Important Channels of Transmission Monetary Policy Shock in South Africa

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ERSA working paper 375

September 2013

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September 17, 2013

Abstract

This paper investigates the different channels of transmission of monetary policy shock in South Africa in a data-rich environment. The analysis contains 165 quarterly variables observed from 1990Q1 to 2012Q2. We use a Large Bayesian Vector Autoregressive model, which can easily accommodate a large cross-section of variables without running out of degree of freedom. The benefit of this framework is its ability to handle different channels of transmission of monetary policy simultaneously, instead of using different models. The model includes five channels of transmission: credit, interest rate, asset prices, exchange rate, and expectations. The results show that all channels seem potent, but their magnitudes and importance differ. The results indicate that the interest rate channel is the most important transmitter of the shock, followed by the exchange rate, expectation, and credit channels. The asset price channel is somewhat weak.

JEL Classification Numbers: C11, C13, C33, C53

Keywords: Bayesian VAR, Monetary policy transmission; Balance sheets, large cross-sections

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*Authors would like to thank Lucrezia Reichlin and participants of the ERSA monetary policy conference. We also thank Domenico Giannone and Marta Banbura for assisting with their Matlab codes.

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1 Introduction

The monetary policy transmission mechanism has gained the attention of policymakers and academics because it reveals the process through which central bank actions affect the real economy and inflation. Boivin, Kiley, and Mishkin (2010) identify two basic types of monetary transmission mechanism: neoclassical channels and non-neoclassical channels. The traditional channels of monetary policy, also known as the neoclassical channels, are based on the neoclassical models of investment proposed by Jorgenson (1963) and Tobin (1969), the permanent income models of consumption developed by Brumberg and Modigliani (1954), Ando and Modigliani (1963), and Friedman (1957), and the ISLM models of Mundell (1963) and Fleming (1962).[1] These channels assume that financial markets operate in an environment of perfect information. The main channel of transmission is the interest rate channel. According to this channel, an expansionary monetary policy results in a decrease in the policy rate, which in turn pushes the real interest rate down and hence the cost of capital decreases, investment spending increases as a result, and ultimately aggregate demand increases, which causes output to increase. The interest rate channel operates more through the real interest rate than the nominal interest rate and the real long-term interest rate seems to have more impact on spending that the short-term interest rate. Many researchers, for example Taylor (1995), Boivin, Kiley, and Mishkin (2010), conclude that the interest rate channel remains the most important channel for the transmission of monetary policy.

Besides the interest rate, other asset prices like equity prices, house prices, and the exchange rate constitute non-negligible channels through which monetary policy affects the real economy. The exchange rate channel operates through international trade. An expansionary monetary policy which decreases the short-term interest rate makes domestic goods cheaper relative to foreign goods. Hence it causes the domestic currency to depreciate, which in turn boosts exports relative to imports. The rise in net exports translates directly into an increase in aggregate demand. Bryant, Hooper, and Mann (1993), Taylor (1993), and Smets (1995) show evidence of the importance of this channel in small and open economies with flexible exchange-rate regimes. Furthermore, the exchange rate channel depends on the sensitivity of the exchange rate to changes in the interest rate. By increasing investment and consumption, the expansionary monetary policy causes upward movements in equity prices.[2] The equity price channel also operates via the value of businesses and housing. As the value of businesses and/or housing increases relative to the cost of replacement, investment spending will rise, and this

[1] See Taylor (1995), Mishkin (1996), and Boivin, Kiley, and Mishkin (2010) for more details on the review of literature on traditional channels of monetary policy.

[2] Note that equity price refers to both stock price and house price.

triggers aggregate demand. The last traditional channel identified in the literature is the expectations channels. Central bank decisions about the future path of the short-term rate affect economic agents' views on the impact of central bank actions and its reactions to various shocks that affect the economy. The expectations of agents will subsequently have an impact on their decisions to spend and invest – and hence will also affect output and price. However, agents' expectations are highly dependent on their beliefs about the credibility of the central banks. If they believe that the central bank is serious about inflation, their expectations on the future price will be anchored around the central bank inflation targets. But if they think that the central bank accommodates more output relative to price stability, their expectations about future price will not be anchored.

The second type of transmission channel identified by Boivin, Kiley, and Mishkin (2010) is the non-neoclassical channel proposed by Bernanke and Gertler (1995), which is commonly referred to as the credit channel.[3] This channel is a result of frictions in credit markets based on the asymmetry of information between lenders and borrowers. It points to the important role played by financial intermediaries in the economy. It becomes more important for small firms and households who are highly dependent on bank loans. There are two types of credit channel, namely, the bank lending channel and the balance sheet channel. The first channel refers to the effects of monetary policy shock on the supply of loans by financial intermediaries, while the latter is concerned with the demand for loans by firms and households. The bank lending channel operates via the external financial premium. Given the imperfect substitutability of bank deposits and other sources of funds, a contractionary monetary policy increases the costs of raising funds externally and the opportunity costs of funding internally, which in turn affects bank deposits and other sources of funds. Therefore it reduces the quantity of bank loans available. Finally, the decline in quantity of loans reduces investment and consumer spending, causing a fall in aggregate demand. Disyata (2011) argues that the bank lending channel operates less through bank deposits and mainly via banks' balance sheet strength and perceptions of risk. The second credit channel is the balance sheet channel. A contractionary monetary policy increases debt service costs, which in turn impairs assets and the collateral of households and firms. These negative effects on firms' balance sheets and the balance sheets of households undermine their creditworthiness. The problem of asymmetrical information in debt financing, which arises from lower net worth, induces a rise in external financial premium. The financial accelerator pushes aggregate demand and output down even further. In contrast to the traditional channels, there is less agreement in the literature on the relevance of the credit channel. While

[3] See these authors and references therein for more details.

Bernanke and Gertler (1995), Kiyotaki and Moore (1997), and Iacoviello (2005) offer theoretical grounds for credit channel, Gertler and Gilchrist (1993 and 1994), Kashyap and Stein (1995), Iacoviello and Minetti (2008), and Berger and Bouwman (2009) find empirical evidence for the existence of this channel. On the other hand, Ramey (1993) and Carlino and Defina (1998), and Fazylov, and Molyneux (2002) raise doubts about the strength of this channel.

Besides Boivin, Kiley, and Mishikin (2010) and Igan et al. (2013), there are few studies that include all five channels in one investigation. In addition, few empirical studies investigate the relevance of both bank lending and the balance sheet channels of monetary policy. Much research focuses on develop countries; the exception is Khundrakpam and Jain (2012), who examine the importance of these channels in India. The current study bridges the existing gap in the literature by investigating the importance of all five channels in South Africa within one framework, like Boivin et al. (2010) and Igan et al. (2013). However, the framework adopted in this study differs from the above articles. Both Boivin et al. and Igan et al. use the Factor Augmented Vector Autoregressive (FAVAR) model, which can accommodate more than a hundred variables. But this model induces the degree-of-freedom issue, which is common in standard VAR models. Given this, the current article uses the Large Bayesian VAR (LBVAR) proposed by Banbura, Giannone, and Reichlin (2010, henceforth BGR) with Minnesota priors. The LBVAR allows us to analyse the impact of contractionary monetary policy, in this case a percentage rise in the policy rate, on any of the variables included in the dataset. In addition, as in standard VAR, we use the variance decomposition to rank all six channels according to their importance for the South African economy.

The current study is closely related to Kabundi and Ngwenya (2011), but the latter considers the credit channel as a whole without including the bank lending channel and the balance sheet channel separately. Breaking down the credit channel into bank lending and balance sheet means that we have a total of six channels. Many studies on channels of transmission of monetary policy in South Africa focus on the interest rate channel of monetary policy. Brink and Kock (2010), in agreement with Disyatat (2011), attest that the bank lending channel operates differently. According to them banks are not constrained by their deposits to supply loans. The supply of loans depends to a large extent on the demand for loans, the affordability of firms and households, and the risk-taking behaviour of banks.

We find that all six channels operate to a significant degree in South Africa, but that their effects vary. As in Boivin et al. (2010), and unlike Khundrakpam and Jain (2012), we find that the interest channel is by far the most important transmitter of monetary policy shock. It is followed by the exchange rate. The important role played by the exchange rate can be attributed to the fact that in a floating exchange rate regime the domestic currency becomes a shock absorber. The bank lending rate comes in the third position. Monetary policy shock affects bank deposits, the total equity of banks, and claims on the domestic private sector alike. This means that monetary policy shock affects both the assets and liabilities of banks. The bank lending channel is followed by the excitations channel, which is more evident in business and consumer confidence than inflation expectations. In contrast to the balances of banks, the balances of households have relatively small effects. Finally, asset prices, both equity price and house price, are the weakest channels through which monetary policy affects the South African economy.

The rest of the paper is organised as follows. Section 2 discusses the LBVAR methodology. We describe the data and their transformations in Section 3. In Section 4 we present the empirical results of all six channels of transmission of monetary policy using the impulse response functions and the variance decomposition. Section 5 concludes the paper with some policy recommendations.

2 Large Bayesian Vector Autoregressive Model

In recent empirical research in macroeconomics there has been an increasing trend of using large-scale models that can contain hundreds of variables (Stock and Watson, 2002; Forni, Hallin, Lippi, and Reichlin, 2000; Bernanke, Boivin, and Eliasz, 2005; Carriero, Kapetanios and Marcellino, 2009; Banbura, Giannone, and Reichlin, 2010; Giannone, Lenza, Momferatou and Onorante, 2010; Carriero, Clark and Marcellino, 2011; Koop, 2011; Koop and Korobilis, 2013). These models can be divided into two main categories: those using factor analysis, which can accommodate large cross-sections of economic variables, and the papers using the Large Bayesian Vector Autoregressive (LBVAR) model, which deal with large number of time series through shrinkage of parameters. The current study adopts the latter approach and follows closely the LBVAR proposed by Banbura, Giannone, and Reichlin (2010; henceforth the BGR).[4] BGR demonstrate that the LBVAR leads to a better identification of monetary policy shock. It solves the problem of prize puzzle and output puzzle, which are common in small-scale VARs. Hence, the LBVAR is an appropriate alternative to factor models.

Assume the VAR model of the form

$$Y = XB + U$$

where $Y = (Y_1, \ldots, Y_T)'$ is a $T \times N$ matrix of dependent variables, $X = (X_1, \ldots, X_T)'$ is a $T \times K$ matrix of explanatory variables, with $X_t = \left(Y'_{t-1}, \ldots, Y'_{t-p}, 1\right)'$, $U = (u_1, \ldots, u_T)'$

[4] See BGR for more technical details of the LBVAR.

is a $T \times N$ matrix of error terms with u_t being independent $N(0, \Sigma)$, and B is a $K \times N$ matrix of coefficients and $K = (Np + 1)$. A large VAR based on quarterly series with 50 variables and four lags contains over 10,000 parameters. With such a model it is possible to obtain reliable estimate of parameters with higher precision, while many coefficients are statistically insignificant. This is known as the *curse of dimensionality* as large VAR models have number of parameters increasing relative to number of observations. Hence, impulse response functions are also imprecisely estimated. Recently, Stock and Watson (2002), Forni, Hallin, Lippi, and Reichlin (2000), and Bernanke, Boivin, and Liasz (2005) adopted the factor analysis framework to deal with the issue of proliferation parameters, and they obtained good empirical results. Hence, they managed to turn the *curse of dimensionality* into a *blessing*. On the other hand BGR, Koop (2011), and Koop and Korobilis (2013) show that the *blessing of dimensionality* can be obtained using the Bayesian approach through the shrinkage of coefficients. The LBVAR imposes prior beliefs on parameters as proposed by Doan, Litterman, and Sims (1984) and Litterman (1986) and modified by Kadiyala and Karlsson (1997), and Sims and Zha (1998).

The main issue in Bayesian analysis is the selection of proper priors, which leads to a valid posterior distribution. This paper uses the prior beliefs suggested by Doan, Litterman, and Sims (1984) and Litterman (1986), also known as Minnesota priors. The principle is to shrink all equations around a random walk with a drift for variables that show persistence and around white noise for variables that are mean-reverting. It addresses the risk of overfitting the data, which is common in large models. This way of shrinking coefficients is simple and very attractive. Even though it is very restrictive and that there are alternative ways of shrinking coefficients in Bayesian VARs, Koop (2011) finds that the LBVAR based on Minnesota priors outperforms other LBVARs based on stochastic variable selection (SSVS) when the cross-section gets larger.

Formally, we have:

$$Y_t = c + Y_{t-1} + u_t \tag{1}$$

Note that in Equation (2) all VAR coefficients are shrunk towards zero, expect for coefficients of own and more recent lags of each dependent variable, which are set to one. The rationale is that more recent lags provide more accurate information about the variable than distant lags. In addition, own lags explain most of the variation in the variable than the lags of other variables.

Equation (1) can be written as a $VAR(p)$:

$$Y_t = c + B_1 Y_{t-1} + \cdots + B_p Y_{t-p} + u_t \tag{2}$$

The Minnesota priors are set as:

$$
\begin{aligned}
E(B_{k,i,j}) &= \begin{cases} \beta_i & j=i,\, k=1 \\ 0 & otherwise \end{cases} \\
\text{and } V(B_{k,i,j}) &= \begin{cases} \frac{\lambda^2}{k^2} & j=i \\ \frac{\theta^2\lambda^2}{k^2} \times \frac{\sigma_i^2}{\sigma_j^2} & otherwise \end{cases}
\end{aligned} \tag{3}
$$

Note that like in equation (3), the Minnesota prior set β to be one for all variables that are nonstationary, while it is zero for all variables that are stationary. The error matrix $\Sigma = diag(\sigma_1^2, \ldots, \sigma_N^2)$is assumed to be diagonal, fixed and known.

The hyperparameter λ specifies the overall tightness of the prior distribution around the random walk or white noise process. It expresses prior knowledge about the importance of the prior beliefs concerning the process that governs the data. λ is set to zero when the data does not influence the estimate and the posterior equals the prior. On the other hand, when λ is ∞, the posterior expectations coincide with the ordinary least squares (OLS) estimates. We choose λ to avoid overfitting the model, which is common in large models, such that parameters are shrunk even more. The $1/k^2$ reflects the rate of decay, which is a shrinkage of the variance with increasing lag length. The scaling factor, σ_i^2/σ_j^2, adjusts for varying magnitudes of the variables across equations i and j. The scalar θ^2 $\left(0 \leq \theta^2 \leq 1\right)$ is used for lags of less important variables with prior means of zero and a decreasing variance as the lag length increases.

The restrictive assumption of fixed and diagonal covariance matrix, proposed by Litterman (1986), makes it impossible to deal with the correlation among the residual of different variables common in structural models. Kadiyala and Karlsson (1997) and Robertson and Tallman modify the Minnesota prior and impose the inverted Wishart prior. They set $\theta^2 = 1$. The main issue with the Minnesota priors is that it assumes in Equation (1) to be known and uses its estimate, $\hat{\Sigma}$. For the VAR, the normal inverted Wishart prior has the form:

$$
\beta \sim N\left(\beta_0, \Sigma \otimes \Omega\right) \quad \text{and} \quad \Sigma \sim iW\left(\Sigma_0, \alpha\right) \tag{4}
$$

where $\beta = vec(B)$ and β_0, Ω, α, and Σ_0 are prior hyperparameters chosen such that prior expectations of B coincide with the traditional Minnesota prior. Here the prior and likelihood can be seen as coming from a fictitious sample, as they have the same distributional form. Like BGR we use a fictitious sample of T_0 dummy observations Y_0 and X_0 to the Equation (1) such that $\Omega = (X_0'X_0)^{-1}$, $\beta_0 = (X_0'X_0)^{-1} X_0'Y_0$, $\Sigma_0 = (Y_0 - X_0\beta_0)' (Y_0 - X_0\beta_0)$. According to Sims and Zha (1998), the dummy observation approach is suitable for structural VARs. According to BGR, in order to have a prior that coincides with the traditional Minnesota prior, the following fictitious sample should be added:

$$Y_0 = \begin{pmatrix} diag(\beta_1\sigma_1, \ldots, \beta_N\sigma_N)/\lambda \\ 0_{(Np-N+1)\times N} \\ diag(\sigma_1, \ldots, \sigma_N) \end{pmatrix} \quad X_0 = \begin{pmatrix} J_p \otimes diag(\beta_1\sigma_1, \ldots, \beta_N\sigma_N)/\lambda & 0_{Np\times 1} \\ 0_{1\times Np} & \varepsilon \\ 0_{N\times Np} & 0_{N\times 1} \end{pmatrix} \tag{5}$$

where $J_p = diag(1, 2, \ldots, p)$, $diag(\cdot)$ denotes a diagonal matrix. As in BGR, the first block of dummies set prior beliefs on the autoregressive coefficients, the second block uses the prior for the covariance matrix, and the last block represents the uninformative prior for the intercept. Note that ε is a very small number.

Putting together the original sample, T, and the fictitious sample, T_0, we obtain:

$$\underset{\sim}{Y} = \underset{\sim}{X} B + \underset{\sim}{U} \tag{6}$$

where $\underset{\sim}{T} = T + T_0$, $\underset{\sim}{Y} = (Y', Y_0')$, $\underset{\sim}{X} = (X', X_0')$, and $\underset{\sim}{U} = (U', U_0')$. BGR show that adding dummy observation serves as a solution to the matrix inversion problem and it helps in imposing further restrictions.

3 Data and data transformation

The dataset contains 165 quarterly periods, including the real variables such as the gross domestic product (GDP), gross fixed investment, final consumption expenditure; nominal variables such as GDP deflator, consumer price index, producer price index, remuneration per worker; financial variables such as stock prices, real effective exchange rate, rand/dollar exchange rate, the repo rate, treasury bill, long-term interest rates; and balance sheet variables from households and banks. The paper does not cover the balance sheets of corporates due to lack of data during the period under investigation. All series are logged, except those in percentages, the series with negative values, and those containing zeros. The dataset covers a period ranging from 2001Q1 to 2012Q2. The choice of the sample coincides with the inflation-targeting regime in South Africa that was implemented in 2000. We believe that it takes close to a year for the first effects of the new regime to become evident.

We use the Generalised Dickey-Fuller (DF-GLS) test, proposed by Elliot, Rothenberg, and Stock (1996), instead of the more popular Augmented Dickey-Fuller (ADF) to assess the degree of integration of all series. This test does not have power and size issues, which weaken the validity of results obtained using the ADF test. In addition, we use the KPSS test proposed by Kwiatowski, Phillips, Schmidt, and Shin (1992), about which we have no doubts. Unlike the DF-GLS, which assesses the presence of unit root in series, the KPSS test uses the null hypothesis of stationary. Note that we do not transform the series to induce stationarity; instead we use the Minnesota priors such that $\beta_i = 1$ for all nonstationary series and $\beta_i = 0$ for series that are mean-reverting. We choose λ in such a way that the LBVAR model has the same fit as the VAR with three variables (GDP, inflation, and the repo rate) estimated with OLS. As in Bernanke, Boivin, and Eiasz (2005), we divide the sample into two. Slow-moving variables are those that react slowly to a monetary policy shock, such as real and nominal variables, while fast-moving variables react contemporaneously to a monetary policy shocks, such as financial variables.[5] We use four lags in the VAR, which corresponds to a year. The identification procedure is such that slow-moving variables come first. These are followed by the policy instrument, the repo rate, while fast-moving variables are ordered last. We use 5,000 replications to construct impulse response functions (IRFs). The posterior coverage of IRFs is set to 90% confidence levels. In this analysis the monetary policy shock increases the repo rate by 1% or 100 basis points.

4 Empirical Results

4.1 Identification of Monetary Policy Shock

Figure 1 depicts the identification of monetary policy which is correctly identified, as predicted by theory. The repo rate increases by 1% at impact and the effects fade away quickly in less than a year. The GDP reacts negatively, reaching the minimum of 0.05% after a year. The impact of the shock lasts for closer to two years. Similarly, inflation decreases, but the effect is short-lived. It is evident that the identification strategy we adopt solves the price puzzle, which is common in small VAR models, such as Bonga-Bonga and Kabundi (2011). The price puzzle occurs when a rise in short-term interest rate leads to an increase in inflation instead of a decrease as predicted by theory. Bernanke et al. (2005) and Banbura et al. (2010) argue that puzzling results obtained in small VARs are the consequence of insufficient information. The BGR show that a model with 20 variables already solves puzzling results in real variables and prices. If realistic information is not taken into account, it is more likely to mix structural shocks and measurement errors. Furthermore, including more than 20 variables does not affect results negatively. Like GDP, the effect on inflation attains its peak of 0.12% after a year and lasts for more than two years. These results point to long-term neutrality of monetary policy. In response to contractionary monetary policy, personal consumption expenditure (PCE) falls significantly. In line with expectations, higher shorter-term

[5] See the Appendix for a description of the dataset.

interest rates make financing consumption through credit more expensive and in turn compress growth in consumption expenditure in less than a year. However, the effect on consumption is somewhat less than the effect on GDP and it is short-lived. It reaches a minimum of 0.03% three quarters after the shock. But the effect on the consumption of durable goods is more pronounced and lasts longer. It declines by 0.13% after four quarters and retreats to baseline level after a year and a half.

It is evident that contractionary monetary policy affects real interest rates and long-term interest rates, which in turn puts pressure on spending on durable goods and ultimately depressing aggregate demand. Conventional analysis of monetary policy transmission attributes strong reaction of consumption of durable goods to the fact that it is the most interest-sensitive part of aggregate demand. The impact on growth in fixed capital formation (GFCF growth) comes with a greater lag of three quarters. This is consistent with the literature.[6] Bernanke and Gertler (1995) explain the delay in reaction by incredibly large adjustment costs. Businesses have a long-term perspective in their investment decisions when faced with changes in interest rates. The short-term interest rate elasticities of investment seem quite small.

4.2 Interest Rate Channel

Figure 2 indicates that the traditional channel of transmission of monetary policy, also known as interest rate channel, is important in South Africa. A rise in repo rate is translated directly into an increase in short-term rates, which in turn affect the cost of capital and cause a drop in investment spending by corporates and households. The three-month treasury bill (TB) and the prime overdraft rate react contemporaneously to a one per cent rise in the repo rate. However, the magnitudes of impact differ. The prime overdraft depicts a stronger reaction of 0.43%, while the TB increases by 0.38%. The increase in short-term interest rates in South Africa differs from the US, where Igan et al. (2013) find a complete transmission from policy rate to Bank Prime Loan rate and three-month treasury bill. The effect on both rates is short-lived: only two quarters after the impact. Long-term interest rates depict the same pattern, which mimics closely the behaviour of the repo rate. As Taylor (1995) points out, there is a degree of correlation between various long rates for any maturity. And it should be noted that the magnitude of effect depends largely on the maturity of long rates. Long-term rates rise by less than short-term rates. The extent to which the bond yields increase differs across the maturity spectrum. The bond yield of zero to three years scores high value of 0.25%,

[6] See Beranke and Gertler (1995), Taylor (1995), and Boivin, Kiley, and Mishkin (2010) for more explanation.

while the 10-year bond has a relatively weak response of 0.06%. As with short-term rates, the effect has the same duration as the policy rate, i.e. two quarters.

4.3 Asset Price Channel

Besides stock, assets include real estate assets, in this case housing. The asset price channel is closely related to the consumption channel, also known as the wealth channel. A rise in the short-term rate affects demand for stock negatively and consequently stock prices drop. The all-share index (JSE) does not react upon impact, and eventually decreases gradually, attaining the lowest level of 0.32% after two quarters (see Figure 3). The decline is consistent with Kabundi and Ngwenya's (2011) findings. The magnitude of decline is relatively high in comparison to the effect on house prices. House prices do not react contemporaneously, but the effect is statistically significant, reaching a minimum value of 0.08% after two quarters. In contrast to Kasai and Gupta (2008), who find evidence of the home price puzzle, the result is in line with theory.[7] In addition, an increase in the repo rate curtails demand for housing and hence residential investment declines. Residential investment decreases sharply, but the effect is contained in the short run. Bernanke and Gertler (1995) observe that the effect of monetary policy on residential investment is larger than the effect on private investment. In contrast to a lag and small reaction of GFCF growth, reaching its lowest level of 0.06% after four quarters, residential investment reacts faster and attains the minimum of 0.15%. Moreover, a positive monetary policy shock impairs the net wealth of households.

4.4 Expectation Channel

Business confidence and consumer confidence levels are closely related to the findings by Kabundi and Ngwenya (2011), even though the magnitude and time of effects differ somewhat. More importantly, the missing variable in Kabundi and Ngwenya (2011) is inflation expectations, which play an essential part in the expectation channel of monetary policy. In Figure 4 we can observe that business confidence (BERBCI) contracts more than consumer confidence (CCI). It indicates that the perception of agents is that a contractionary monetary policy affects business more than consumers. BER BCI attains a maximum decline of 0.61% after two quarters and the effects vanish gradually. The effect on consumer confidence is short-lived and reaches the maximum decline of 0.15% at the same time. The reactions of both business confidence and consumer confidence

[7] Gupta, Jurgilas, and Kabundi (2010) find that the home price puzzle observed in Kasai and Gupta (2008) is due to information deficiency in small VAR models. They solve the puzzle with a FAVAR model containing 246 variables.

lead real variables (GDP, PCE, and PCE Durable) by approximately two quarters. This is essential for the conduct of monetary policy, especially in inflation-targeting regime. Monetary policy authority aims at anchoring expectations of economic agents. It seems the SARB has been successful when it comes to the effects of the policy on the real economy.

However, the outcome is different concerning the expectations about inflation. Inflation expectations increase and stay positive for about a year and then become negative, and finally die out gradually. The reaction of inflation expectation may be due to backward-looking expectation formation of market participants in South Africa. Kabundi and Schaling (2013) attribute this behaviour to the fact that the implicit inflation target is higher that the official inflation target.[8] In addition, they find that the weight allocated to output deviation from its full potential is higher than the weight allocated to inflation deviation from its target.

4.5 Exchange Rate Channel

Boivin et al. (2010) argue that the strength of the exchange rate channel in the monetary policy transmission depends on two main factors. Firstly, the exchange rate is sensitive to changes in interest rate. The exchange rate channel is potent when the exchange rate is very sensitive to interest rate movements, as in the case of uncovered interest rate parity. Secondly, the channel seems larger in open economies. Figure 5 shows that the real effective exchange rate reacts immediately upon impact and increases slightly and becomes significant and stays high for eight quarters, and then becomes insignificant. However, the rise in interest rate does not translate into the inflow of funds into South Africa, seeking a high yield, but it does stop funds from leaving the country. Capital outflows drop; nevertheless, the decline is short-lived. The appreciation of the domestic currency puts pressure on exports, which decline temporarily. The negative impact on exports pushes aggregate demand down even further. The impact on the current account is delayed by about a year and then improves for about a year.

4.6 Lending Channel

The lending channel of monetary policy, as one of the non-neoclassical channels, also known as the credit channel, is based on market imperfections. These imperfections are the consequences of asymmetrical information between lenders and borrowers.[9] The

[8] Kabundi and Schaling (2013) estimate the implicit inflation target to be 6.7%, which is consistent with Klein (2012), while the midpoint of the target range is 4.5%.

[9] Bernanke and Gertler (1995) for more details on credit channels.

lending channel refers to the effects monetary policy has on the supply of loans to both households and firms. Mortgage advances, money supply M3, and total credit extended to private sector deal with both supply and demand for loans. Unlike Kabundi and Ngwenya (2011), who discuss the credit channel as a whole, this paper distinguishes between the lending channel and balance sheet channel of monetary policy, and analyses these two components of the credit channel separately.

It is clear from Figure 6 that a percentage increase in the repo rate decreases mortgage advances, total loans and advances, the credit extended to private sector, and the money supply (M3) by almost the same magnitude, except for credit to the private sector, which registers a considerable decline of 0.12%. The decline in total loans and advances becomes significant four quarters after the shock and lasts until the tenth quarter. Similarly, total credit to private sector declines between six and ten quarters. Bank balance sheets are impaired. Equity and liability of banks increase shortly after the impact and then decrease and reach the minimum two years after the shock and then the effects die out gradually. It is evident that contractionary monetary policy to some extent affects the ability of the financial intermediary to supply loans to both corporates and households. It is even clear when we consider the separately equity and deposits. Total equity drops immediately upon impact and attains the minimum of 0.21% after three quarters, while total deposits decrease gradually, reaching the minimum five quarters after the shock. Furthermore, the asset side of the balance sheets of banks is affected even more than the liability side. As Disyatat (2011) suggests, the bank lending channel affects the demand for loans more. Total claims on the private sector decrease gradually and attain a minimum of 0.12% five quarters after the shock.

Moreover, the ratio of deposits to liability shows an important decline right after the shock, but it recovers quickly. Consequently, financial institutions record a rise of non-performing loans (NPLs), attaining a maximum of 0.17% after three quarters due to the inability of households and firms to pay back loans. In addition, financial intermediaries deleverage quickly following an increase in short-term rates. The ratio of total equity and liability to total liability shrinks, indicating the negative effects of monetary policy on the size of the balance sheets of banks. In this environment banks become risk averse. This implies that contractionary monetary policy reduces the risk-taking behaviour of banks, which is common in lower interest rate regimes. The realised volatility of monthly returns on bank stocks, as a measure of overall risk to banks, decreases sharply upon impact. Finally, interest received as a percentage of credit extended to the private sector and interest paid as a share of total deposits both increase.

4.7 Balance Sheet Channel

There is also evidence that monetary policy affects households through the household balance channel. This channel accounts for the effects of monetary policy on the demand for loans. Given the lack of information on the balance sheets of firms, the analysis focuses on the balance sheets of households. Household disposable income falls significantly for nearly two years. At the peak effects of a monetary policy shock, disposable income falls by nearly 0.08% in the third quarter. Household total assets fall significantly, and the impact lasts for about a year. The decline in fixed assets follows the same pattern as that of total assets. It reaches the maximum value of 0.09% three quarters after the shock and recovers quickly. The combination of lower net wealth and the negative effects of household assets push up the external financial premium to 0.1%, which stays up for three quarters. Because the balance sheets of households are impaired, the cost of raising funds externally increases.

The household's liability side, which comprises loans, is highly responsive to a monetary policy shock. The liabilities of households remain depressed for two years, which is double the period experienced by households' assets. Debt servicing costs rise by 0.85% on impact, with the effects dissipating within a year. In addition, total household debt contracts for two years. In addition we find that the prime overdraft rate increases by 0.43% on impact, which is less than the increase in repo rate.

4.8 Variance Decomposition

Table 1 depicts the variance decomposition, which in turn indicates the importance of analysing the different channels of monetary policy shock. It is clear from the table that the interest rate channel seems the most potent. This accords with the views of Boivin et al. and Bernanke and Gertler (1995). Short-term interest rates, represented by prime overdraft and the three-month treasury bill, score the highest values of variance decomposition. They are followed by long-term interest rates of different maturities. It is evident that the traditional channel of transmission of monetary policy is still the most important channel in South Africa, post the inflation-targeting era. It is essential to note that short-term rates translate directly into interest received and interest paid by banks, which in turn affect the balance sheet of banks. Similarly, changes in short-term interest rates induce movements in debt servicing costs, which affect the balance sheets of households, and therefore the demand for loans. They also directly affect the external financial premium, which subsequently affects the balance sheets of households.

The second most important channel is the exchange rate channel. As correctly pointed out by Boivin et al. (2010), this channel seems to be large in small, open economies, like South Africa. Since the adoption of the inflation-targeting policy, the country adopted a floating exchange rate, which has become a non-negligible channel of transmission of various shocks. With the variance decomposition of 0.58%, the exchange rate channel is weak relative to the interest rate channel. Similar to the results obtained from the IRFs, the exchange rate channel seems to transmit more via capital outflows, exports, and imports than through capital inflows. A rise in the repo rate does not translate into massive capital inflows; instead, it stops capital from leaving the country.

The lending channel is the third most important in South Africa. Along the same lines as the exchange rate channel, the lending channel depicts a variance decomposition of 0.39% for deposits to liability ratio, which is somewhat weak. The percentage of equity and liability as a share of total liability scores a variance decomposition of 0.13%. It is evident from this analysis that the lending channel is more important than the balance sheet channel. Thus a contractionary monetary policy affects the supply of loans more than it does the demand for loans. Even though the balance sheets of households are impaired the impacts are not comparable to those of financial intermediaries. The variance decomposition of household disposable income, financial liabilities, and debts are 0.23%, 0.20%, and 0.18% respectively. Household total assets and household equity and investment funds show very low values of variance decomposition of (0.08% and 0.04% respectively). The results point to the fact that households are directly affected through the interest rate channel and the amplification of the shock through their balance sheets is rather weak. The story would have been different had the analysis included the balance sheets of corporates.

The expectation channel is the fourth most important channel after the interest rate, the exchange rate, and the lending channel. The variance decomposition portrays the same picture observed with the IRFs. Business confidence is the most important channel when it comes to expectation, with a variance decomposition of 0.29% compared to 0.16% for consumer confidence. Even though inflation expectations depict a higher value of variance decomposition, 0.87%, Figure 4 shows they mainly lag behind business confidence and consumer confidence.

Finally, the asset price channel is outweighed by all the other channels. They have the lowest values of variance decomposition – 0.13% for house price, 0.12% for JSE, and 0.07% for household net wealth. The relative unimportance of the asset price channel can be attributed to the fact that only a small proportion of South Africans hold shares on the stock exchange. In addition, there are few people in the country who use their houses as collateral to get more loans.

5 Conclusions

This paper analyses the importance of the six channels of transmission of monetary policy in South Africa after the institution of the inflation-targeting regime. Besides the neoclassical channel of transmission of monetary policy, the analysis includes the non-neoclassical channels proposed by Bernanke and Gertler (1995). The empirical framework consists of the large Bayesian vector autoregressive (VAR) model of Banbura et al. (2010), which contains 162 quarterly variables, including the real variables, nominal variables, financial variables, and balance sheet variables of households and banks. The dataset covers a period ranging from 2001Q1 to 2012Q2.

The results from impulse responses indicate that all channels are relevant in South Africa. The interest channels are the most important. Short- and long-term interest rates react quickly upon impact and are forcefully transmitted to real and nominal variables. GDP, consumption expenditure and investment drop and recover slowly. Similarly, prices decline, but the impact is not permanent. The data-rich environment solves the puzzling results observed in most small-scale VAR models. Asset price prices, both stock prices and house prices, are affected by contractionary monetary policy. Importantly, the policy during the inflation-targeting regime affects expectations about the real economy more, but does not anchor price expectations. Inflation expectations lag considerably. Like most open economies, the exchange rate channel seems a somewhat important transmitter of monetary policy. It operates more via capital outflows and trade than through capital inflows. In addition, the paper finds evidence that non-neoclassical channels are essential transmitters of monetary policy. The balance sheets of banks and households alike are affected, hence impairing the supply of and demand for loans. A rise in the external financial premium due to the worse state of the balance sheets of households further affects the supply of loans to households. Although the paper does not comprehensively address the risk-taking channel of monetary policy, the results show that the ratio of deposits to liability shows an important decline right after the shock; consequently, financial institutions record a rise of non-performing loans (NPLs). In addition, financial intermediaries deleverage quickly following an increase in short-term rates. The ratio of total equity and liabilities to total liabilities shrinks, indicating the negative effects of monetary policy on the size of the balance sheet of banks. In this environment banks become risk averse. This implies that a contractionary monetary policy reduces risk-taking behaviour of banks, which is common in lower interest rate regimes. The realised volatility of monthly returns on bank stocks, as a measure of bank overall risk, decreases sharply at impact.

The results obtained from variance decomposition point to the superiority of the interest rate channel of monetary policy over the other five channels. The new policy regime, inflation-rate targeting, which advocates a floating exchange rate, makes the latter a shock absorber. Exchange rate has become a transmitter of various shocks, including monetary policy shocks. The third important channel is the lending channel, followed by the expectation channel. Unlike the balance sheets of banks, the balance sheets of households do not play a major role in transmitting monetary policy shocks to the economy. Finally, asset prices secure the last position among the six channels included in this study.

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Rank	Series	VD	Rank	Series	VD	Rank	Series	VD
1	Prime overdraft rate	18.475	16	Inflation	0.553	31	Equity and Liability	0.129
2	Treasury Bill	16.851	17	Deposits to liabilities	0.391	32	House Price	0.125
3	Received banks % of claims	13.778	18	GFCF Residential buildings	0.366	33	JSE	0.117
4	Paid banks % of deposits	13.399	19	BER Business Confidence	0.285	34	FCE Durable	0.110
5	Yield 0 to 3 years	7.766	20	GFCF growth	0.275	35	Exports	0.099
6	Yield 3 to 5 years	6.871	21	HH diposable income	0.233	36	Imports	0.097
7	Yield 5 to 10 years	3.178	22	HH Financial liabilities: Loans	0.200	37	Household assets	0.085
8	Financial leverage	2.456	23	Total HH debt	0.180	38	Current Account	0.074
9	External Financial Premium	2.427	24	PCE	0.171	39	Household net wealth	0.073
10	Debt service costs	2.303	25	BER Consumer Confidence	0.157	40	M3	0.054
11	Yield 10 years and more	1.071	26	Total credit to private sector	0.155	41	HH Equity & investment fund	0.042
12	Inflation Expectations	0.866	27	Total loans and advances	0.145	42	NPLs	0.031
13	GDP	0.829	28	Mortgage advances	0.145	43	Capital in	0.002
14	Bank risk	0.780	29	HH Fixed assets	0.142			
15	REER	0.579	30	Capital out	0.136			

Table 1: Variance Decomposition

Figure 1 Identification of Monetary Policy Shock

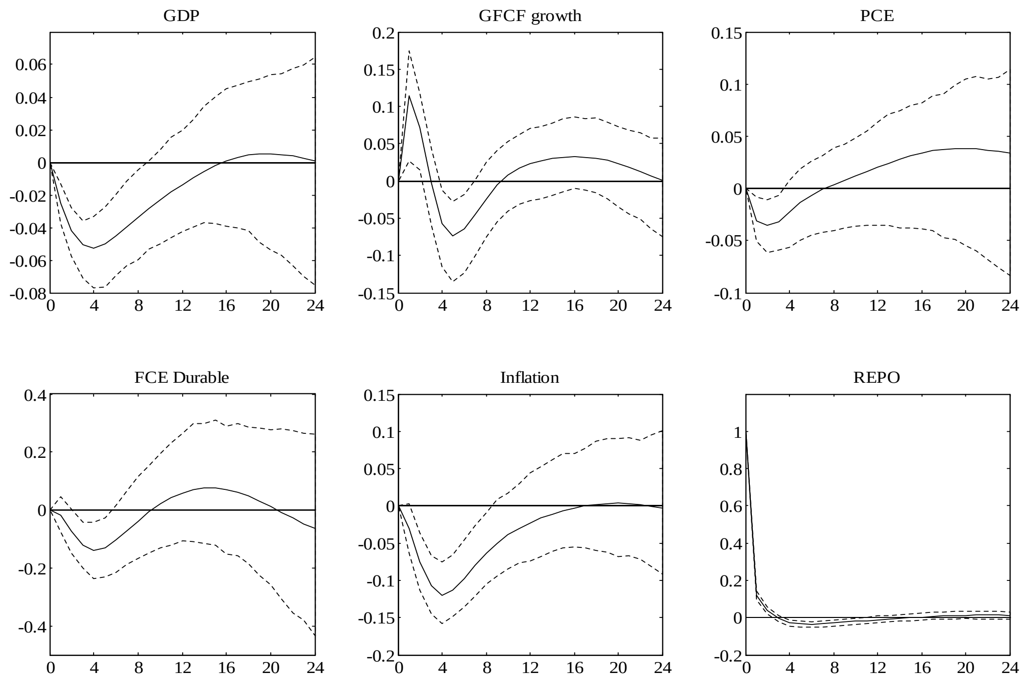


Figure 2 Interest Rate Channel

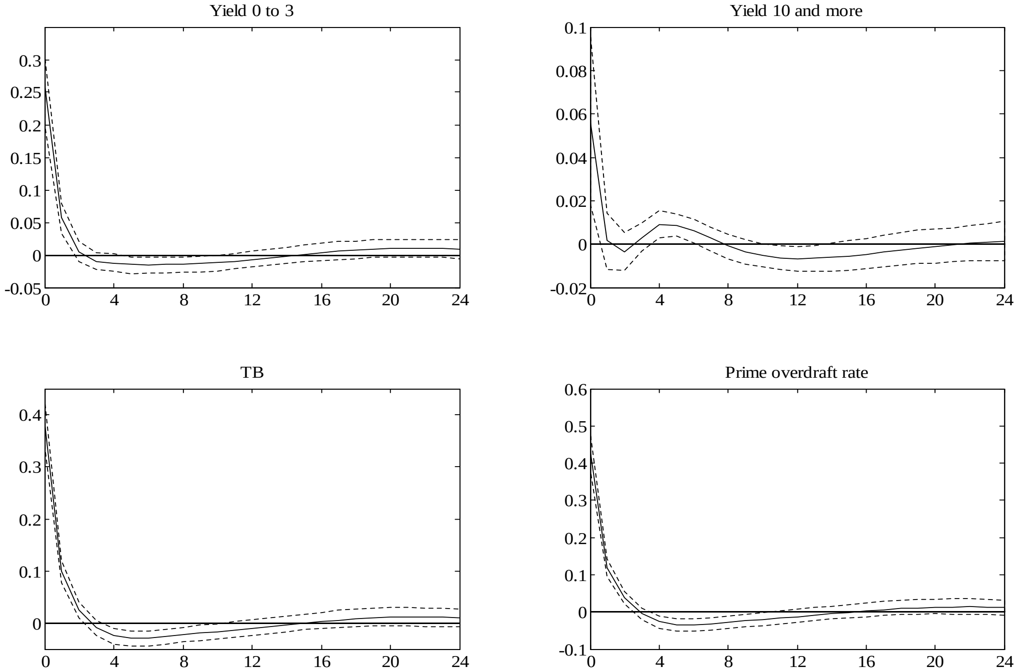


Figure 3 Asset Price Channel

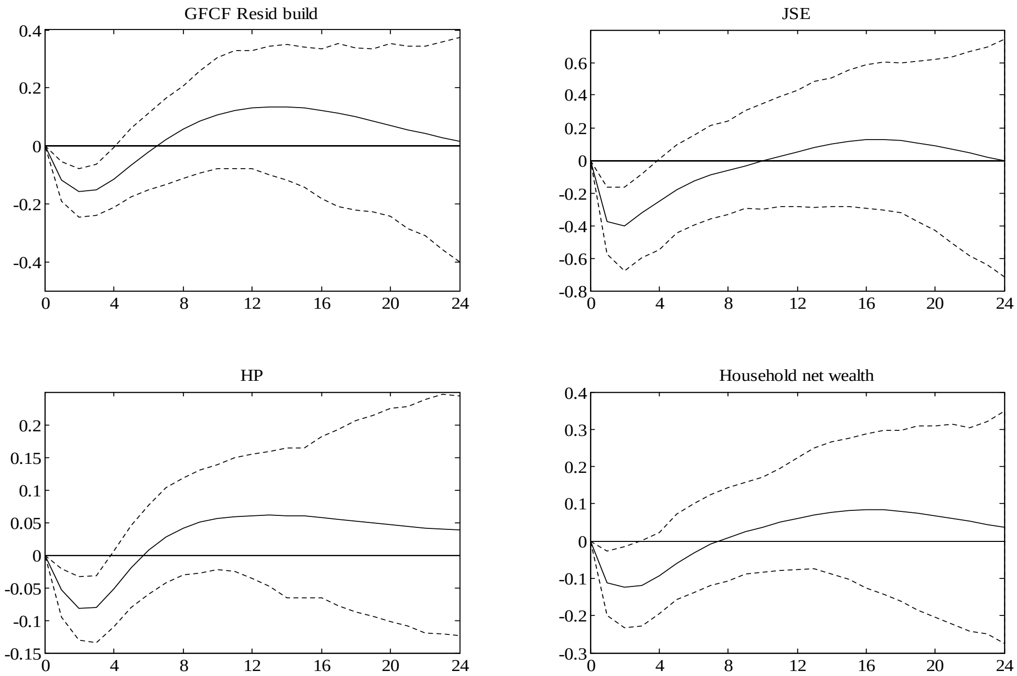


Figure 4 Expectation Channel

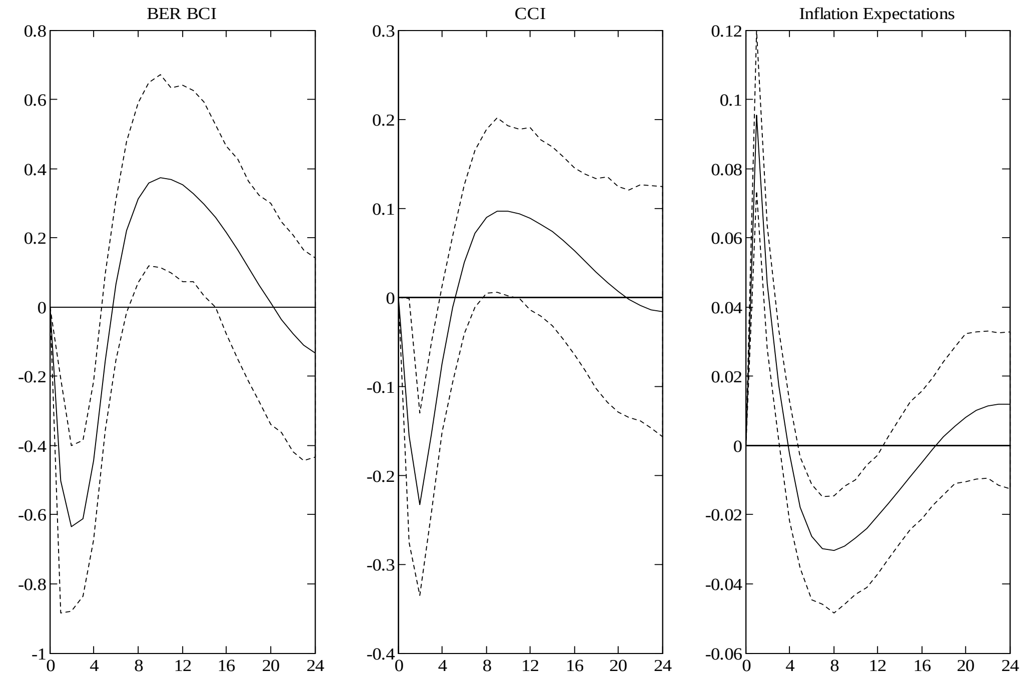


Figure 5 Exchange Rate Channel

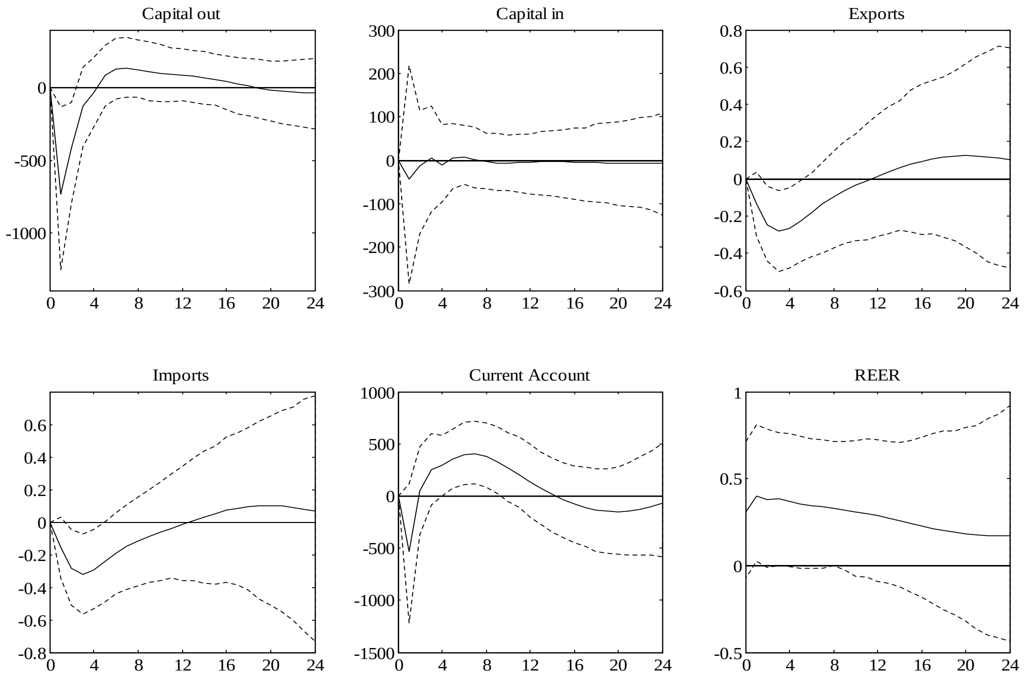


Figure 6 Lending Channel

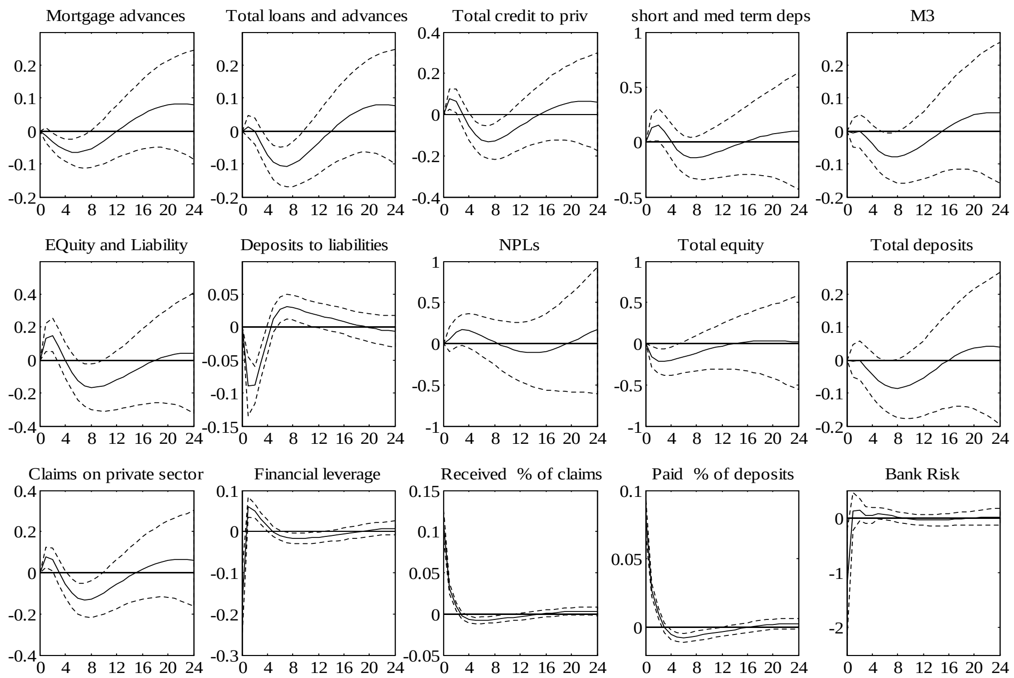
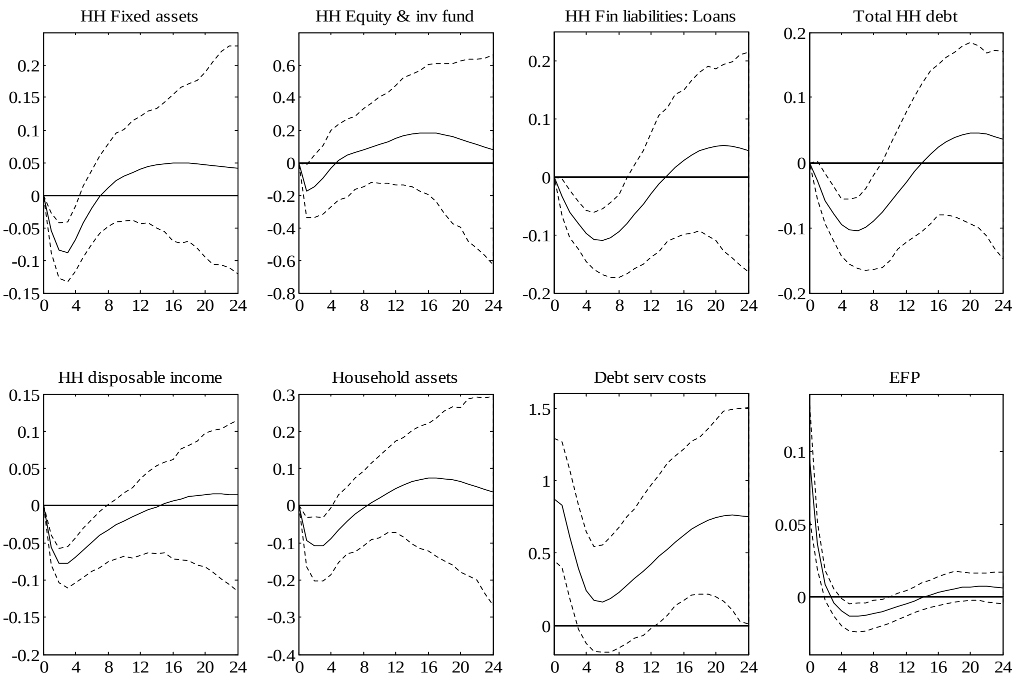


Figure 7 Balance Sheet Channel



Appendix: List of Variables and their treatments

	Variables	Treatment
1	GDP	5
2	Employment Total Public sector	5
3	Employment National departments	5
4	Employment Provinces	5
5	Employment Total Private sector	4
6	Employment Total Mining	5
7	Employment Gold mining	5
8	Employment Non gold mining	5
9	Employment Manufacturing	5
10	Employment Construction	5
11	Remuneration per worker in the non-agricultural sector: Public sector, real	5
12	Remuneration per worker in the non-agricultural sector: Private sector, real	5
13	Total remuneration per worker in the non-agricultural sector, real	5
14	Labour productivity in the non-agricultural sectors	5
15	Nominal unit labour costs in the non-agricultural sectors	5
16	Gross national income (GNI)	5
17	Gross saving - Total	5
18	Net saving by general government	1
19	Compensation of residents	5
20	Disposable income of households	5
21	Savings by households	1
22	Gross fixed capital formation: Residential buildings - Total (Investment)	5
23	Gross fixed capital formation: Non-residential buildings - Total (Investment)	5
24	Gross fixed capital formation: Construction works - Total (Investment)	5
25	Gross fixed capital formation: Transport equipment - Total (Investment)	5
26	Gross fixed capital formation: Mining and Quarrying (Investment)	5
27	Gross fixed capital formation: Manufacturing (Investment)	5
28	Gross fixed capital formation: Electricity, gas and water (Investment)	5
29	Gross fixed capital formation (Investment)	5
30	Gross fixed capital formation: General government (Investment)	5
31	Gross fixed capital formation: Private business enterprises (Investment)	5
32	Final consumption expenditure by households: Total (PCE)	5
33	Final consumption expenditure by general government	5
34	Change in inventories	2
35	Final consumption expenditure by households: Durable goods	5
36	Deflator Gross domestic product at market prices	6

	Variables	Treatment
37	Deflator Gross domestic expenditure	6
38	CPI	6
39	CPI Services (index)	5
40	CPI Goods (index)	5
41	CPI food (index)	5
42	CPI headline inflation rate	2
43	CPI Services inflation rate	2
44	CPI Goods inflation rate	2
45	CPI food inflation rate	2
46	PPI agric, mining and fishing (growth)	2
47	PPI manufacturing (growth)	2
48	PPI electricity(growth)	2
49	PPI total(growth)	2
50	PPI imported(growth)	2
51	PPI agric and fishing (index)	5
52	PPI mining (index)	5
53	PPI Food (index)	5
54	PPI total (index)	5
55	PPI imported (index)	5
56	Credit Investments	5
57	Bills discounted	4
58	Instalment sale credit	5
59	Leasing finance	5
60	Mortgage advances	5
61	Other loans and advances	5
62	Total loans and advances	5
63	Total credit extended to the private sector	5
64	notes and coin	5
65	cheques	5
66	M1A	5
67	Demand deposits	5
68	M1	5
69	short and med term deps	5
70	M2	5
71	Long term deps	5
72	M3	5
73	Bank notes and subsidiary coin	5

	Variables	Treatment
74	Reserve and clearing account held with SARB	2
75	Treasury bills	5
76	Government stock	5
77	Land bank bills	2
78	Total holdings	5
79	Required holdings	5
80	Capital movements of liabilities: Total direct investment	1
81	Capital movements of liabilities: Direct investment: private non-banking sector	1
82	Capital movements of liabilities: Total portfolio investment	1
83	Capital movements of liabilities: Portfolio investment: public authorities	1
84	Capital movements of liabilities: Portfolio investment: public corporations	1
85	Capital movements of liabilities: Portfolio investment: banking sector	1
86	Capital movements of liabilities: Portfolio investment: non-banking sector	1
87	Capital movements of liabilities: Total other investment	1
88	Capital movements of liabilities: Other investment: monetary authorities	1
89	Capital movements of liabilities: Other investment: public authorities	1
90	Capital movements of liabilities: Other investment: public corporations	1
91	Capital movements of liabilities: Other investment: banking sector	1
92	Capital movements of liabilities: Other investment: private non-banking sector	1
93	Capital movements of assets: Total direct investment	1
94	Capital movements of assets: Direct investment: private non-banking sector	1
95	Capital movements of assets: Total portfolio investment	1
96	Capital movements of assets: Portfolio investment: banking sector	1
97	Capital movements of assets: Portfolio investment: private non-banking sector	1
98	Capital movements of assets: Total other investment	1
99	Capital movements of assets: Other investment: monetary authorities	1
100	Capital movements of assets: Other investment: public authorities	1
101	Capital movements of assets: Other investment: public corporations	1
102	Capital movements of assets: Other investment: banking sector	1
103	Capital movements of assets: Other investment: private non-banking sector	1
104	JSE Gold	5
105	JSE General	5
106	JSE Total mining	5
107	JSE Total financial	5
108	JSE Total industrial	5
109	JSE All shares	5
110	HP ABSA prices (level)	6

	Variables	Treatment
111	HP ABSA prices (index)	6
112	Yield Zero to three years	1
113	Yield Three to five years	1
114	Yield five to ten years	1
115	Yield Ten years and more	1
116	Eskom bonds	1
117	REPO	1
118	Treasury bills: 91 days tender rate	1
119	Prime overdraft rate	1
120	Merchandise exports (seasonally adjusted and anualised)	5
121	Net gold exports (seasonally adjusted and anualised)	5
122	Merchandise imports (seasonally adjusted and anualised)	5
123	Current account of the balance of payments: Seasonally adjusted	5
124	REER (average)	5
125	Rand US dollar exchange rate	5
126	Leading indicator	1
127	Coincident Indicator	1
128	Lagging Indicator	1
129	Labour productivity in the non-agricultural sectors	5
130	Nominal unit labour costs in the non-agricultural sectors	5
131	RMB/BER Business Confidence Index	4
132	Consumer Confidence Index	1
133	HH Non-financial assets	5
134	HH Fixed assets	5
135	HH Financial assets	5
136	Currency and deposits	5
137	HH Debt securities	5
138	HH Loans	5
139	HH Equity and investment fund shares or units	5
140	HH Insurance, pensions and standardised guarantee schemes	5
141	HH Financial liabilities	5
142	HH Financial liabilities: Loans	5
143	HH Financial liabilities: Other accounts receivable/payable	5
144	HH Total assets of households	5
145	Total household debt	5
146	Disposable income	5
147	Debt servicing cost to disposable income ratio	1

	Variables	Treatment
148	Debt servicing costs R millions	5
149	Total equity and liabilities	5
150	Deposits to liabilities	1
151	NPLs all loans as % of all loans	1
152	Financial leverage (risck measure)	1
153	Interest received by banks as a percentage if total claims	1
154	Interest paid by banks as a percentage of deposits	1
155	EFP	1
156	Bank Risk	1
157	Capital gearing	5
158	Household assets	5
159	Household net wealth	5
160	HH assets/HH net worth	5
161	NPLs	5
162	Inflation Expectations	1
163	Total equity	5
164	Total deposits	5
165	Claims on private sector	5

Note transformation codes are as follows: 1 = no transformation; 2 = second difference; 4 = logarithm; 5 = first difference of logarithm; 6 = second difference of logarithm