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Structural estimates of the South African sacrifice ratio

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Abstract: This paper estimates the output cost of fighting inflation—the sacrifice ratio—for the South African economy using quarterly data spanning the period 1998Q1–2019Q3. To compute the sacrifice ratio, the structural vector autoregressive model developed by Cecchetti and Rich (2001) based on Cecchetti (1994) is employed. Our findings show us a small sacrifice ratio, which lies within the range 0.00002–0.231 per cent with an average of 0.031 per cent, indicating a low level of output to be sacrificed while fighting inflation. Hence, the reserve bank is recommended to sustain an inflation rate within the target range and reap the benefits of a predictable and stable price path, as restrictive monetary policy has only a transitory effect on real variables like output.

Key words: inflation targeting, output, sacrifice ratio, South Africa, structural VAR model

JEL classification: E32, E52

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1 Introduction

Policy-makers are expected to outline a set of goals for the performance of the economy as well as to know the effects of the monetary policies that are implemented to achieve these goals. Monetary policy was considered ineffective in curbing high inflation rates until the early 1970s. Before then, policy-makers relied on fiscal policy as the main policy framework in controlling inflation as well as boosting the economy. However, from the mid-1970s, monetary policy authorities in advanced economies tried to control inflation using monetary aggregates; and later on, in the early 1990s, countries shifted from monetary targeting to inflation targeting (Kumo 2015). Inflation-targeting monetary policy was first employed by New Zealand, in 1990. Subsequently, a group of countries took inflation targeting as a prime goal of monetary policy. By 2010, 26 countries, half of them low-income countries and emerging market economies, had adopted an inflation-targeting monetary policy framework (Roger 2010), while two others were in the process of establishing a full inflation-targeting monetary policy (Hammond 2012). By the end of 2012, after Albania adopted an inflation-targeting monetary policy, 28 countries were following inflation-targeting monetary policies (Jahan 2012); and in 2016, India and Japan also adopted inflation targeting.

Inflation-targeting monetary policy differs in two ways from other monetary policies: in its emphasis on policy accountability and transparency; and in the existence of explicit public dedication to controlling inflation as the prime policy goal. As stated by Mishkin (2004) and Roger (2010), the inflation-targeting monetary policy approach has four core elements. First, there is a high degree of operational autonomy and an explicit central bank authority to adopt price stability as the primary goal of monetary policy. Second, there are explicit quantitative targets for inflation. Third, the central bank is at the top of the accountability chain for the performance of the inflation-targeting policy, mainly because of the high transparency of its policy strategies and their implementation. Fourth, it is founded on a forward-looking assessment of inflationary pressures. However, irrespective of the tools of the operational framework applied by the central bank, contractionary monetary policy actions are mostly associated with significant output losses (Hušek and Formánek 2005).

In recent years, controversies have arisen among economists regarding the establishment of price stability as the main goal of monetary policy. The proponents of price stability argue that it has only a transitory effect on real variables like output and unemployment, and they recommend that the monetary authority focus on price stabilization to reap the benefits of a predictable and stable price path (Aron and Muellbauer 2007; Mnyande 2008; Van der Merwe 2004). In contrast, its opponents argue that, since various rigidities are inevitable in every economy, such a policy will generate economic downturns and its cost will outweigh the benefits. The cost of disinflation is estimated through the use of the sacrifice ratio (SR) coefficient (Cecchetti and Rich 1999; Gali 1992). The SR is defined as the cumulative loss in output, measured as a percentage of one-year gross domestic product (GDP), associated with a one percentage point permanent reduction in the inflation rate (Neely and Waller 1996).

In today's economies, the disinflations due to the adoption of low inflation-targeting monetary policies are perhaps the dominant cause of recessions. In the United States, for example, there were recessions in the early 1970s, mid-1970s, and early 1980s. All of these downturns were associated with falling inflation stemming from tight monetary policy (Romer 1991).

A remarkable decline in inflation has been witnessed by the global economy since the early 1970s. Worldwide, inflation has fallen, with median annual national consumer inflation down from a peak of nearly 17 per cent in 1974 to about 1.7 per cent in 2015, which is the lowest level of consumer price inflation in almost half a century. In line with the global trend, a sharp decline in inflation over the same time horizon has been experienced by emerging markets and developing economies (EMDEs). After reaching its highest rate in 1974 at 17.3 per cent per annum, inflation in the EMDEs declined to 3.5 per cent per annum in 2017. Besides, several monetary authorities became more committed to low inflation targets.

In South Africa, for example, on 13 March 1998, the bank rate was replaced by the repurchase (repo) rate at which the South African Reserve Bank (SARB) provides liquidity to the South African banks. The SARB operates objectively to maintain the consumer price index (CPI) inflation rate within 3–6 per cent, which was the initial inflation band for 2002 and 2003. A narrower inflation target band was set at 3–5 per cent for the years 2004 and 2005, though the initial target range, 3–6 per cent, remains intact as of today. To achieve the targeted inflation rates, the SARB has been using the repo rate as its main instrument.

The introduction of inflation-targeting monetary policy brought a declining trend in South Africa's inflation rate. The average rate of inflation was 6.8 per cent from 2000 to 2008, compared with 7.4 per cent from 1995 to 1999. It further declined to an average of 5.55 per cent between 2000 and 2013. The period from 2003 to 2006 is considered the most successful period in the implementation of the targeting policy, with an inflation rate of between 3 and 6 per cent. Even though the global financial crisis had a significant impact on both domestic and global inflation between 2008 and 2009, the average level of inflation for South Africa more or less followed the same trend as its major trading partners.

In recent reports, inflation forecasts have shown moderating expectations, two-year forecasts being reduced in 2015 from a maximum of 6.2 per cent to 5.4 per cent and five-year forecasts to 5.2 per cent. In 2018/19, inflation averaged 4.6 per cent and it is forecast to remain within the inflation target range of 3–6 per cent (SARB 2018/19).

Although policy-makers consider the SR very carefully when taking macroeconomic policy measurements, calculating the size of the coefficient of the SR is a difficult task, as it demands proper identification of changes in the monetary policy and an evaluation of their impact on the trend of inflation and output. In the literature, the standard approaches to estimate the SR are the time-varying Phillips curve (Phillips and Perron 1998), Ball's method (Ball 1994), and the structural vector autoregressive (SVAR) model. The first two approaches are vulnerable to serious criticisms. The time-varying Phillips curve method is criticized for its assumption of a constant trade-off between output and inflation throughout the business cycle and for treating the output cost of inflation as the same for all the disinflations. Cecchetti and Rich (2001) criticize Ball's approach for assuming each disinflation episode to be generated only by a monetary policy change as well as for ignoring any exogenous shocks, particularly supply shock. The SVAR model developed by Cecchetti and Rich (2001), based on Cecchetti (1994), and applied for the estimation the SR, overcomes the aforementioned drawbacks, generating an uninterrupted estimate of the SR, which is popularly used for international comparisons. Hence, in this paper we use only the SVAR model.

Few empirical studies have been undertaken for South Africa in the area of SR. Burger and Markinkov (2006), Kabundi et al. (2016), and Ngalawa (2020) all used the time-varying Phillips curve, over different periods. Bearing in mind the criticisms of Cecchetti and Rich (2001) of the Phillips and Ball models, as well as to reap the advantages of SVAR model, we employ an SVAR model based on Cecchetti and Rich's (2001) specifications to estimate the SR for the South African economy over the period of 1998Q1–2019Q3.

The rest of the paper proceeds as follows: Section 2 provides a review of the relevant literature; Section 3 presents the data used; Section 4 explains the empirical model employed; Section 5 presents the results and a discussion of these; Section 6 outlines the robustness checks applied to the results; and Section 7 concludes.

2 Literature review

2.1 Theoretical literature

There exists a broad literature on the interrelationship between inflation and output, as well as on methods of estimating the SR. To address these issues, we divide this section into two parts. First, theories on the relationship between inflation and output are discussed and second, the theoretical justifications for the three models that are widely used in the literature are discussed.

The relationship between inflation and output

Though currently it is generally understood that price stability is attained at a cost of economic losses, discussion of the relationship between inflation and output has a long history, from the theories of the classical economists up to the endogenous growth model. Although the link between changes in the price level and tax effects on profit and output was not articulated specifically in the classical growth theories, a negative relationship between inflation and a firm's profit levels through inflated wage costs was implicitly indicated (Vikesh and Subrina 2004). On the other hand, Keynesian economists (e.g. Blanchard and Kiyotaki 1987; Dornbusch et al. 1996) suggested that, with an upward sloping aggregate supply curve, changes in aggregate demand affect both price and output. This holds with the fact that changes in fiscal and/or monetary policy, expectations, and the cost of the labour force and other factors of production have a positive effect on prices and output in the short run.

In contrast, the monetarists, led by Milton Friedman, emphasize the long-run properties of the economy, including the neutrality of money and the quantity theory of money. According to Friedman, inflation occurs when the money supply grows faster than the economy. As long as inflation is a monetary phenomenon, the monetary authority should use monetary policies that decrease the money supply. In their model, the monetarists suggested that prices are exclusively affected by the growth rate of money, while they have no real effect on economic growth in the long run (Snowdon and Vane 2006).

It was Solow (1956) and Swan (1956) who articulated the earliest neoclassical models, Mundell (1963) being among the first to postulate a relationship between inflation and economic growth. According to Mundell's model, an incremental change in the inflation or expected inflation rate contemporaneously reduces people's wealth. Hence, people save their capital in the form of assets to accumulate the desired level of wealth, driving the price of the assets up and thus reducing the interest rate. In line with Mundell's model, Tobin (1965) postulated a positive relationship between inflation and output, assuming the existence of substitution between investment and real money balances. Tobin (1972) also argued that, because of downward rigidities of prices, during a period of economic growth, an upward price movement of some individual prices could better achieve an adjustment in relative prices. Contrary to the other neoclassical economists, assuming the existence of complementarity among investment and real money balance, Stockman (1981) proved that an increase in the inflation rate causes a lower steady-state level of output and a reduction in people's welfare. Sidrauski (1967) added major developments to neoclassical economics with his masterpiece on the infinitely lived representative agent model. Assuming the 'super neutrality' of money, he found that the steady-state capital stock is not affected by an increase in the inflation rate.

Emerging from the Keynesian school of thought, Neo-Keynesians developed the concept of 'potential output', which was initially called natural output. According to the Neo-Keynesians, inflation depends on the natural rate of unemployment and the level of actual output. Moreover, the structuralists argue that inflation is the main engine for growth in developing countries (Guru 2015). Finally, the endogenous growth model postulates the negative effect of inflationary pressures on economic growth (see Lucas 1980, 1988; Lucas and Stokey 1987; McCallum and Goodfriend 1987).

Sacrifice ratio estimation: models and theoretical framework

Even if there exist various theories on the relationship between inflation and output, in the modern literature there is consensus that sacrifices in output are inevitable when inflation is reduced. These economic costs are captured by the response of output to a reduction in inflation in the short run and are the focus of the extensive empirical literature on the SR.

Traditionally, the literature on the inflation–growth trade-off has focused on assuring economic growth and a substantial increment of employment at the cost of an inflated general price level. In this context, given a vertical Phillips curve, a rise in the level of output will lead to a higher level of inflation (Friedman 1968; Phelps 1967). To the contrary, an inflation-targeting monetary policy aimed at reducing inflation rates would result in output loses. In the literature, the standard approaches employed to estimate the output cost of disinflation are the time-varying Phillips curve, episode-specific methods (e.g. Ball's method), and the SVAR model.

Okun (1978) introduced the estimation of the SR primarily from the traditional perspective. Okun estimated a family of Phillips curve models to compute the coefficient of the SR. This method of SR estimation captures the output–inflation trade-off for the given period. The basic equation of the SR is stated in the following way:

$$\Pi_t = \Pi^e + \alpha(y_t - y_t^*) \tag{1}$$

Where y_t and y_t^* refer to actual and potential output, respectively, whereas $(\Pi_t - \Pi^e)$ is the disinflation that would occur at time t. As α gets larger, the cost of disinflation increases accordingly. The main flaw of this methodology is that it necessarily assumes the existence of a uniform trade-off between disinflation and output cost over time, and the output cost of fighting inflation is assumed to be the same for all disinflations during a given time series. Besides, this approach assumes a linear relationship between inflation and output (Ball 1994). The assumptions made in building this method are not consistent with recent theoretical and empirical macroeconomic insights. Okun (1962) did not postulate a detailed estimation of the SR, but there are evident features of the measurement. First, the cost of disinflation is stated as a permanent reduction of inflation rather than a temporary one. Second, the costs of disinflation can be stated in terms of either output or employment and are usually calculated for a one-point reduction in the rate of inflation; and third, the output losses are calculated as the cumulative losses during the period of disinflation.

The second approach applied to measure the SR is the episode-specific method (e.g. Ball's method), which is based on individual disinflation episodes. Ball's method (Ball 1994) provides very simple and appropriate estimates of the SR when inflation and output dynamics are isolated during a particular disinflation episode and when investigating the determinants of the output cost of disinflation. According to this method, the SR for each episode is the ratio of the total output loss to the change in trend inflation.

Accordingly, the SR is estimated over each pre-identified episode. This approach is heavily criticized on three main points. First, the model takes only periods of disinflation into account and ignores the potentially important causal relationship between output growth or unemployment and inflation during other episodes in the business cycle. Second, the method assumes each disinflationary episode to be exclusively generated by a monetary policy shock (demand shock), neglecting the impact of supply shocks and other demand shocks (such as money demand shocks or fiscal shocks) on the behaviour of inflation and output during these disinflation episodes. Third, the calculation of the SR's point estimates for particular country-specific disinflations varies according to the nature of the estimation, making it difficult to draw generalizations and international comparisons. Moreover, Ball's approach does not allow the effect of monetary policy shocks to be separated (Cecchetti and Rich 2001).

Finally the SVAR model, which was developed by Cecchetti and Rich (2001), based on Cecchetti (1994), permits the distinction between structural supply shocks and structural demand shocks. Moreover, it permits the breakdown of the effect of monetary policy shocks into a systematic component (a reaction function that explains the historical reaction of the monetary policy authority to a change in some key macroeconomic variables) and a stochastic component (a reaction from the central bank that cannot be described by the monetary policy shocks). This model provides 'uninterrupted' estimates of the SR. Accordingly, the effect of monetary policy shocks (aggregate demand shocks) on both output and inflation (cumulative impulse response functions for a given time horizon, presumed to be five years) is estimated. In our case, the output cost of disinflation for the South African economy over the period 1998Q1–2019Q3 is estimated using the SVAR model, since it has many advantages over the other two approaches and it is in line with the objective of estimating the coefficient of the SR, which is comparable over time and across countries.

2.2 Empirical literature

Empirical works on the growth–inflation trade-off have shown that high inflation is crucial to long-run economic growth, and disinflationary measurements result in a substantial welfare loss (Bruno and Easterly 1998). Price stability is achieved with no free lunch and is usually associated with substantial output losses (Ball 1994). In this empirical literature, studies on the SR are structured in two ways. The first sub-section below discusses studies that have been done on a cross-country basis, starting with research using the Phillips curve, followed by Ball's method, and finally autoregressive models. Research papers in the area of SR with an exclusive focus on South Africa are discussed in the second sub-section.

Cross-country empirical literature

By examining a family of Phillips curve models for the US economy, Okun (1978) was the first to estimate the SR: at between 6 per cent and 18 per cent. Accordingly, he estimated that, on average, a 1 per cent reduction in the inflation rate causes a 10 per cent fall in a year's GNP. Gordon and King (1982) revised Okun's methodology, which assumed a linear Phillips curve, by employing traditional and autoregression models and found the SR to be between 0 and 8 per cent. Similarly, Cuñado and Pérez de Gracia (2003) estimated the SR by adopting a version of the Phillips curve with adaptive expectations for the eurozone countries. By using the unemployment gap as a measure of real activity, they estimated the SR at between 0.55 and 1.96 per cent in terms of an annualized rise in the unemployment rate. However, the SR coefficient estimate of some countries (France, Italy, Luxembourg, and Spain) was negative and insignificant. Beccarini and Gros (2008) also estimated the SR using the Phillips curve with adaptive expectations for the eurozone countries as well as for the US and found an SR of between 1.35 and 4.08 per cent for the eurozone, and between 2.26 and 3.19 per cent for the US.

In contrast to the above research done using the Phillips curve, Ball (1994) employed the historical disinflation episode method, calculating the SR by including a sample of industrialized countries, and estimated the SR at between -0.86 and 3.92 per cent of GDP. Following Ball's approach, Bernanke et al. (1999) estimated the actual SR in the first disinflation episode after the adoption of inflation-targeting monetary policy and found it to be greater than the number projected using the coefficients of their estimated Ball's regression for three countries out of four inflation-targeting followers. They concluded that the first disinflation under targeting monetary policy does not appear to be less costly than subsequent disinflation episodes.

Using a more popular approach, Cecchetti and Rich (2001) estimated the SR for the US economy using three model identifications—namely Cecchetti (1994), Gali (1992), and Shapiro and Watson (1988). Cecchetti and Rich (2001) computed the SR using three SVAR models. The first model considered only two variables, namely inflation rate and real GDP; the second model included real interest rate; and the third model incorporated real money supply. From the impulse response functions, computed by Monte Carlo simulations based on 10,000 replications, an SR estimate of between 0.19 per cent and 9.87 per cent of GDP was obtained. Following the shock identification of Cecchetti and Rich (2001), Coffinet et al. (2007) measured the output cost of disinflation for the eurozone for the period 1985Q1–2004Q4 and estimated the SR at between 1.2 per cent and 1.4 per cent, which means that the short-term cost to output incurred due to a 1 per cent reduction in inflation is over 1 per cent of GDP. From the estimated results, it was also pointed out that a greater wage stickiness leads to an increment in the SR, and the existence of an asymmetric effect of wage stickiness on the SR was confirmed. In their research on West African countries, Dramani and Thiam (2012) estimated the SR using an SVAR based on the Cecchetti and Rich (2001) model specification and found a coefficient estimate of SR that ranged from 0.06 to 1.3 per cent.

Applying two models of SR estimation, namely Cecchetti and Rich's (2001) SVAR specification and Ball's method, Belke and Böing (2014) estimated the SR for the eurozone countries. From their empirical findings, most countries were found to have an SR of between -1 and 2 per cent of real GDP for a given 1 per cent point reduction in inflation. In exceptional cases, these estimates provide a negative coefficient of SR. Kinful (2007) estimated the size and magnitude of the SR for Ghana by applying three methods—Ball's method, an SVAR model, and drawing aggregate supply curves—and found an estimate of the SR of between 0.001 per cent and 5.1 per cent. For the sake of comparison, Durand et al. (2008) examined the structural dispersion of SRs within the eurozone over the period 1972–2003. The results, based on the SVAR model, indicated a recent increment in the average SR, which could be due to the simultaneous decrease in the average inflation rate. No evidence of a reduction in the European SR dispersion was provided.

Additionally, on the basis of vector autoregressive and vector moving average (VMA) representations, Hušek and Formánek (2005) provided two alternative estimates of SR for the Czech economy. In terms of accuracy, the results were very sensitive to variation in the definition of monetary shocks. During the transition period, the SR coefficient was negative, with relatively low absolute values, signifying a monetary restriction resulting in only a short-term negative impact on output. Using a time-varying Autoregressive Distributed Lag (ARDL) model with transition in a parameter and stochastic volatility component, Dipankar et al. (2015) estimated the SR for India over the post-liberalization period. According to the findings, estimates of the SR have steadily increased during the periods of monetary policy expansion and fallen during the periods when contractionary monetary policy was adopted, and average SR estimates of 2.8 during the time of expansion and 2.3 in times of contraction phase were found.

Edeme et al. (2018) analysed the impact of inflation reduction on output and unemployment for the Nigerian economy for the period 1970–2015 by adopting the Instrumental Variables Generalized Method of Moments (IVGMM). Their findings indicate that inflation inertia is negatively and significantly related to the actual rate of inflation in Nigeria. It was also revealed that the amount of real GDP that must be given up annually to reduce inflation is 5.1 per cent, while it was 53.6 per cent in 1982. Moreover, in the same year, 26.6 per cent of cyclical unemployment occurred and the highest percentage of GDP was sacrificed in 1990 and the lowest in 2007.

Studies on South Africa

Though there is little research that deals exclusively with the estimation of the SR for South Africa, there are some studies that concentrate on the estimation of South Africa's Phillips curve as well as the SR. For example, Burger and Markinkov (2006) discussed whether there exists a triangular Phillips curve in South Africa. A triangular Phillips curve demonstrates the presence of output level effects, inflation inertia, and rate of change effects. It also shows that inflation inertia has distinct effects on the economy. However, there are almost no output effects, implying the presence of output hysteresis. More recently, Ngalawa (2020), using the difference Generalized Method of Moments (GMM), estimated the inflation expectation-augmented Phillips curve for the period 2000Q3–2015Q1. The shape of the Phillips curve was found to be concave and asymmetric. The simulation results reveal that a negative shock to aggregate demand reduces output and inflation, while the same magnitude of positive demand shock results in a smaller rise in inflation and a substantial rise in output. Most importantly, Kabundi et al. (2016) computed the SR for the South African economy using the time-varying Phillips curve for the period 1994Q4–2014Q4 based on quarterly data on the inflation rate and unemployment rate. Using a bounded random-walk model, they showed that the slope of the Phillips curve has flattened since the mid-2000s, particularly after the great financial depression. The computed Phillips curve signifies, on average, a lower estimate of the SR for the South African economy. According to the results, it reveals that the SR has changed substantially from 3.1 in the 1990s to between 1 and 1.5 in recent times. The results also show that the slope of the Phillips curve and the inflation persistence determine the estimated time-varying SR. The steeper the Phillips curve, the lower the SR and vice versa. Moreover, the higher the persistence of inflation, the lower the SR.

Furthermore, the SARB (2016) noted exchange rate as a major driver of inflation in South Africa, the transmission mechanism operating through import prices. According to the SARB, since the inception of the flexible inflation-targeting monetary policy framework, South Africa has experienced a flat Phillips curve. Suggesting that inflation is less responsive even to demand factors, the Phillips curve has further flattened with global financial crises. The slope of the Phillips curve increased from 0.16 in 1996 to 2.7 in 2003, and in 2016 it declined to 0.25. This flattened Phillips curve indicates that the SARB is focused on reducing the inflation rate to maintain the target range, at the cost of a higher output gap.

In another study on this issue, Bold and Harris (2018) assessed the SARB's monetary policy rule and investigated whether it takes into account labour market conditions and inflation expectations. Based on the Taylor rule, the results indicate that the SARB puts more weight on inflation expectation than the output gap, which is aligned with its responsibility of maintaining price stability. Hence, the SARB is committed to maintaining the inflation rate within the stated target range even if the output level deviates from its potential. Specifying a time-varying Vector Autoregression (BVARTVP), Leroi (2018) also analysed the monetary policy reaction function for South Africa both before and after the recent financial crisis and found a negligible reaction of the monetary policy interest rate to an increase in inflation rate both pre- and post-financial crisis.

As the foregoing empirical review indicates, there is limited research work that deals exclusively with estimation of the SR. In South African studies, the Phillips curve is widely employed. In this approach, the output–inflation trade-off is assumed to remain constant throughout the business cycle (i.e. assumed to be the same during disinflation and accelerating inflation episodes). This approach also constrains the output cost of fighting inflation to be the same for all disinflations during a given time series. Unlike the Phillips curve, the SVAR model, developed by Cecchetti and Rich (2001) and based on Cecchetti (1994), allows the distinction of structural demand and supply shocks, as well as the breakdown of monetary policy shocks. Most importantly, the SVAR model provides us with uninterrupted and internationally comparable estimates of the SR. Hence, in this paper we employ the SVAR model to estimate the SR for South Africa over the period 1998Q1–2019Q3. In this paper a two-variable model estimate of the SR is obtained, and for the robustness checks we use a three-variable model.

3 Data

This study employs quarterly data over the sample period of 1998Q1 to 2019 Q3 (from the time when the bank rate was replaced by a repo rate). To keep the analysis as parsimonious as possible, as in Belke and Böing (2014) and Durand et al. (2008), two variables are generally included to estimate the SR, namely real GDP and the CPI. Both our variables are transformed into their growth forms through differencing. Growth of real GDP is defined as the first difference of the value of final goods and services produced domestically rebased (i.e. revised) to 2010. The CPI is revised data and calculated for all items. Aiming to obtain a robust estimate, we incorporate a third variable, broad money supply (M3). In this case, M3 is defined as the notes and coins in circulation in addition to domestic private sector bank deposits.

The data for GDP and M3 are obtained from the SARB. Since the data for the CPI is not available from the SARB, we opted to use the International Monetary Fund (IMF) as a data source for the CPI. All our variables are seasonally adjusted quarterly data. The M3 data were available on a monthly basis and hence were converted to seasonally adjusted quarterly series, with seasonal adjustment made using Census X-13.

4 Empirical model

To analyse the effects of monetary policy shocks on output, the SVAR model has remained a popular technique. In a SVAR model, dynamic simultaneous equations are stated with identifying restrictions based on sound economic theory. In particular, the model associates the observed fluctuations in a variable with a set of structural shocks, which are fundamental and have an economic interpretation. While formulating the identification assumptions, we fit the model to the economic theories that allow us to interpret structural innovations as a monetary policy shock. For that reason, the SVAR model is found to be the appropriate model for evaluating the effects of monetary policy shocks on output.

This paper's method of analysis is in line with the method adopted by Boone and Mojon (1998), Cecchetti (1994), and Cecchetti and Rich (2001). While estimating the SR using SVAR, it is essential to begin by specifying the bivariate unrestricted VAR model as follows:

$$\begin{cases} \Delta y_t = \sum_{i=1}^{n} \phi_{11}^{i} \, \Delta y_{t-i} + \sum_{i=1}^{n} \phi_{12}^{i} \, \Delta \pi_{t-i} + \mu_t^1 \\ \Delta \pi_t = \sum_{i=1}^{n} \phi_{21}^{i} \, \Delta y_{t-i} + \sum_{i=1}^{n} \phi_{22}^{i} \, \Delta \pi_{t-i} + \mu_t^2 \end{cases} \tag{2}$$

where y_t is the log of GDP at time t, π_t is the inflation rate between time t and t-1, being expressed on a quarterly basis, $\mu_t = [\mu_t^1, \mu_t^2]'$ is the innovation vector, consisting of shocks that affect the vector of endogenous variables $X_t = [\Delta y_t, \Delta \pi_t]'$ at time t, and t starts from 1 and goes up to T.

It is also assumed that the innovation vector, being a diagonal matrix, is identified and normally distributed with zero mean and constant variance–covariance of the innovation vector $\Omega(\mu_t \approx iid\ N(0, \Omega)$.

Since our objective is to figure out the effect of a demand shock on both real GDP and inflation, it is inevitable to link the unrestricted VAR model to its underlying structural form. Hence, the innovations represented in the unrestricted VAR do not have any economic interpretation.

After linking the structural form with the unrestricted VAR model, we get the SVAR model, as extracted from Cecchetti (1994):

$$\begin{cases} \Delta y_t = \sum_{i=1}^{n} b_{11}^{i} \, \Delta y_{t-i} + b_{12}^{0} \Delta \pi_t + \sum_{i=1}^{n} b_{12}^{i} \, \Delta \pi_{t-i} + \mathcal{E}_t^{y}, \\ \Delta \pi_t = \ b_{21}^{0} \Delta y_t + \sum_{i=1}^{n} b_{21}^{i} \, \Delta y_{t-i} + \sum_{i=1}^{n} b_{22}^{i} \, \Delta \pi_{t-i} + \mathcal{E}_t^{\pi} \end{cases} \tag{3}$$

which can be rewritten more conveniently as:

$$\mathrm{B(L)} \begin{bmatrix} \triangle\, y \\ \triangle\, \Pi \end{bmatrix} = \begin{bmatrix} \mathcal{E}_t^{y} \\ \mathcal{E}_t^{\Pi} \end{bmatrix} \tag{4}$$

where t = 1.....T, $\mathcal{E}_t = [\mathcal{E}_t^{y}, \mathcal{E}_t^{\pi}]$ is the vector of innovations, containing the shocks to aggregate demand $\mathcal{E}_t^{\pi}$ and to aggregate supply $\mathcal{E}_t^{y}$. The demand disturbance is assumed to be a monetary shock. It is also assumed that $\mathcal{E}_t \approx iid\ N(0, \sum)$ is a diagonal matrix, where $\sum$ is a variance–covariance matrix of the vector innovation.

The next task is to provide the infinite moving average representation of the SVAR model. Assuming that the VAR (p) model is stable, this is done through the use of Wold's decomposition theorem as follows:

$$y_t = \mu + A_1 y_{t-1} + u_t$$

Using recursive substitution,

$$y_t = (1 + \ A_1 + A_1^2 + \ldots + A_1^j)\mu + A_1^{j+1} y_{t-(j+1)}$$

$$+(u_t + A_1 u_{t-1} + \ A_1^2 u_{t-2} + \ldots + A_1^j u_{t-j}$$

where, $A_1^0 = I$. When the process is stable, $\left(I + A_1 + A_1^2 + \ldots + A_1^j\right)\mu \rightarrow (I - A_1)^{-1}\mu$ as j→ ∞. Besides, as $A_1^{j+1} y_{t-(j+1)} \rightarrow 0$, it will be the case that j → ∞. Hence, the equation reduces to:

$$y_t = \varphi + \sum_{j=0}^{\infty} A_1^j u_{t-j} \quad (5)$$

where φ =$(I - A_1)^{-1}$μ. The above equation is called the moving average representation of the VAR model. This could be written in terms of the moving average coefficients as:

$$y_t = \varphi + \sum_{j=0}^{\infty} B_j u_{t-j} \quad (6)$$

where $B_j = A_1^j$ and $B_0 = I$.

Hence, following the same fashion and treating the SVAR model disturbances as exogenous variables, the infinite VMA representation of the SVAR model is stated as:

$$\begin{bmatrix} \Delta y_t \\ \Delta \pi_t \end{bmatrix} = \begin{Bmatrix} \sum_{i=0}^{\infty} a_{11}^i . \mathcal{E}_{\mathrm{t-i}}^y + \sum_{i=0}^{\infty} a_{12}^i . \mathcal{E}_{\mathrm{t-i}}^\pi \\ \sum_{i=0}^{\infty} a_{21}^i . \mathcal{E}_{\mathrm{t-i}}^y + \sum_{i=0}^{\infty} a_{22}^i . \mathcal{E}_{\mathrm{t-i}}^\pi \end{Bmatrix} = \begin{bmatrix} A_{11}(L)\ A_{12}(L) \\ A_{21}(L)\ A_{12}(L) \end{bmatrix} \begin{bmatrix} \mathcal{E}_{\mathrm{t}}^y \\ \mathcal{E}_{\mathrm{t}}^\pi \end{bmatrix} \quad (7)$$

where, t = 1.....T.

In this case, the coefficients in $A_{12}(L)$ represent the cumulative effect of monetary policy shocks on the level of output. In the case of inflation, the sum of the first τ coefficients in $A_{22}(L)$ measures the effect of demand shocks (monetary policy shocks) on its level τ periods forward.

In deriving the estimates of the effects of the structural shocks, the vector innovation is assumed to be linear and the structural shocks are assumed to be uncorrelated and to have unit variances. Following the methodology adopted by Blanchard and Quah (1989) as well as Cecchetti and Rich (2001) to estimate the SRs, the cumulative long-run effect of a demand shock on real GDP is assumed to be zero:

$$\sum_{i=0}^{\infty} a_{12}^i = 0$$

Hence, we can state the long-run matrix representation as:

$$\mathrm{A} = \begin{bmatrix} a_{11} a_{12} \\ a_{21}\ a_{22} \end{bmatrix} \quad (8)$$

In this long-run matrix, a_{12} indicates the response of output to a demand shock, which is in this case assumed to be zero based on the restriction. The coefficient of a_{11} represents the cumulative impulse response of output to supply shock, while the cumulative impulse response of inflation to supply shock is represented by the coefficient of a_{21}. Finally, the cumulative response of inflation to its own shock is indicated by the coefficient of a_{22}.

To compute the SR $S(\tau)$ over a given time horizon τ, we use the VMA representation and compute the impulse response functions that yield the estimates of the parameters: a_{11}^{i}, a_{12}^{i}, a_{21}^{i}, and a_{22}^{i}.

The SR can be explicitly stated as a function of the time horizon τ, and computed as follows:

$$S(\tau) = \frac{\sum_{j=0}^{\tau}\left({\delta y_{t+j}}/{\delta \mathcal{E}_t^{\pi}} \right)}{\left({\delta \pi_{t+\tau}}/{\delta \mathcal{E}_t^{\pi}} \right)} = \frac{\sum_{i=0}^{\tau}(\sum_{j=0}^{i} a_{12}^{t})}{\sum_{j=0}^{i} a_{22}^{i}} \tag{9}$$

From the above equation of the SR, we deduce:

The cumulative final effect of a monetary policy shock $\mathcal{E}_t^{\pi}$ undertaken at time t on the inflation rate level at time t+τ is stated by the denominator of the SR formula. While the numerator of the SR is defined as the cumulative output loss between times t and t+τ following the same monetary shock $\mathcal{E}_t^{\pi}$, it is not just the cumulative effect of this disturbance on the real GDP level at time t+τ, but the sum of its effects through the first τ periods as well.

5 Results and discussion

5.1 Descriptive statistics

Table 1 presents the statistical behaviour of the variables used in our estimation. The standard deviation of the variables reveals that real GDP (LNRGDP) has the lowest standard deviation, with most of the observations lying around the mean. Mean, median, and maximum values are higher for the log value of the broad money supply (LNM3), whereas the first difference in the inflation rate (dCPI) has many observations located too far from the sample mean. Looking at the skewness of the variables, all the variables are almost normally skewed since the magnitude of the skewness deviates from zero by a small amount. Furthermore, all variables have a kurtosis that is less than and around 3, indicating a normal distribution.

Table 1: Descriptive statistics

	LNM3	LNRGDP	DCPI
Mean	15.27639	14.75372	1.256059
Median	15.54686	14.80239	1.254289
Maximum	16.23534	14.96668	3.076559
Minimum	13.81720	14.42075	-1.415724
Std. Dev.	0.701645	0.178920	0.843702
Skewness	-0.450719	-0.486008	-0.055654
Kurtosis	1.854634	1.811509	3.134434
Jarque-Bera	7.612635	8.447082	0.109155
Probability	0.022230	0.014647	0.946885

Source: authors' calculations based on IMF and SARB data.

5.2 Preliminary analysis

The SR estimates are constructed from the SVAR model using quarterly data on inflation and output for the South African economy over the sample period of 1998Q1–2019Q3. The inflation rate ratio (INFR) is measured by the growth rate of the CPI, and real GDP is taken as a proxy for output. In addition, to check for robustness, we added a third variable: broad money supply. As preliminary stationary analysis of the series is crucial, a standard stationarity test is conducted using Augmented Dickey-Fuller (ADF) tests based on Dickey and Fuller (1981) and Phillips-Perron tests (Phillips and Perron 1988) for all our variables at their non-transformed original data. The series of all our variables proved to be non-stationary at level (i.e. they contain a unit root). Hence, as can be seen from Table 2, the variables are differenced to fit into our VAR model and all the variables are stationary at their first difference.

Table 2: Results of stationarity test

Variables	Lags (SIC)	ADF-test		PP-test		Order of integration
		t-statistic	p-value	t-statistic	p-value	
INFR	(1)	-2.9689	0.0421	-5.9057	0.0000	I(1)
RGDP	(0)	-5.1190	0.0000	-5.0062	0.0001	I(1)
MONEY SUPPLY	(0)	-10.49160	0.0000	-24.15501	0.0001	I(1)

Source: authors' calculations based on IMF and SARB data.

These stationarity results provide support for the definition of the output cost of disinflation as well as for our model specification. The denominator of the SR represents the cumulative effect of monetary shock on the inflation rate. For the sake of avoiding a zero denominator, the variation in the inflation rate from its initial level must not be transitory. Furthermore, non-stationarity series of real GDP is required to satisfy our long-run identifying restriction, as we are assuming that aggregate supply shock exerts a long-lasting effect on the real GDP series.

We also apply a cointegration test, employing the methodologies and tests proposed by Engle and Granger (1987). Results of the cointegration test indicate the rejection of the alternative hypothesis (i.e. no cointegration exists between inflation rate and real GDP). From this, it can be noted that the non-existence of cointegration between the variables is in line with our long-run identifying restriction from our SVAR model (there is no permanent long-run effect of monetary policy shocks on real GDP).

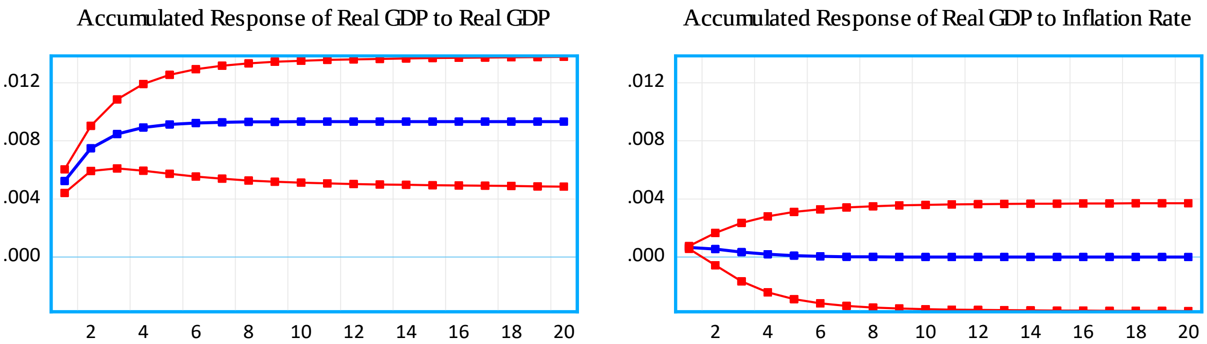
In econometric analysis, the number of lags to be included in a model has a considerable impact on the result of the analysis. It therefore becomes necessary to include the optimal lags in running our model. Initially, in this study, the first step is identifying an appropriate lag length for our standard VAR model. Accordingly, lag one was selected on the basis of Schwarz information criteria (SIC) and the Hannan-Quinn information criterion (HQ), which would seem perfect with our nature of data frequency. The reason behind the use of SIC and HQ is that fewer lagged differences are selected by these two information criteria than any other information criteria. This can help us to get accurate estimates by selecting the most parsimonious model, since we have fewer sample sizes (87 quarters in this case) and lag one is sufficient to generate a vector of white-noise innovations and is found to be consistent.

Our results are estimated over a nearly 22-year period beginning in 1998Q1. Many things might have changed in South Africa, and at a global level as well, during this period. Besides, our model assumes an explicit or implicit monetary policy reaction function, given changes in the coefficient of the estimates because of change in the policy regime. After experiencing weak domestic production volumes in 2003, growth in South Africa's real GDP rose decisively to an annualized rate of more than 3 per cent in 2004 due to a rise in the oil price from US$29 per barrel in 2003 to US$40 in 2004 and due to the recovery of the global economy, which contributed to the commodity price boom. Generally, all the main economic sectors experienced increases in output in the first half of 2004 (SARB 2004). Additionally, in the international financial system, the global financial crisis that deepened to unprecedented levels during 2008 was the culmination of a period of exceptional leverage and credit growth.

To examine these issues, before proceeding directly to the estimation of the SR, a structural break check was performed by using a Chow multiple breakdown test, and structural breaks were found in 2004Q1 and 2008Q3. These breaks could be attributed to the oil price shock and the recovery of the global economy in 2004 and to the world financial market turmoil that occurred in 2008. Hence, a dummy variable is generated to absorb these exogenous changes. The next task in our estimation is to compute the impulse response functions of the system to the supply shock and demand shock using the long-run identifying restrictions. Each shock in the cumulative impulse response function is the size of one standard deviation and the confidence bands in the graphs are two standard errors wide. In other words, they are approximately 95 per cent confidence bands computed by Monte Carlo simulations based on 10,000 replications, as in Cecchetti and Rich (2001) and Durand et al. (2008).

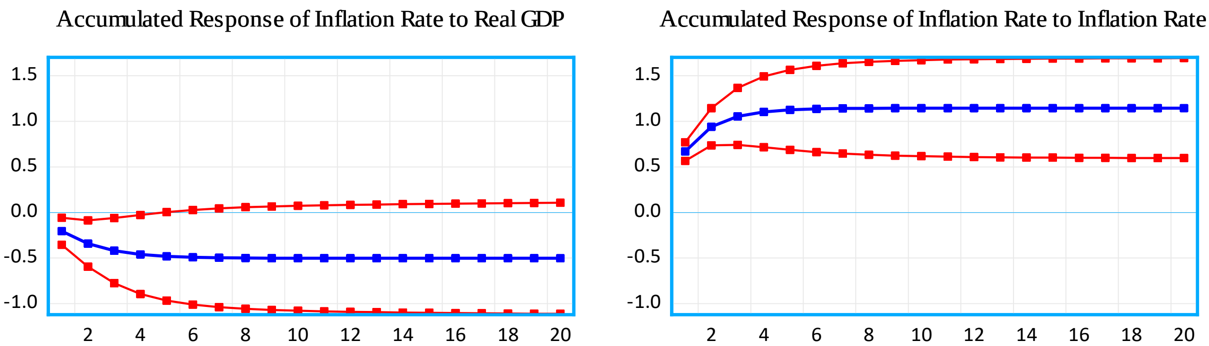
The cumulative impulse response function of our VAR model is reported in Figures 1 and 2, and our identifying restriction signifies a positive but transitory effect of aggregate demand shock (presumed to be monetary policy shock) on output, while it has a positive and permanent cumulative effect on inflation.

Figure 1: Cumulative impulse responses of real GDP to one standard deviation structural shocks with 95 per cent confidence bands



Source: authors' illustration based on IMF and SARB data.

Figure 2: Cumulative impulse responses of inflation rate to one standard deviation structural shocks with 95 per cent confidence bands



Source: authors' illustration based on IMF and SARB data.

Accordingly, the effect of monetary policy on output and inflation is found to be consistent with our identifying restriction as well as with our computation of the SR and existing theory. Moreover, as can be seen from the results, the cumulative impulse effect of supply shocks on output has a positive and permanent effect, whereas the cumulative effect of supply shocks on inflation remains transitory and negative.

5.3 Sacrifice ratio estimation

The next step is estimating the SR according to our methodologies and long-run restrictions specified in Section 4. Table 3 presents the point estimates of the SR for a time horizon set in five years. The estimates are positive throughout the entire period, 1998Q1–2019Q3, indicating the existence of a positive short-run trade-off between inflation and output. It can be noted that, unlike Ball's episode-specific method, the SVAR model gives us a linear combination estimate of the SR during the times of disinflation and escalating inflations (Cecchetti 1994; Durand et al. 2008).

Table 3: Estimates of the SR for the South African economy over the period of 1998Q1–2019Q3

Periods	$\tau = 1$	$\tau = 4$	$\tau = 8$	$\tau = 12$	$\tau = 16$	$\tau = 20$
SR	0.231	0.06	0.00896	0.001323	0.000195	0.0000287

Source: authors' calculations based on IMF and SARB data.

Our estimate of the SR, on average, is found to be 0.031 per cent with a maximum of 0.231 per cent in the first quarter and a minimum of 0.00002 per cent in the final quarter. This indicates that, on average, 0.031 per cent cumulative output loss is incurred in South Africa because of one percentage point permanent reduction in the yearly inflation rate. This indicates that when a restrictive monetary policy is undertaken each year by the SARB, it has no significant long-term effect on the level of output.

Furthermore, our estimates of the South African SR are lower than those obtained, following the same model specification, by Durand et al. (2008) for the eurozone and Cecchetti and Rich (2001) for the US economy; they estimated the SR to be within the range of -1 to 2 per cent and within the range of 1–10 per cent, respectively. Kabundi et al. (2016) found an SR estimate of 3.1 in the 1990s and between 1 and 1.5 in 2014/15. Our results, however, are closer to the findings of Dramani and Thiam (2012), obtained using SVAR with the same model specification, for West African countries over the period 1970–2007, which ranged from 1.3 per cent to 0.06 per cent.

Our estimate of the SR can be attributed to two factors, namely, the slope of the Phillips curve and inflation persistence. As stated by Kabundi et al. (2016), the Phillips curve was found to be somewhat steep and inflation persistence to have risen on average. Hence, the flatter the Phillips curve, the higher the SR; and the higher the inflation persistence, the lower the SR (Kabundi et al. 2016). As well as the slope of Phillips curve and inflation persistence, the nature of the South African economy in terms of trade openness and capital mobility determined the size of the SR. The more the economy became open to the rest of the world and capital was mobilized, the less was the effect of inflation reduction on output. Given these factors and as long as firms set their prices in accordance with the expected price level and monetary policy, the reason for the low SR for the South African economy could be firms' decision-making assumptions. Moreover, the more the economy becomes open to the rest of the world, the more firms decide to adjust their prices in line with nominal changes in the economy, resulting in high price flexibility, which leads to a lower output cost of restrictive monetary policy (Daniels and VanHoose 2009).

6 Robustness checks

To provide a more robust estimate of the SR, we checked if the two variable estimates of our SR became insensitive when a third variable was incorporated. Accordingly, we estimated the SR adding broad money supply (M3) as a third variable. Hence, our three-variable model is specified as follows:

$$\begin{bmatrix} \triangle y_t \\ \triangle \Pi_t \\ \triangle m_t \end{bmatrix} = \mathrm{A(L)} \begin{bmatrix} \mathcal{E}_t^y \\ \mathcal{E}_t^\Pi \\ \mathcal{E}_t^m \end{bmatrix} \tag{10}$$

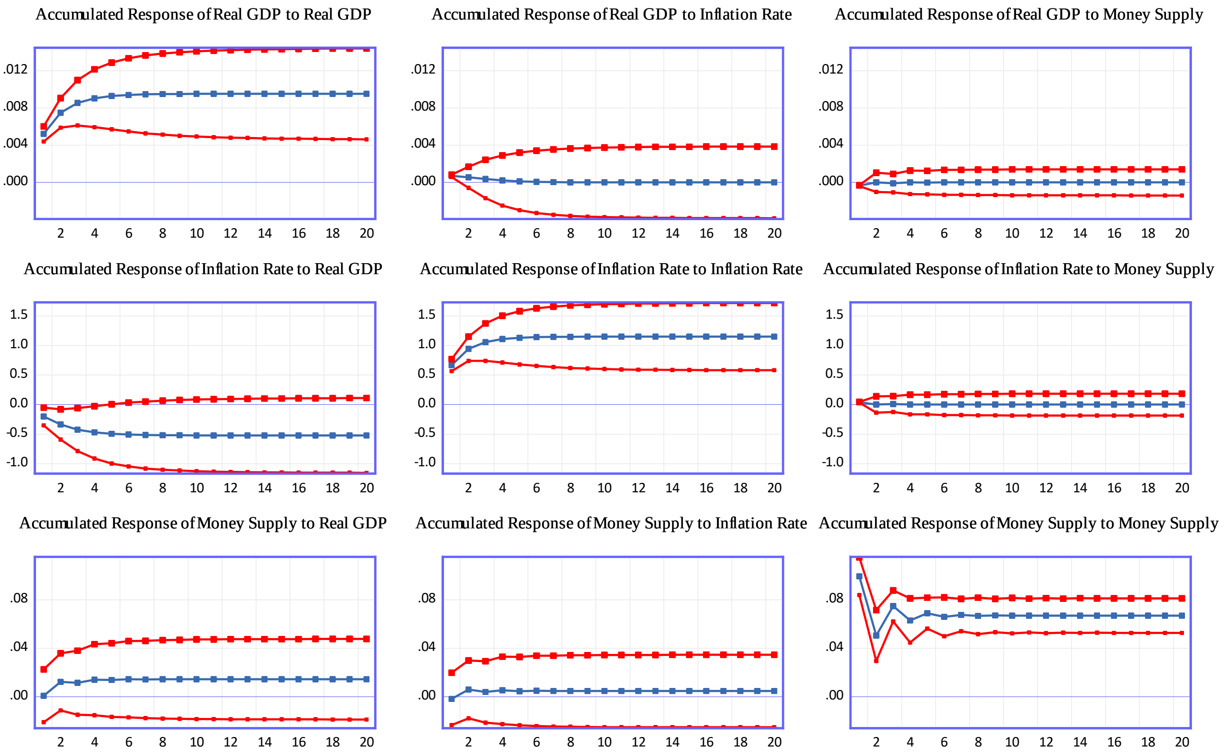
where, m_t is the log of M3, $\triangle m_t$ is the growth of M3, and $\mathrm{A(L)}$ represents a (3x3) matrix of polynomial lags. We can identify three structural shocks from our three-variable model: $\mathcal{E}_t^y$ represents aggregate supply shock, and aggregate demand shock is decomposed into an inflation shock ($\mathcal{E}_t^\Pi$) and money supply shock ($\mathcal{E}_t^m$). In our three-variable model, retaining the Blanchard-Quah (1989) restriction, it is assumed that aggregate demand shock has no permanent effect on output ($a_{12}^0 = a_{13}^0 = 0$).

$$\mathrm{A} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \tag{11}$$

From this long-run matrix representation, a_{12}^0 represents the cumulative impulse response of supply shock (output) to inflation, whereas a_{13}^0 indicates the response of output to M3. Finally, our second assumption is that a_{23}^0 is zero, which indicates the contemporaneous effect of money supply shock on inflation. In this case, the impulse response functions are estimated and are the size of one standard deviation. The confidence bands in the graphs are two standard errors wide (approximately 95 per cent confidence bands), as computed by Monte Carlo simulations based on 10,000 replications.

Accordingly, our three-variable model reveals that, on average, 0.022 per cent cumulative output is sacrificed when a one percentage point permanent reduction in inflation occurs yearly. When compared with the result of our baseline model, our estimate of the SR is almost the same (0.031 in the case of our baseline two-variable model). Hence, our estimate of the SR is insensitive to the incorporation of an additional variable. Moreover, the assumption that demand shock has no permanent effect on output is confirmed by the cumulative impulse response of real GDP to inflation rate and broad money supply (Figure 3).

Figure 3: Cumulative impulse responses to one standard deviation structural shocks with 95 per cent confidence bands



Source: authors' illustration based on IMF and SARB data.

The final task in this study was checking the stability of our VAR model using autoregressive roots. The result shows that the roots and the modules lie inside the unit circle, assuring the stability of our model.

7 Conclusion

When any central bank tries to lower the inflation rate, even an independent central bank, there is no free lunch, as there exists an output level to be sacrificed. This study estimates the output cost of fighting inflation for South Africa over the period 1998Q1–2019Q3 by employing an SVAR model. The results show that the estimate of the SR lies within the range 0.00002–0.231 per cent. On average 0.031 per cent of output is sacrificed when a one percentage point permanent reduction in inflation occurs yearly. Even after incorporating a third variable to check for robustness, the estimated coefficient is 0.022 on average, which confirms our two-variable estimate.

When compared with other structural estimates of the SR, our estimate is somewhat lower. This can be associated with the persistent inflation, trade openness, capital mobility, and steeper Phillips curve characterizing the South African economy. Hence, deducing from our findings, the reserve bank is recommended to keep the inflation rate within the target range, as the output cost of fighting inflation remains insignificant. Our finding supports the ideas of Aron and Muellbauer (2007), Mnyande (2008), and Van (2004) that restrictive monetary policy exerts only a transitory effect on real variables like output and unemployment. Hence, the reserve bank is advised to reap the benefits of a predictable and stable price path.

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