$$i_t = i_t^* + \pi_t + \beta\left(\pi_t - \pi_t^{target}\right) + \alpha(y_t) \qquad (6)$$

In the equations above π_t denotes inflation, y_t is the output gap, and i_t is the interest rate. On the other hand, $\bar{i}_t$,$\bar{\pi}_t$and p represent a four-quarter average bank rate, four-quarter inflation, and optimal lags. Equation (4) relates the output gap to lags of inflation which is consistent with the adopted characterisation of the Phillips curve. The assumption is that the summation of the lagged values of inflation is unitary. Equation (5) is the IS equation that relates output to the short-run interest rate. Finally, equation (6) is the Taylor rule that shows the Central Bank's reaction to deviations in inflation or output.

Equation (7) below shows the Markov Switching (MS) model, which is implemented to capture the possible non-linear relationship of the shocks on monetary policy. The general form of the MS model can be denoted as follows:

$$p(y_t \,|\, Y_{t-1}, X_t, s_t) = \begin{cases} f(y_t \vee Y_{t-1}, X_t; \vartheta_1)\ if\ s_t = 1 \\ f(y_t \vee Y_{t-1}, X_t; \vartheta_M)\ if\ s_t = M \end{cases} \qquad (7)$$

Where $Y_{t-1} = \{y_{t-j}\}_{j=0}^{\infty}$represents the history of y_t; X_t are strongly exogenous variables; ϑ_m is a parameter vector associated with regime *m*.

The formulation of a mechanism that governs the evolution of the stochastic and unobservable regimes on which the parameters of (7) depend is required for a complete definition of the statistical model. The development of regimes can be inferred from data once a law has been defined for the states s_t. The regime-generating process in MS models is a finite-state ergodic Markov chain with a finite number of states identified by transition probabilities:

$p_{ij}; Pr(s_{t+1} = j|s_t = i), \sum_{j=1}^{M} p_{ij} = 1\forall_{i,j} \in \{1, \ldots\ldots, M\}$ (8)

The transition probability matrix is specified as:

$$P = \begin{bmatrix} p_{11} & p_{1M} \\ p_{M1} & p_{MM} \end{bmatrix} \qquad (9)$$

Thus, the probability that the model changes from one state to another or stays in one regime depends on: $s_{t-1}; Pr(s_t|Y_{t-1}, X_t, S_{t-1}) = Pr(s_t|S_{t-1})$.

The corresponding MSVAR is represented in equation (10).

$$y_t = \beta_{1,s_t} + \beta_{2,s_t}\varepsilon_t^{\pi} + \beta_{3,s_t}\varepsilon_t^{i} + \beta_{4,s_t}\varepsilon_t^{y} + \sum_{j=1}^{p} y_{t-j,s_t} + \mu_{s_t} \qquad (10)$$

Where $\varepsilon_t^{\pi}, \varepsilon_t^{i}$ and ε_t^{y} denote the Phillips curve shock (aggregate supply shock), Taylor rule shock (monetary policy shock) and IS curve shock (aggregate demand shock), respectively. p is the optimal lag and μ_{s_t} represents the state-dependent errors.

3.2 Data and Estimation Method

The quarterly data used is sourced from the Central Bank of Botswana, compiled for 1994Q1-2019Q4. First, a structural vector autoregressive (SVAR) and Markov switching structural vector autoregressive (MS-SVAR) models are estimated using three variables: (i) output gap as the measure of real economic activity (ii) quarterly inflation, which is computed as percentage change, year-on-year, quarterly growth rates in the cost-of-living index; and (iii) the bank rate which is the monetary policy instrument measured in percentages. Then, through the estimation of the SVAR model, the effects of the monetary shocks series on the specified variables can be observed. After that, a Markov switching model is adopted. Markov Switching behaviour in a VAR model with multiple regimes effectively describes the data generating process, provides a basis for forecasting changes in central banks reaction function, and help in evaluating central banks' monetary policy strategy (Alstadheim et al., 2013).

Though Botswana is an open economy, for this study, the closed economy model is employed. According to Rudebusch and Svensson (1998), each proposed monetary policy rule should perform well in a variety of models. Most importantly, it must have a structure that is similar to that of end-users' (central bankers). A standard Central Bank policy model is used in this analysis, which uses short-term interest rates, output gap instead of output growth, and a Phillips curve with adaptive expectations that is consistent with the natural rate hypothesis. Furthermore, Kganetsano (2007) highlighted that monetary policy in Botswana affects real output and inflation through the interest rate channel, while the exchange rate channel is not strong. This is possibly due to the fact that a large part of the domestic economy is dominated by the mining industry, which accounts for approximately a third of government revenue. To ensure that other sectors of the economy are not overly influenced by the foreign price of diamonds, the exchange rate is determined on the basis of a peg to a small basket of currencies (which currently includes the SA rand and the IMF's SDR). Hence, the inclusion of exchange rate in a model for monetary policy in Botswana would not necessarily include the same amount of information, as would be the case for those countries that make use of managed or floating exchange rates. For these reasons, though the model glosses over the exchange rate channel, it still has enough richness.

Bayesian methods are used for the estimation of the parameters. First, a prior distribution for the parameters of the model is postulated. Then, this prior is updated using the information contained in the data, which is extracted using the likelihood function. Prior information is used in a Bayesian framework to help researchers discipline the model's behaviour. The posterior distributions defined as mean or mode are the focus of Bayesian estimation (Lubik and Matthes, 2015). All data transformations and estimation techniques are carried out in R and MATLAB software.

4 Empirical Results and Discussion

The section reports the results of empirical data analysis, including graphical and descriptive presentations, unit root, the MS-SVAR results, Impulse Response Function (IRF), historical and variance decompositions.

4.1 Descriptive Results

Table 1 below depicts the summary statistics of all the variables employed in the study. From the table, all the variables have positive average values (mean and median). In addition, the deviation of the variables from their means is small, as shown by the standard deviation, suggesting the data points are closer to the mean over the period under consideration. Regarding skewness, gross domestic product and bank rate were negatively skewed while inflation was positively skewed.

Table 1: Summary Statistics

	GDP	BANK RATE	INFLATION
Mean	0.0002	0.0276	0.0172
Median	0.0023	0.0146	0.0320
Maximum	0.0867	0.0380	0.0668
Minimum	-0.1031	0.0118	0.0009
Std. Dev.	0.0386	0.0087	0.0109
Skewness	-0.2540	-0.6113	1.3685
Kurtosis	2.5361	1.8767	6.2915

4.2 Unit Root Tests for Stationarity

Gujarati (2004) underscores the importance of ensuring stationarity in time series data before the analysis to avoid spurious results, given that macroeconomic variables tend to exhibit non-stationarity in the mean. For non-stationary variables, two transformation methods may be employed depending on whether the non-stationarity is due to deterministic or stochastic trends. Augmented Dickey-Fuller tests are used in this study to check for stationarity in the variables. The results of the Augmented Dickey-Fuller (ADF) tests with constant, time trend & constant and with no time trend and no constant at levels and first difference are presented in Table 2 below. The output gap is stationary in all three tests at level (i.e. I(0)). However, the bank rate and inflation were stationary after the first differencing (i.e. I(1)). The results confirm that none of the variables is stationary at the second difference, I(2). This means that when using the variables in levels, we need to proceed with caution, where the impulse response functions may indicate that the results may be spurious if the effects of the shocks fail to dissipate.

Table 2: Unit Root Test

	ADF test					
With Constant	**Level**			**First Difference**		
Variable	**ADF Stats**	**Critical**	**Order**	**ADF Stats**	**Critical**	**Order**
Output gap	-4.2708***	-3.5	I(0)	-4.5398	-3.5	
Bank rate	0.4535	-3.5		-3.1706**	-3.5	I(1)
Inflation	-0.2732	-3.5		-6.9887***	-3.5	I(1)
With Constant & Trend	**Level**			**First Difference**		
Variable	**ADF Stats**	**Critical**	**Order**	**ADF Stats**	**Critical**	**Order**
Output gap	-4.2433***	-4.05	I(0)	-4.5176	-4.05	
Bank rate	-1.1795	-4.05		-5.8897***	-4.05	I(1)
Inflation	-0.9709	-4.05		-6.9851***	-4.05	I(1)
Without Constant & Trend	**Level**			**First Difference**		
Variable	**ADF Stats**	**Critical**	**Order**	**ADF Stats**	**Critical**	**Order**
Output gap	-4.2975***	-2.59	I(0)	-4.5682	-2.59	
Bank rate	-1.1010	-2.59		-2.9585***	-2.59	I(1)
Inflation	-1.6436*	-2.59	I(0)	-6.7252	-2.59	

*Note: ***, **, * indicates the rejection of the null hypothesis of non-stationarity at 1%, 5%, 10% levels of significance respectively.*

4.3 Discussion of Econometric Results

The results from the two model estimations: Structural VAR and Markov switching regressions are presented below. Table 3 displays the in-sample statistics for the baseline model (non-Switching), along with the model that allows for switching in the monetary policy rule. These statistics appear to suggest that there is minimal difference in the in-sample fit of the two models. However, the Log-likelihood shows that the preferred model for this study is the Markov Switching SVAR.

Table 3: In Sample Statistics

	Non-Switching	Markov Switching
Log posterior	1062.8560	1078.1224
Log-likelihood	1074.6819	1091.2538
Log prior	-11.8259	-13.1314
Log MDD (Laplace)	1032.2126	1037.3455

Table 4 presents the prior and posterior parameter estimates for the non-switching model and the model with switching in the monetary policy rule.

Table 4: Parameter Estimates

Parameter	Distribution	Prior Mean	Non-switching		Markov Switching	
			Post mode	Post std	Post mod	Post std
$\alpha_{\pi1}$	Gamma	0.9	0.1512	0.2708	0.1520	0.2857
$\alpha_{\pi2}$	Normal	0.05	0.0593	0.5808	0.0607	0.6280
α_y	Gamma	0.1	0.0970	0.1611	0.0971	0.1708
δ_{y1}	Gamma	0.9	0.4256	0.4148	0.4251	0.4497
δ_{y2}	Normal	0.05	-0.3951	1.0032	-0.3959	1.2637
δ_r	Gamma	0.1	0.1567	0.1894	0.1567	0.1942
$\rho_i(k=1)$	Beta	0.6	0.9704	0.0160	0.9761	0.0072
$\rho_i(k=2)$	Beta	0.6			0.3945	0.5317
$\gamma_y\ (k=1)$	Gamma	0.5	0.2129	0.2284	0.1463	0.1184
$\gamma_y\ (k=2)$	Gamma	0.5			0.2782	0.0830
$\gamma_\pi\ (k=1)$	Gamma	1.5	1.2704	0.7946	1.5887	0.4312
$\gamma_\pi\ (k=2)$	Gamma	1.0			1.5877	0.1735
p_{12}	Beta	0.15			0.0554	0.0758
p_{21}	Beta	0.15			0.3818	0.2387
σ_π	Weibull	0.1	0.0112	0.0013	0.0112	0.0008
σ_y	Weibull	0.1	0.0383	0.0033	0.0383	0.0025
σ_i	Weibull	0.1	0.0010	0.0001	0.0007	0.0001

Parameter estimates. ρ_i, γ_y and γ_π show the interest rate smoothing probabilities, Central Bank's response to output and inflation, respectively.

The results from table 4 show that the coefficients of the smoothing probabilities differ slightly in the non-switching model and regime one of the switching model. For instance, the coefficient of the smoothing probability, ρ_i is 0.9704 in the non-switching model, while in regime one of the switching model (k=1), it is 0.9761. However, in regime two (k=2) it is 0.3945, which allows for relatively small smoothing in the interest rate. With regards to the value of the Central Bank's response to inflation, $(1-\rho_i)\gamma_\pi$, it is observed that the value is 0.0376 for the non-switching model. In regime one and regime two of the switching model, the values are 0.0380 and 0.9614 respectively. The results show that the Central Bank responds aggressively to changes in inflation in regime two of the switching model but moderately in the non-switching model and regime one of the switching model.

The results further suggest that when in regime one, the Bank responds in a manner that is like the non-switching model. That is, in the non-switching model, the value is $(1-\rho_i)\gamma_y$ = 0.0063 while in the switching model, the value is $(1-\rho_i)\gamma_y$ (k=1) = 0.0035. On the other hand, the value of the Bank's response to output in regime two is $(1-\rho_i)\gamma_y$(k=2) is 0.1685.

By way of summary, the Central Bank's response to inflation and output in the non-switching model is like that of regime one in the switching model. However, for the case of regime two, the response is slightly higher for both inflation and output. Finally, the Central Bank favours a high degree of smoothing when in regime one than regime two.

Figure 2 below shows the smoothed transition probabilities for the MS-SVAR model for two regimes together with the graphs of the actual data. The transition probabilities are essential to determine the time path of the various regimes.

From all the three graphs, regime two captures the main structural break (the global financial crises) in 2008/09, and the transition probabilities are less volatile. That is, the MS process spends more time in regime one ($p_{12} = 0.0554$) relative to regime two ($p_{21} = 0.3818$) and spells in regime two are much shorter.

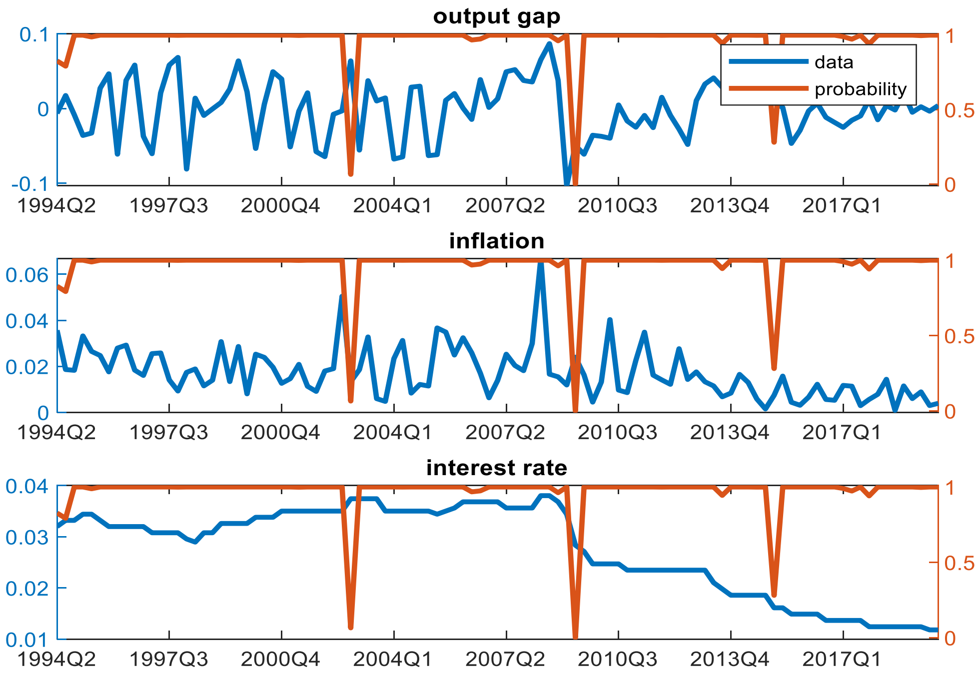


Figure 2: Smoothed Transition Probabilities

4.4 Impulse response functions

This approach is designed to determine the impact of policy shocks on other macroeconomic variables in vector autoregressive models (Kapetanios, Shin and Snell, 2006). Koop, Pesaran and Potter (1996) contributed to the literature, exploring the simple impulse responses for non-linear models. Hamilton (1989) and Kim and Nelson (1998) illustrated the analysis of simple impulse response functions in regime switching models. These regime invariance functions capture the relationship between endogenous variables and fundamental disturbances within each regime. The approach incorporates the hidden Markov process in a linear state-space representation.

The transmission mechanism of monetary policy is the trajectory along which the Central Bank's adjustments of monetary tools affect the economy. Due to the complexity of every economy, an abrupt change in the reserve bank's strategy propagates through many mediums to affect the intended target. The evaluation of the effectiveness of the Central Banks' monetary policy can be linked to the interpretation of the impulse response functions. Shocks can be transmitted to the money market via different routes.

Borrowing rate route

A reduction in the central bank rate lowers the cost of borrowing and capital acquisition and effectively increases gross demand for goods and services (Mishkin, 2004). With supply being constant, the average price level increases (Agha et al., 2005). It is worth noting that this mechanism pivots on the real interest rate.

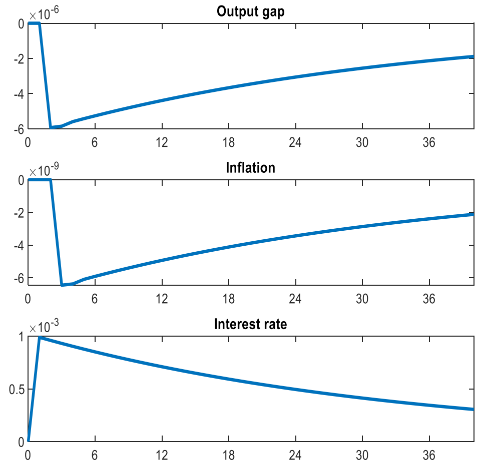
Monetary policy expansion $\Rightarrow$ market rate$\downarrow\Rightarrow$ investment $\uparrow\Rightarrow$ aggregate demand (GDP)$\uparrow\Rightarrow$ inflation$\uparrow$

The IRFs portray a mixed response of the variables to the various shocks. IRFs can show the effect of unpredictable shocks on observable macro aggregates. As observed in the methodology, the structural shocks can be recovered linearly from the history of the observed data, which is the defining property of the SVAR model. The study follows the estimation of structural IRFs from SVAR models using the economic intuition of backward-looking models. According to Bagliano and Favero (1998), the SVAR models focus on departures from the rules rather than the rules themselves. As a result, when Central Banks stray from their norms, it becomes possible to collect valuable data on macroeconomic variables' responses to monetary policy impulses, which can then be compared to forecasts from alternative theoretical models.

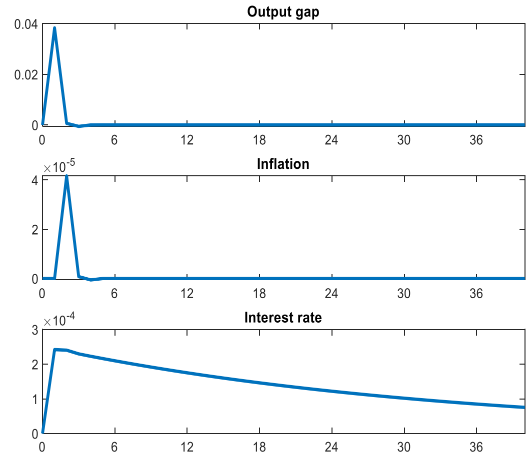
Figure 3 below shows the impulse response functions for IS curve shock, Philips curve shock and the Taylor rule shock. A positive IS curve shock resulting from a shift of the aggregate demand curve to the right results in a sharp increase in output gap and inflation. First, they increase with the occurrence of the shock but decrease immediately after two quarters to the steady-state for the entire period. Inflation, however, responds with a lag in the beginning. On the other hand, the interest rate increases instantaneously to an IS curve shock but gradually decays. As a result, the interest rate is the most persistent among all series. The IS curve shock dissipates after the impact period. Consequently, output gap and inflation revert to their equilibrium state over time. It is worth noting that an IS curve shock does not pose a threat to the Central Bank though it can move both the output gap and inflation simultaneously in the same direction. According to optimal theory (Clarida, Gali and Gertler, 2000), if the Central Bank is inflation averse, it should fully deal with the demand shock. Unfortunately, this cannot be achieved automatically via the Taylor rule used by the Central Bank. From the IS curve shock, the Taylor rule requires that the Central Bank raise the nominal interest rate in response to a positive demand shock. However, this action merely causes a movement along the aggregate demand curve without necessarily causing a shift as expected (Alpanda, Honig and Woglom, 2011). In this regard, if the Central Bank wants to mitigate the total demand shock, then it should increase interest rate more than required by the Taylor rule to "force" the aggregate demand curve to shift.

Phillips curve shock affects the three variables in a similar pattern as the IS shocks. However, unlike inflation which responds immediately, the output gap shows a slightly delayed response. The variables also respond by a higher percentage to a Phillips curve shock compared to that of IS curve.

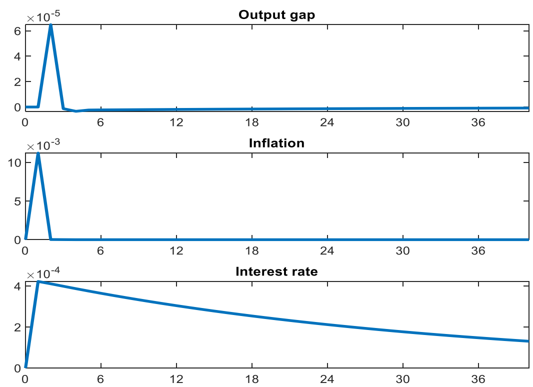
In this economy, the Taylor rule shock results in a contraction for both output and inflation. Output drops at the impact of the shock around quarter 2. After that, it rises again though remaining below the steady-state level. Inflation falls in response to a Taylor rule shock and then returns towards the steady-state value over an extended period. Even after 36 quarters, inflation is still below steady state. The interest rate jumps by about 1.0 percentage points and slowly decays but persistently stays above its steady-state level. The Taylor rule shocks did not dissipate overtime for all the variables.



IRFs to Taylor rule shock



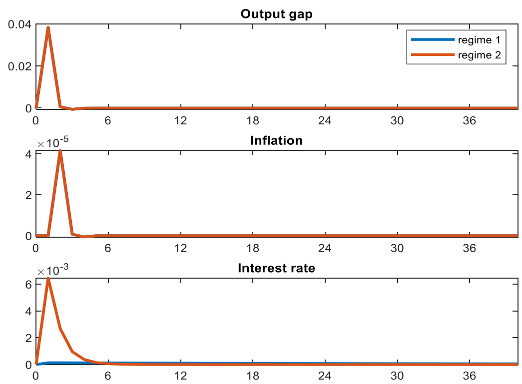
IRFs to IS curve shock



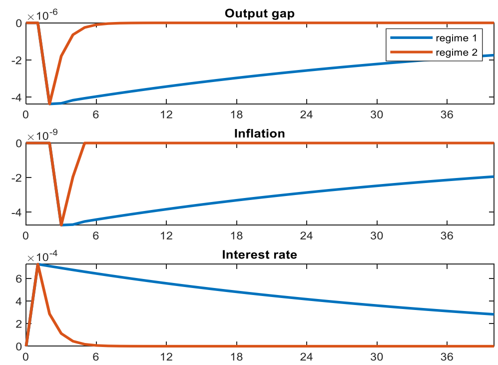
IRFs to Philips curve shock

Figure 3: Impulse Response Functions (IRFs) for SVAR model

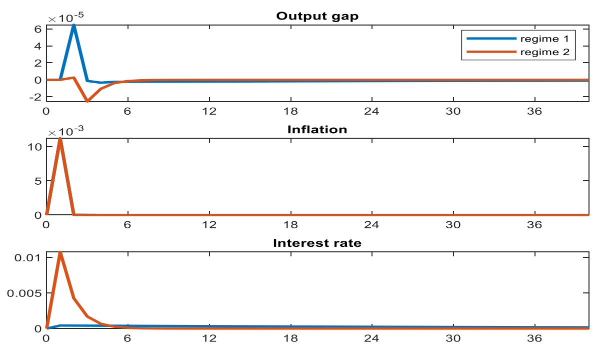
From figure 4, it is observed that output and inflation respond to an IS curve shock in the same manner. Specifically, both variables instantaneously rise in response to the shocks, and then later, they revert to equilibrium after the shock dissipates. On the other hand, the interest rate responds differently in both regimes. Notably, in regime two, it reacts positively and dissipates over time, but no response was observed in regime one. The impact of Taylor rule shock on the respective variables is different in both regimes. In regime one, output and inflation decline in response to the Taylor rule shock; after that, they rise again though remaining below the steady-state level. However, in regime 2, they decrease and then return to a steady-state over an extended period. In both regimes, the interest rate responds to the Taylor rule shock by an immediate increase followed by a gradual decrease. In regime one, the shock persists over the sample period, while it reverted to equilibrium in regime two. Lastly, the Phillips curve shock results on inflation and interest rate in both regimes are like those of the IS curve. On the other hand, output responds positively to the Phillips curve shock in regime one but negatively in regime two after the third quarter. However, they both return to a steady-state after the impact of the shock. Regime two can be associated with declining output and low inflation, where the Central Bank would also try to respond by implementing low-interest rates to stimulate economic activity.



IRFs to IS curve shock



IRFs to Taylor rule shock



IRFs to Phillips Curve shock

Figure 4: IRFs for Markov-switching SVAR model

Summing up the IRFs, it can be deduced that unanticipated changes in the policy rate have a significant negative impact on output and inflation, and the effect lasts longer in regime one. These results show that the implementation of monetary policy by the Central Bank conforms to the theoretical expectations. The monetary policy has a symmetric impact on the output gap and inflation. Therefore, it can be noted that non-linearities in the structural model do not necessarily imply asymmetric effects of shocks.

Historical decomposition of shocks and initial conditions

The historical decomposition shows the impact of shocks to deviations of the output gap, inflation, and interest rate from their equilibrium state. The irregular black line illustrates the up and down movement of the smoothed value of the corresponding endogenous variable from its equilibrium state at the specified parameter set represented by the posterior mode. The grey, red, green, and blue show the initial conditions, IS curve shock, Phillips curve shock and Taylor rule shock, respectively. The Philips curve relates inflation to the output gap, and the IS curve relates the output gap to the policy rate. The Taylor rule shows how the Central Bank responds to inflation or output changes. The initial condition shows the unobserved dynamics in the variables of interest. The negative contribution of shocks to inflation does not necessarily indicate disinflation.

The results from figure 4 below show the economic relevance and timing of various shocks that contribute to the dynamics of output, inflation, and interest rates. Each turning point in Botswana's business cycle corresponds with a peak or trough in the historical decomposition. In both the non-switching SVAR (top panel) and MS-SVAR (lower panel) models, monetary policy shocks (Taylor rule) do not have any role in the fluctuation of the inflation rate and output gap. On the other hand, output gap volatility depends entirely on IS curve shocks in both models. Moreover, inflation dynamics depends on the initial conditions and Phillips curve shocks. Notably, the initial conditions are associated with upward movement of the mean for the period whilst the Phillips curve shocks explain dynamics of both upward and downwards movement of inflation. This result suggests that the monetary policy rule (Taylor rule) has no direct impact on the inflation dynamics.

In addition, all three shocks explain the dynamics of interest rates. However, the initial shocks were more relevant in the only upward movements, whilst the Phillips curve and Taylor rule shocks explain the downwards dynamics. Therefore, the results underscore the role of initial conditions in understanding the overall dynamics in interest rates and inflation.

The model captures the timing of each of the shocks quite accurately. Our sample's most significant contraction phase occurs in 2008/9, which coincides with the Global Financial Crisis. Turning to output, the positive contribution of aggregate demand shocks declines sharply and contributes negatively to output dynamics until the end of the crisis and a few years into recovery. During the period under review, while the aggregate demand shocks were exerting negative effects on output, aggregate supply shocks, on the other hand, led to an increase in interest rates and inflation.

In summary, the result from the SVAR model is like that of the MS-SVAR model, especially concerning how output and inflation respond to shocks. However, the main difference between the two models is much clearer on the decomposition of interest rates. In the MS-SVAR model, all three shocks could replicate the time series of interest rates over the sample period. However, the IS shocks were almost insignificant in influencing the sequence of the interest rates in the SVAR model. This finding affirms the ability of the regime-switching models to describe economic activity through a data generating process effectively (see: Balcilar, Gupta and Kotzé 2017; Anguyo, Gupta and Kotzé 2020).

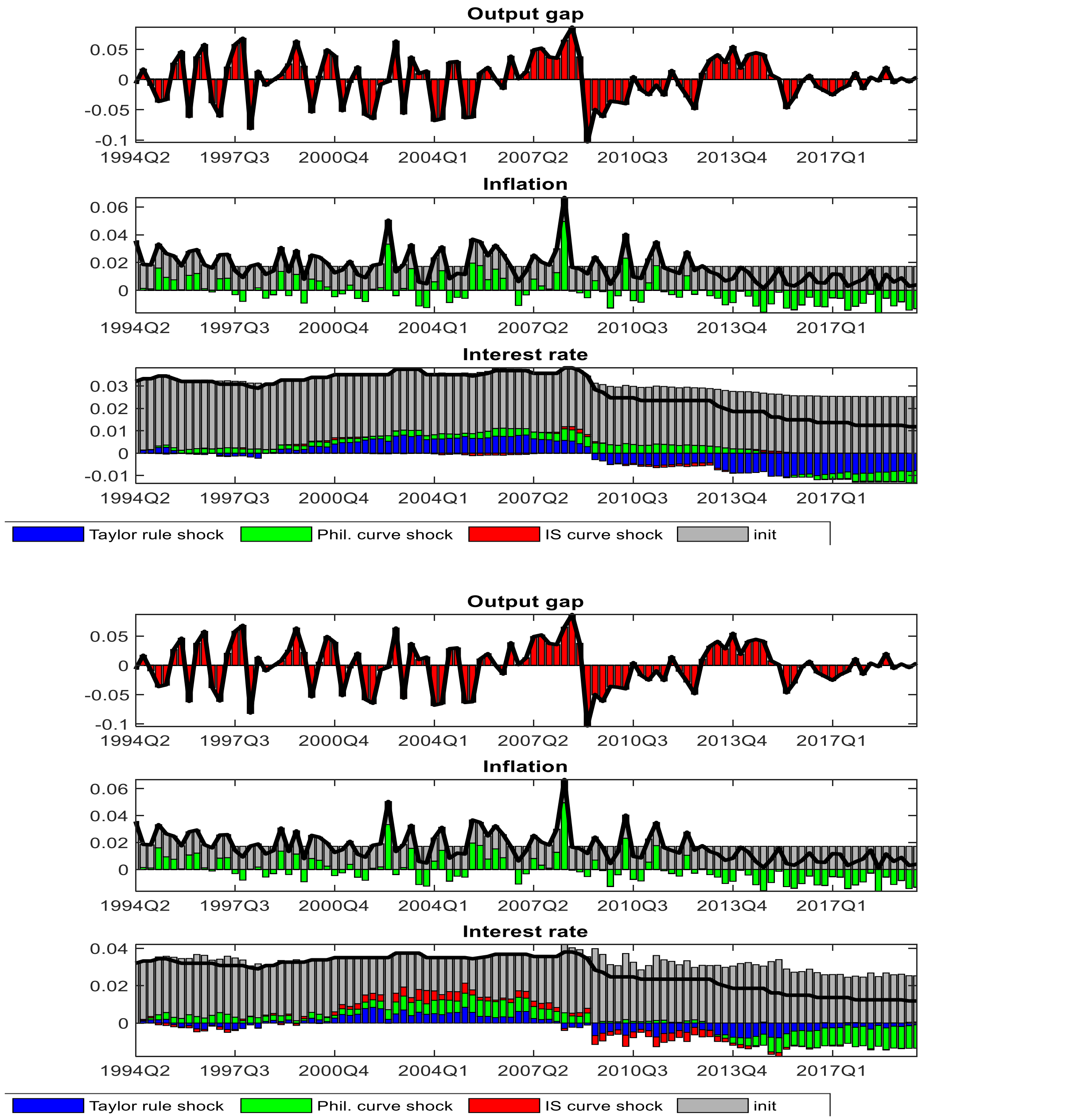


Figure 4: Historical decomposition of shocks: non-switching (top panel) and MS-SVAR (bottom panel)

Variance decomposition of shocks

Figures 5 and 6 below present the variance decomposition of the SVAR and the MS-SVAR, respectively. The blue colour represents the Taylor rule shock, green denotes the Philips curve shock, and grey represents the IS curve shock. The figures show how the three shocks explain the variations in the output gap, inflation, and interest rate. The contribution of each shock to the total variability of each endogenous variable is determined by the variance decomposition. As a result, it is utilised to figure out how much of each variable's variability is explained by a certain shock. The VAR model's dynamic nature also means that the contribution of each shock may fluctuate over time. One shock, for example, may be significant in the short term but less so in the long run.

Figure 5 shows that the Philips curve shock and IS curve shock explains the variations in the output gap and inflation accordingly, while the interest rate is explained by the Taylor rule and the Philips curve shocks. However, the Taylor rule dominates over the Philips curve in explaining interest rate dynamics.

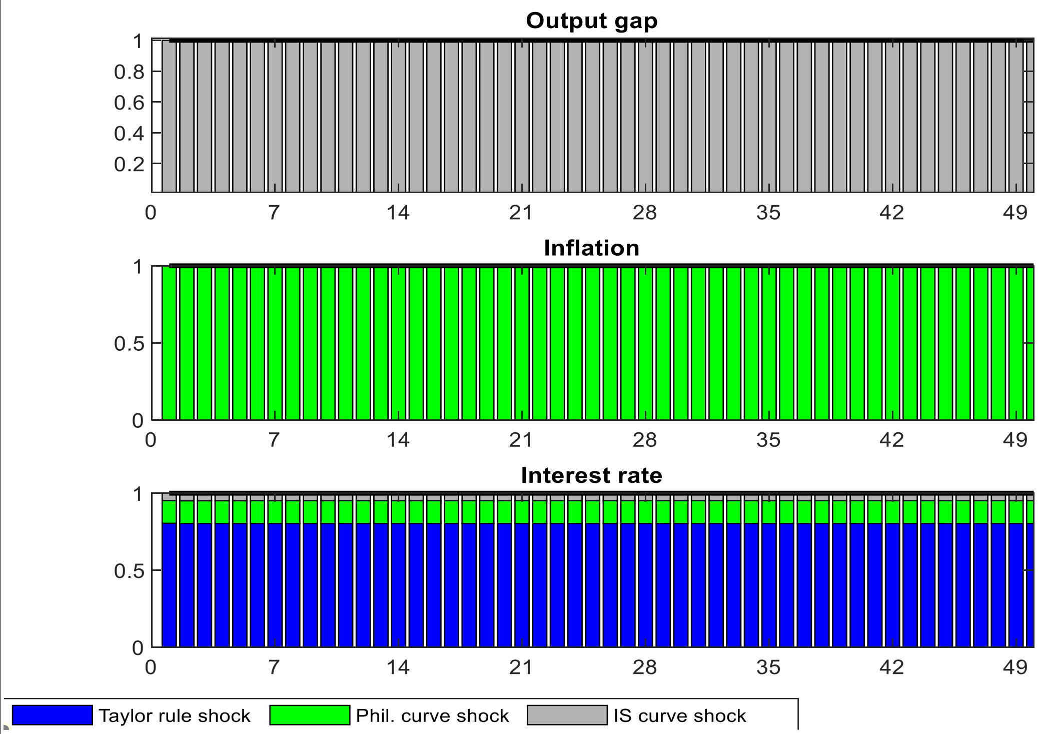


Figure 5: Variance Decomposition of Shocks in the non-switching model

Figure 6 shows the MS-SVAR in the two regimes. It can be observed that the IS curve explains the variations in output gap only, while inflation is explained by the shocks in the Phillips curve in both regimes. On the other hand, the results indicate that the Phillips curve and Taylor rule explain the variation in interest rates in regime one (left graph), but the Taylor rule explains (more than 50%). In regime two (right graph), the interest rate dynamics are illustrated by the IS curve and the Phillips curve; however, the Phillips curve shock dominates over the IS curve shock.

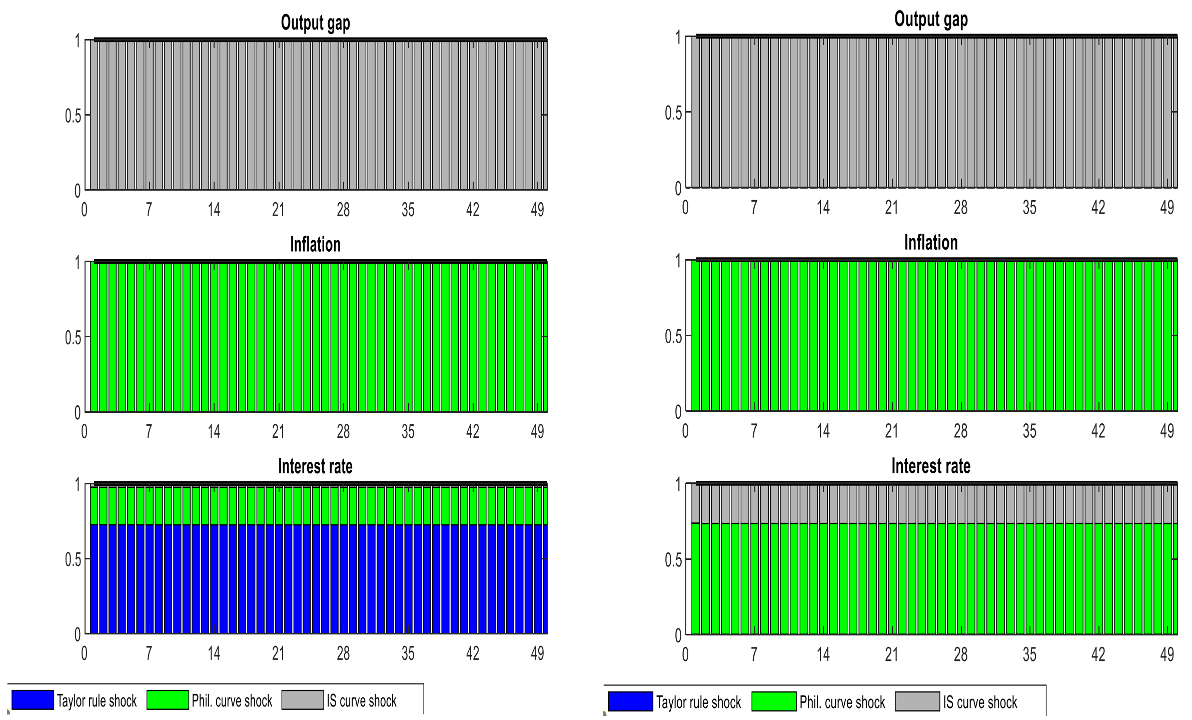


Figure 6: Variance Decomposition: Regime 1 and regime 2 of the switching model

Overall, the result from the SVAR is like that of the MS-SVAR in regime one. In both models, the Taylor rule dominates in explaining the dynamics in interest rate compared to the Philips curve. In regime two of the MS-SVAR, however, the Philips curve shock dominates over the IS curve in explaining the dynamics in interest rate. The historical and variance decomposition of shocks show that the Phillips curve shocks influence the inflation dynamics in Botswana. This implies that inflation relies more on its past values and dynamics in the output gap. Therefore, the transmission mechanism of monetary policy shock in Botswana conforms to the traditional economic theory.

5 Conclusion

This paper examined the effects of monetary policy on the output and inflation in Botswana as a developing economy using the MS-SVAR approach over 1994: Q1 to 2019: Q4. The variables considered in the study are output gap, inflation, and interest rates. Further, the study examined the shocks of Taylor rule (Central Bank's policy rule), Phillips curve (aggregate supply shock) and IS (aggregate demand) on the interest rate (bank rate), output gap and inflation. The first part of the study presented the outcome from the SVAR and Markov-switching SVAR models. After that, the various shocks were analysed. The result gives an insightful analysis of monetary policy in Botswana.

The transition probabilities indicate that the coefficients of the smoothing probabilities differ slightly in the two models. The results show that the Bank of Botswana reacts aggressively to changes in inflation in regime two of the switching model but moderately in the non-switching model and regime one of the switching model. Also, the Central Bank favours a high degree of smoothing when in regime one than regime two.

The impulse response functions for the SVAR model portray a mixed response of the variables to the various shocks. In this economy, the Taylor rule shock is negative for both output and inflation. Output drops at the impact of the shock around quarter 2; after that, it rises again though remaining below the steady-state level. Inflation too drops in response to a Taylor rule shock and then peaks over an extended period. Even after 36 quarters, inflation is still below steady state. The interest rate initially jumps but afterwards slowly decays and persistently stays above its steady-state level.

The estimated IRFs for the IS shocks show that output gap and inflation respond similarly. First, they increase with the occurrence of the shock but decrease immediately after two quarters to the steady-state for the entire period. Inflation, however, responds with a lag in the beginning. The interest rate, on the other hand, increases immediately to an IS curve shock but gradually decays. In fact, the interest rate is the most persistent among all series.

Phillips curve shock affects the three variables in a similar pattern as the IS shocks. However, unlike inflation which responds immediately, the output gap shows a slightly delayed response. The variables also respond by a higher percentage to a Phillips curve shock compared to that of IS curve.

For the MS-SVAR model, it can be deduced that unanticipated changes in the policy rate have a significant negative impact on output and inflation, and the effect lasts longer in regime one. This finding aligns with the transition probabilities results that revealed that the MS model spends more time in regime one than in regime two. Regime two can be associated with periods of declining output and low inflation where the Bank would also try to respond by implementing low-interest rates to stimulate economic activity.

The monetary policy has a symmetric impact on the output gap and inflation. Therefore, it can be noted that non-linearities in the structural model do not necessarily imply asymmetric effects of shocks. The results from the SVAR and the MS-SVAR models reveal the latter's superiority compared to the former. It is evident that models that include regime-switching features can inform policymakers, especially the Central Bank of Botswana, on the impact and transmission channel of monetary policy to achieve its aim of maintaining stable prices to promote economic development.

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