Spillovers of the Conventional and Unconventional Monetary Policy from the US to South Africa*

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Abstract

We investigate the effect of the US monetary policy on South Africa during the period 1990 and 2016. We separate our sample by pre- and post-crisis period. In the pre-crisis period, from January 1990 to December 2007, we identify monetary policy shock from the US based on the conventional monetary policy scheme. Whereas, during the post-crisis period, from January 2008 to November 2016, we identify monetary policy shock from the US based on the unconventional monetary policy due to the zero-lower bound during this period. Our results indicate that monetary policy in South Africa is independent - the policy rate only respond to inflation and output. Our results are consistent with the "fear of floating" arising from the pass-through of the exchange rate to domestic prices. Furthermore, we find that structural issues in the economy prevent South Africa from taking advantage of the local currency depreciation during the period of conventional monetary policy nor global economic recovery during the period of unconventional monetary policy. Therefore, the reaction of the central bank can incorrectly be seen as leaning against the wind, whereas in fact, it is the structural issues of the domestic economy that make the objective of price stability and economic growth at odds.

1 Introduction

Recently there has been a resurgence of the debate on the validity of the Mundellian trilemma hypothesis since the famous intervention of Rey (2015) at the Jackson Hole meeting of 2013. The trilemma hypothesis is based on the Mundell-Fleming argument which emphasises the impossibility of having simultaneously a fixed exchange rate regime, full capital mobility, and monetary policy independence. It infers that monetary policy independence is only possible in a floating exchange rate regime with free capital mobility. Rey (2015, 2016) argues that in the context of a globalised world with high degree of financial integration where the US dollar plays a central role in international transactions, monetary policy in peripheral economies seems less independent even in a flexible exchange rate regime with full capital mobility. She contends that the US monetary policy is transmitted to other countries through an international credit and/or risk-taking channel. This is possible partly because of strong comovement in

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risky assets across the globe. From this comovement emerges a global financial cycle which is strongly correlated with the VIX. Since the US monetary policy affects the VIX, it also influences the global financial cycle which in turn alters risky assets in other countries and hence monetary policy is compelled to react to prevent financial instability.

This paper examines empirically the applicability of Rey (2015) findings for South Africa (SA). We proceed first by looking at the possibility of monetary policy independence in SA. Similar to Obstfeld et al. (2004, 2005), Shambaugh (2004), Hofmann and Takats (2015), Hofmann et al. (2016), Obstfeld (2015); Obstfeld et al. (2017) and Obstfeld et al. (2017), we examine the independence of monetary policy in South Africa by regressing the South African short-term interest rates on the US short-term interest rates. Unlike, Hofmann and Takats (2015) who find evidence of comovement in both short-term and long-term interest rates between countries in the periphery and the US, Obstfeld (2015), Obstfeld et al. (2017), and Obstfeld (2017) find evidence of relationship only between long-term interest rates. We follow these authors and investigate the relationship the possibility of correlation between the US and the SA short- and long-term interest rates.

Second, as suggested by Rey (2015, 2016) and Bruno and Shin (2015), the link between monetary policies of the two countries could be facilitated by the comovement in risky financial assets. We investigate this hypothesis by extracting the SA financial cycle from a panel of financial variables, using the dynamic factor model. We then determine the correlation, on the one hand between the extracted SA financial cycle and the global cycle, and on the other hand between the financial cycle and some measures of global financial risk.

Thirdly, to assess the channels through the US monetary policy is transmitted to SA, we use a large Bayesian vector autoregressive (LBVAR) model with Minnesota priors, proposed by Bańbura et al. (2010) covering the period ranging January 1990 to November 2016. We identify monetary policy shock from the US, and then determine its spillovers to SA. We account for change in monetary policy regime in the US since the Global Financial Crisis which coincides with massive large-scale asset purchases (LSAPs) with the Fed Funds rate at zero low bound (ZLB), by dividing the sample size into two sub-samples. To test whether the identified monetary policy in both sub-samples is indeed from the US, we estimate both models with US variables only. The results confirm that monetary policy does emanate from the US as the results are the same.

In the pre-crisis period, from January 1990 to December 2007, we identify monetary policy shock from the US based on the conventional monetary policy. We use the zero-restriction identification scheme with a 100 basis points rise in the Fed Funds rate. We resrict real and nominal variables to move slowly following and monetary policy shock, which means they do not react contemporaneously to the shock. On the other hand financial variables respond contemporaneously to monetary policy shock. Hence, they are fast moving.

The second sample contains monthly series observed from January 2008 to November 2016. Note that the identification scheme followed in the first sub-sample is not feasible in this case owing to the ZLB policy. We use instead the sign-restriction identification scheme which captures closely the unconventional monetary policy consisting of LSAPs which prevails mostly during this period. Like Gambacorta et al. (2014) and Boeckx et al. (2014) we identify the LSAPs such that it increases assets of the Federal Reserve Bank and decreases the VIX and the long-term interest rates. This identification scheme is consistent with recent findings by Swanson (2017) and Woodford (2016) that the LSAPs followed by the US after the GFC led to a decline in risk and long-term interest rates.

We present our results separately for the conventional and unconventional monetary policy period. In both periods, we firstly start with verifying that monetary policy in the US is well-identified. Then given the policy identification in the US, we then proceed to analyse the spillover effects to South Africa.

Starting with the period of conventional monetary policy, we find that a contractionary monetary policy in the US reduces activity in both the real and financial sector. Consistent with Rey (2016), our measures of global factors show that global risk increase and the global factor declines. For South Africa, the results show that asset prices decrease, causing the local currency to depreciate. The depreciation of the Rand is inflationary, indicating the lack of the local currency to play any stabilisation role. This then lead to an increase in the policy rate, which dampens industrial production. The lack of responsiveness of exports to a weaker Rand means that Bernanke (2017)'s expenditure-switching effect channel is limited. Therefore, the reaction of the central bank can incorrectly be seen as leaning against the wind, whereas in fact, it is the structural issues of the domestic economy that make the objective of price stability and economic growth at odds.

For the unconventional monetary policy in the US, we find that the expansionary policy reduces global risk and stimulate the real and financial sector in the US. However, the expansionary foreign policy has a contractionary effect on the South African real economy - both output and inflation decrease. Contrary, we find that asset prices in South Africa increase, causing the local currency to appreciate. However, this expansionary effect does not feed into the real economy. In fact, we find that the South African policy rate becomes expansionary in response to the real economy. Therefore monetary policy in South Africa is fundamentally independent because of this lack of transmission from asset prices to the economy.

Overall, we find evidence of monetary policy independence in South Africa. The results indicate a shift in the transmission of the US monetary policy shock from the financial sector during the period of conventional monetary policy to the real sector during the period of quantitative easing. However, due to structural issues in the real economy, South Africa is not able to take advantage of the local currency depreciation during the period of conventional monetary policy nor global economic recovery during the period of unconventional monetary policy. This in turn makes monetary policy seem as anti-growth.

The rest of the paper is organised as follows: We start with the literature review in Section 2. Then we discuss the model and data in Section 3 and 4, respectively. The results for the ordinary least square estimation and VAR analysis are then presented in Section 5. Finally we conclude in Section 6.

2 Literature review

The effectiveness of monetary policy is measured by how well the central bank is able to meet its domestic objectives. The monetary policy trilemma states that a country can only achieve two of the following policy objectives: monetary policy independence, free capital flows and exchange rate stability. There is empirical evidence suggesting that the US not only enjoys the status of being the world's biggest economy, but that it also sets the monetary policy tone in both developed and developing economies. The extent of this importance remains an ongoing debate to which this paper also wishes to contribute to. On one extreme, this importance is seen as invalidating the trilemma by Rey (2015). According to the author, monetary policy in the US affects monetary policy in other developed economies and the rest of the world. Therefore, monetary policy independence is not really independent. This lack of independence reduces the policy trilemma to a dilemma. The channel through which the US monetary policy is transmitted to other countries is broadly defined as the financial channel (Gerko and Rey (2017)). Broadly speaking, the financial channel is the transmission of policy from one country to the other via financial variables - credit, leverage, asset prices and other variables. The two main channels used to explain policy spillovers are the international credit channel [1] and the risk-taking channel [2]. The risk-taking channel by banks posits that in a globally and financially connected world, global banks based in the US channel funds from the US to their subsidiaries or borrowers in other countries during periods of low global risk - Bruno and Shin (2013).

Both Rey (2015) and Bruno and Shin (2015) have received recognition for advancing the literature on monetary policy spillovers or financial stability. However, Rey (2015)'s extreme views are not unanimous. In defense of the US Fed's monetary policy stances post the 2008 crisis and the global importance of the US, former US Fed chairman Bernanke (2017) provides arguments against the dilemma and therefore the importance of the US. Amongst his arguments, he points out that the existence of the co-movement of financial assets does not invalidate the Mundellian trilemma. Firstly, asset prices (and monetary policies across the globe) can co-move in response to a global common shock. In addition, he argues that emerging markets forgo their monetary policy independence voluntarily by pursuing trade competitiveness in addition to their domestic objectives. This then results in a zero-sum game as any policy rate reaction to fight local currency volatility can be at odds with their objectives of output stability. Therefore, the problem is not that the US policy spillovers, but rather that emerging markets try to use a single instrument (policy rate) to achieve both output and financial stability objective. That is monetary policy in emerging markets is independent. Obstfeld et al. (2017) also support the validity of the trilemma. However, contrary to Bernanke (2017), the authors argue that monetary policy is not completely independent since the impact of the US policy depends on the exchange rate regime.

There is empirical evidence of policy spillovers: For developed countries, results by Rey (2015, 2016), Bruno and Shin (2015), Miranda-Agrippino and Rey (2015) and Gerko and Rey (2017) show that US monetary policy affect both monetary policy and financial variables in major economies and financial centers like UK, Canada, New Zealand and the Euro area. Similarly, for the emerging markets, Hofmann and Takats (2015)[3] find evidence of policy spillovers. These papers support the existence of both monetary policy spillover and the financial channel from the US to the rest of the world. But more importantly, the authors find lose of monetary policy independence in these recipient countries and therefore the inability of the flexible exchange rate regime to insulate external shocks as claimed by the trilemma.

On a different note, Obstfeld et al. (2017) investigate the relevance of the exchange rate regime for financially integrated emerging economies between 1986 and 2013 using panel data analysis. They find that domestic financial conditions (with exception to asset prices) respond more to the global financial conditions in a fixed exchange rate regime than they do in a floating exchange rate regime. Even though these results are supportive of the insulation of flexible exchange rate, the authors find that there is no statistical difference between intermediate (managed) exchange rate regimes and the free-floating regimes. This according to the authors, implies that countries do not have to have a completely free-floating exchange rate to enjoy the benefits of a flexible exchange regime.

There is little research on US monetary policy spillovers to South Africa. The only study that we are aware of is Algu and Creamer (2017). However, South Africa has been included in international studies (Hofmann and Takats (2015), Anaya et al. (2017), and Obstfeld (2015) amongst others). Most of these studies use panel study and therefore provide average responses. Some of the studies, Bowman et al.

[1] Bernanke and Gertler (1995).

[2] This view is formally modeled by Bruno and Shin (2013), which they refer to as the risk-taking channel through the banking sector. However, according to the authors, "Borio and Zhu (2012) coined the risk-taking channel of monetary policy to denote the impact of monetary policy on market participants to take on risk exposures".

[3] Hofmann and Takats (2015) find that domestic macroeconomic variables and global risk (proxied by the VIX) significantly affect both interest rates and policy rates and that exchange rate flexibility does not enhance monetary policy independence. The authors conclude that their findings support Rey (2015) dilemma.

(2015) and Obstfeld (2015), provide country specific results within their panel analysis.

Starting with the local study, Algu and Creamer (2017) evaluate the existence of monetary policy trilemma and dilemma in South Africa during the period 1970Q1 and 2012Q4 using two methodologies. With the first methodology, they perform a linear regression of the macroeconomic trilemma indices - monetary policy independence, exchange rate stability, and capital flow index. Furthermore, they also use a three-variable vector autoregressive model which includes inflows, exchange rate and the 3 months Treasury bills. Overall, their results support monetary policy independence in South Africa, thereby validating the trilemma in South Africa.

Bowman et al. (2015) and Anaya et al. (2017) analyse the effects of US unconventional monetary policy on emerging markets. Bowman et al. (2015) estimate both a panel and country-specific impulse response functions using daily data. The results for the impulse response function for South Africa (and most of the other emerging countries) are mostly insignificant. However, average results indicate that sovereign risk respond significantly whereas exchange rate and stock prices are insignificant. Anaya et al. (2017) use structural global VAR for the period January 2008 to December 2014 using monthly data. The results are mainly consistent with the literature - an expansionary policy stance in the US causes inflows to emerging countries which results in local currency appreciations and increase in asset prices. However, the authors find that monetary policy in emerging markets become expansionary amidst the increase in output. Even though the results are the averages for the emerging markets, we suspect that this expansionary response is because the authors did not control for inflation in their model. Alternatively, since they use real interest rates for monetary policy, it might be that the increase in inflation is more than the nominal rates and therefore resulting in a decline of real rates.

Our study on policy spillovers to South Africa improves on these studies in several ways: Firstly, Algu and Creamer (2017) indicate that they cannot apply Rey (2015)'s VAR analysis and hence they restrict their VAR analysis to a small VAR. We show that by using a medium scale BVAR, we are better able to include both US and South African variables, to study the monetary policy spillover from the US to South Africa. This is because large Bayesian VAR enables the researcher to include more variables, even up to 130 as in Bańbura et al. (2010), without losing the degrees of freedom. Therefore, we are able to overcome the problem of omitted bias which might be present in Algu and Creamer (2017). In fact, our impulse response functions are much better Algu and Creamer (2017) and Bowman et al. (2015). By including more variables, this methodology also allows us carefully craft our story. We are also able to compare our results to the international literature - Rey (2016), Bruno and Shin (2015), Miranda-Agrippino and Rey (2015) and Gerko and Rey (2017). Secondly, we separate our analysis by pre and post 2008 crisis. This then enables us to analyse the effect of conventional and unconventional monetary policy separately. Bruno and Shin (2015) find a structural break when they extend their analysis from 1995 - 2007 to also cover the crisis or post-crisis period. Contrary, Miranda-Agrippino and Rey (2015) indicate that their analysis for the period is not affected by the crisis. Despite these opposing views, we find it beneficial to us to separate our analysis. Empirical results for unconventional monetary policy indicate that the effects of this policy in both the real and the financial sectors is short-lived in both the US and Europe. Therefore, we want to see if this short-lived effects have a significant effect on South African variables. Lastly, unlike Anaya et al. (2017), we specifically control for inflation since South Africa is an inflation-targeting country. Therefore, unlike their results, our results for the period of unconventional monetary policy (2008 to 2016) show that monetary policy become contractionary and not expansionary. This is expected and shows the monetary policy response to the increase in inflation and industrial production. In support of our results, Boeckx et al. (2014) also find that an innovation to the European Central Bank total assets during the period January 2007 and December 2014 lead to an increase in both inflation and output and thereby an increase in the policy rate.

3 The VAR analysis

We use a vector-autoregressive (VAR) analysis to jointly analyse the impact of monetary policy in the US on the South African monetary policy and thereby on the local financial and real sectors. To achieve this, we follow Miranda-Agrippino and Rey (2015) and Bańbura et al. (2010) and employ a medium-scale Bayesian VAR model. As discussed in Bańbura et al. (2010), large Bayesian VAR analysis overcomes the size limitation problem of variables which is common in regression analysis and particularly the VAR analysis. This then allows the researcher to include more variables - disaggregated, sectoral and geographical data in the information set. Therefore, Bayesian VAR is an alternative to factor models and panel VARs. Since we want to include both US and South African variables, we apply this methodology. We use monthly data from January 1990 to November 2016 and divide our sample into two sub-samples - the pre-crisis period of 1990 to 2007 and the crisis and post period of 2008 to 2016. These pre- and post-crisis sub-samples allow us to look at the effects of conventional and unconventional US monetary policy spillover on the local economy. Our model include real variables for the US and South Africa, monetary policy instruments in the two countries and financial variables for the two countries.

3.1 Model and identification of shocks

Consider the following VAR (p) model:

$$Y_t = c + B_1 Y_{t-1} + ... + B_p Y_{t-p} + \nu_t \tag{1}$$

where $Y_t = (y_{1,t}, y_{2,t}, ..., y_{n,t})'$ is an $N \times 1$ vector of random variables, $c = (c_1, c_2, ..., c_n)'$ is a $N \times 1$ vector of the constants terms and ν_t' is a $N \times 1$ vector of the error terms with a covariance matrix of $E(\nu_t \nu_t') = \Psi$. Given the large dimension of the matrix Y_t, the VAR model is estimated using the Bayesian VAR (BVAR), Blake et al. (2012), Canova (2007) and Bańbura et al. (2010). The Bayesian VAR imposes prior restrictions on the parameters to be estimated, thereby reducing the the curse of dimensionality. The approach followed in this literature is to set the prior distribution using the "non-strict" Minnesota prior. The Minnesota prior assumes that the variables in Y_t follow an AR (1) process or a random walk. The prior assumes a random walk if the diagonal elements of the B_1 matrix = 1 and an AR (1) process if the variables in the vector Y_t are stationary. Making $\tilde{B_0}$ the mean of the prior for the VAR coefficients, then the prior distribution is, $p(B) \sim N(\tilde{B_0}, H)$, where the variance H is given by the following relations for the VAR coefficients b_{ij}: $(\frac{\lambda_1}{l^{\lambda_3}})^2$ if $i = j$, $(\frac{\sigma_i \lambda_1 \lambda_2}{\sigma_j l^{\lambda_3}})^2$ if $i \neq j$ and $(\sigma_1 \lambda_4)^2$ for the constant.

The subscript i refers to the dependent variable in the i^{th} equation and j to the independent variables in the equation. The variances of the error terms from the AR regressions are estimated via the ordinary least squares and their ratio, $\frac{\sigma_i}{\sigma_j}$, accounts for the differences in the units of measurement of different variables. The parameter l is the lag length and the λ's are parameters that control the tightness of the prior as follows. λ_1 controls the standard deviation of the prior of own lags, where $\lambda_1 \to 0$ has the effect of shrinking the diagonal elements of the B_1 matrix towards 0 and all other coefficients to zero. $\lambda_2 \in (0, 1)$ controls the standard deviation of the prior on lags of variables other than the dependent variable where $\lambda_2 \to 0$ shrinks the off-diagonal elements to 0. If $\lambda_2 = 0$, there is no difference between own lag and the lags of other variables. λ_3 controls the the degree to which lags higher than 1 are likely to be zero where as $\lambda_1 \to \infty$ coefficients on lags higher than 1 are shrunk to 0. Lastly, λ_4 controls the prior variance of the constant. The constant is shrunk to 0 as $\lambda_4 \to 0$.

The strict Minnesota prior assumes that the covariance of the residuals of the VAR is diagonal with the diagonal elements fixed using the error variance from AR regressions σ_i. The current practice is to replace the Minnesota prior with the Normal inverse Wishart prior. The prior assumes a normal prior for the VAR coefficients and an inverse prior for the covariance matrix. This prior allows the random walk aspect of the Minnesota prior on the coefficients to be used without having to impose a fixed and diagonal error covariance matrix. The prior for the VAR parameters are:

$$p(B_0|\Psi) \sim N(\tilde{B_0}, \Psi \otimes \bar{H}) \tag{2}$$

$$p(\Psi) \sim IW(\bar{S}, \alpha) \tag{3}$$

The matrix $\bar{H}$ is a diagonal matrix where the diagonal elements are defined as

$$(\frac{\lambda_0 \lambda_1}{\sigma_i l^{\lambda_3}})^2 \tag{4}$$

for the coefficients on lags, and

$$(\lambda_0 \lambda_4)^2 \tag{5}$$

for the constant. The matrix $\bar{S}$ is defined as a $N \times N$ diagonal matrix with diagonal elements given by

$$(\frac{\sigma_i}{\lambda_0})^2 \tag{6}$$

where λ_0 controls the overall tightness of the prior on the covariance matrix. All other priors are as already explained. However, with the normal inverse wishart, $\lambda_2 = 0$, which implies that the lags of dependent variable and of other variables are treated the same. Following the literature, we also implement the normal inverse Wishart prior using dummy variable. The advantage of this method is that it helps to incorporate the prior that the variables have unit root, Blake et al. (2012). Using T_d dummy variables Y_d and X_d, we regress Y_d on X_d to get the prior mean of the VAR coefficients b_0 and the sum of the squared residuals gives the prior scale matrix for the error covariance matrix S:

$$\begin{aligned} b_0 &= (X_d' X_d)^{-1}(X_d' Y_d) \\ S &= (Y_d - X_d b_0)'(Y_d - X_d b_0) \end{aligned} \tag{7}$$

The regression is equivalent to imposing the normal inverse Wishart prior

$$\begin{aligned} p(B|\Psi) &\sim N(\tilde{b_0}, \Psi \otimes (X_d' X_d)^{-1}) \\ p(\Psi) &\sim IW(S, T_d - K) \end{aligned} \tag{8}$$

where K is the number of regressors in each equation. We generate the dummy variables by:

$$Y_d = \begin{pmatrix} diag(\xi_1\sigma_1, \dots, \xi_N\sigma_N)/\lambda \\ 0_{N\times(P-1)\times N} \\ \\ diag(\sigma_1, \dots, \sigma_N) \\ \dots \\ 0_{1\times N} \end{pmatrix}, X_d = \begin{pmatrix} J_P \otimes diag(\sigma_1, \dots, \sigma_N)/\lambda & 0_{NP\times 1} \\ \\ 0_{N\times(NP)} & 0_{N\times 1} \\ \\ 0_{1\times N} & c \end{pmatrix} \quad (9)$$

where ξ_1 are the prior means for the coefficients on the first lags of the dependent variables (which can be different from 1) and $J_P = diag(1 \dots P)$. Appending the data with the dummy variables we get $Y* = [Y; Y_d]$ and $X* = [X; X_d]$ with length $T* = [T; T_d]$. We can now re-write equation (10) as:

$$Y_t^* = c + B_1 Y_{t-1}^* ... + B_p Y_{t-p}^* + \nu_t^* \quad (10)$$

Now the conditional posterior distribution of the appended data is:

$$\begin{aligned} p(B|\Psi) &\sim N(vec(B*), \Psi \otimes (X^{*\prime}X^*)^{-1}) \\ p(\Psi) &\sim IW(S*, T*) \end{aligned} \quad (11)$$

where $B* = (X^{*\prime}X^*)^{-1}(X^{*\prime}Y^*)$ and $S* = (Y^* - X^*B*)'(Y^* - X^*B*)$.

Furthermore, additional priors are imposed on the sum of coefficients to improve the forecasting performance, (Bańbura et al. (2010)). This is called "inexact differencing". To do this, we re-write equation 10 in an error-correction form:

$$\triangle Y_t = c + (I_n - B_1 - ... - B_p)Y_{t-1} + A_1 \triangle Y_{t-1} + ... + A_{p-1} \triangle Y_{t-p+1} + \nu_t \quad (12)$$

A VAR in first difference requires $(I_n - B_1 - ... - B_p) = 0$. Letting $\Pi = (I_n - B_1 - ... - B_p)$, we set a prior that shrinks Π to zero. To achieve this, "inexact differencing", we augment the first lines of equation 13 with the following:

$$Y_d = \begin{pmatrix} diag(\xi_1\sigma_1, \dots, \xi_N\sigma_N)/\tau \end{pmatrix} \quad , X_d = \begin{pmatrix} J_P \otimes diag(\sigma_1, \dots, \sigma_N)/\lambda & 0_{NP\times 1} \end{pmatrix} \quad (13)$$

where the hyperparameter τ controls the degree of shrinkage - shrinkage decreases as τ approaches inf. Following Bańbura et al. (2010), we set τ, which controls the degree of shrinkage, to a loose prior of 10λ. The overall shrinkage λ is set to match the fit of the simple three-VAR model estimated by the ordinary least squares method.

3.2 Structural analysis

Similar to Rey (2016) and Miranda-Agrippino and Rey (2015), we analyse monetary policy spillovers from the US to South Africa using a medium scale Bayesian VAR model. Overall, the model contains 35 variables for the period of conventional monetary policy - January 1990 to December 2007. Given the shortness of the second sub-sample, we reduce the variables to 22 under the period we regards as unconventional monetary policy - January 2008 to November 2016. As is standard in the medium to large Bayesian VAR literature, we order the slow moving variables first, and then the fast moving variables last. We assume the following ordering structure, $Y_t = (X_t^{us}, X_t^{sa}, r_t^{us}, Z_t^{us}, r_t^{sa}, Z_t^{sa})'$, where X_t^{us} and X_t^{sa} represent the slow moving variables for the US and SA respectively, r_t^{us} is the monetary policy in the US, Z_t^{us} represents the fast moving variables in the US, r_t^{sa} is the monetary policy in South Africa and lastly Z_t^{sa} is the fast moving variables in South Africa. With this ordering structure, we assume that the slow moving variables in both the US and South Africa do not respond contemporaneously to US monetary policy. In addition, we assume that the fast moving variables respond contemporaneously to everything. We treat the South African monetary policy as a fast moving variable, but put it before the South African variables. This ordering allows us to maintain the ordering of slow and fast moving variables within the South African block as $Y_t^{sa} = X_t^{sa}, r_t^{sa}, Z_t^{sa}$. That is, within the local economy, monetary policy authorities can only respond with a lag to fast moving variables.

The structural VAR can be represented as:

$$A_0 Y_t = c + A_1 Y_{t-1} ... + A_p Y_{t-p} + \eta_t \tag{14}$$

where Y_t is the N vector of endogenous variables, A_0 is the $N \times N$ contemporaneous impact matrix, c is a N vector of coefficients and η_t is the $N \times N$ error matrix. The reduced form equation can be written as:

$$Y_t = B_0 + B_1 Y_{t-1} ... + B_p Y_{t-p} + \varepsilon_t \tag{15}$$

where $B_0 = A_0^{-1} c$, $B_i = A_0^{-1} A_i$ for $i = 1, ..., p$ and $\varepsilon_t = A_0^{-1} \eta_t$. And the variance covariance matrix of the reduced form VAR is given by:

$$E(\varepsilon_t \varepsilon_t') = E(A_0^{-1} A_0^{-1\prime}) = \Sigma \tag{16}$$

3.3 Identification of monetary policy in the US

3.3.1 Conventional monetary policy

For the sub-sample January 1990 to December 2007, the period of conventional monetary policy, we use the Federal Fund rate as our monetary policy instrument. Therefore, monetary policy is identified as an exogenous innovation to the Federal Fund rate. We impose zero restrictions on the contemporaneous impact matrix A_0. Using the lower triangular Cholesky decomposition of the reduced form covariance-variance matrix Σ, we can identify the structural shocks. Given the ordering of our variables, this means that we assume that real or slow moving variables in the US do not contemporaneously respond to the US monetary policy. The Federal Fund rate respond contemporaneously only to the real variables in the US. This identification is consistent with Bańbura et al. (2010). Given our interest in the risk-taking channel, correct identification should also show an increase in the VIX and a reduction in asset prices across major financial markets (proxied by the global financial factor).

3.3.2 Unconventional monetary policy

For the crisis and post crisis period, 2008M01 - 2016M11, we follow Boeckx et al. (2014) and Gambacorta et al. (2014) and use total assets of the Federal Reserve Bank as our monetary policy instrument. In this case, a one-standard deviation of the total assets shock proxies the effects of the large-scale asset purchases (LSAPs) policies by the Fed. Since the Fed's rate was in the zero lower bound, we exclude it altogether in our estimation. Following the 2008 financial crisis, central banks in major economies could not use their interest rates to stimulate demand due to the near zero interest rates. Therefore central banks had to use unconventional measures to stimulate the economy. For example, the US Federal Reserve bought long-term securities to put downward pressure to the long-term rates and also bought mortgage-backed securities to help the housing market, Swanson (2017). These asset purchases increased total assets of the Federal Reserve Bank. Several studies have looked at the effects of such unconventional monetary policy actions (Boeckx et al. (2014), Gambacorta et al. (2014) and Swanson (2017) amongst others). Using a cross-country analysis, Gambacorta et al. (2014) find that for countries that increased their central banks' balance sheets (US, UK, Canada and Euro area), both prices and output increased. Boeckx et al. (2014) finds similar results for the European area. However, the author finds that the effects of unconventional monetary policy actions are short-lived, only lasting for 2 - 3 months.

As in Boeckx et al. (2014) and Gambacorta et al. (2014), we use a combination of zero restrictions and sign restrictions to identify monetary policy. We impose the following restrictions: First, we assume that real variables do not contemporaneously respond to the central bank balance sheet. Second, we assume that an expansionary unconventional monetary policy dampen risk. Given that the aim of the Central Bank was to put downward pressure on long-term rates or dampen financial uncertainty at the time in the financial markets, this restriction is also consistent with the Bruno and Shin (2015) risk-taking channel view that reduction in interest rates dampen risk in the financial markets and therefore increase leverage. Third, we also impose that the increase in the Central Bank assets reduces long-term rates. As with other fast moving variables, we do not impose zero restrictions on both the VIX and the long-term rates. Overall, the zero restrictions imposed are the same as that in the conventional monetary policy analysis. That is, slow moving variables are ordered before the Central Bank assets and the fast moving variables after the Central Bank assets.

Table 1: Identification of monetary policy

Slow moving variables (real & nominal)	VIX	Central bank assets	Long-term rate
0	≤ 0	≥ 0	≤ 0

Notes: Output is proxied by the US industrial production, central bank assets by the Federal Reserve Bank total assets and long-term rates by the yields on 10 year US bonds.

The Gibbs sampling algorithm to find the coefficients of the VAR involves finding an A_0 impact matrix that is consistent with the imposed sign and zero restrictions. As discussed in Blake et al. (2012)[4], the procedure involves: estimating the parameters of the VAR using the posterior distributions in Equation 11. Then once past the burn-in stage, the candidate A_0 matrix is calculated for every retained Gibbs draw that meet the restrictions in Table 1.

4 Data

4.1 Financial cycles

The financial cycle captures swings in perceptions and attitudes about financial risk which are reflected in the associated co-movement of global financial developments, Ng (2011). The literature on the international credit channel or the risk-taking channel postulate that these these changes in perceptions and attitudes by investors are influenced by monetary policy in the US, amongst other things.

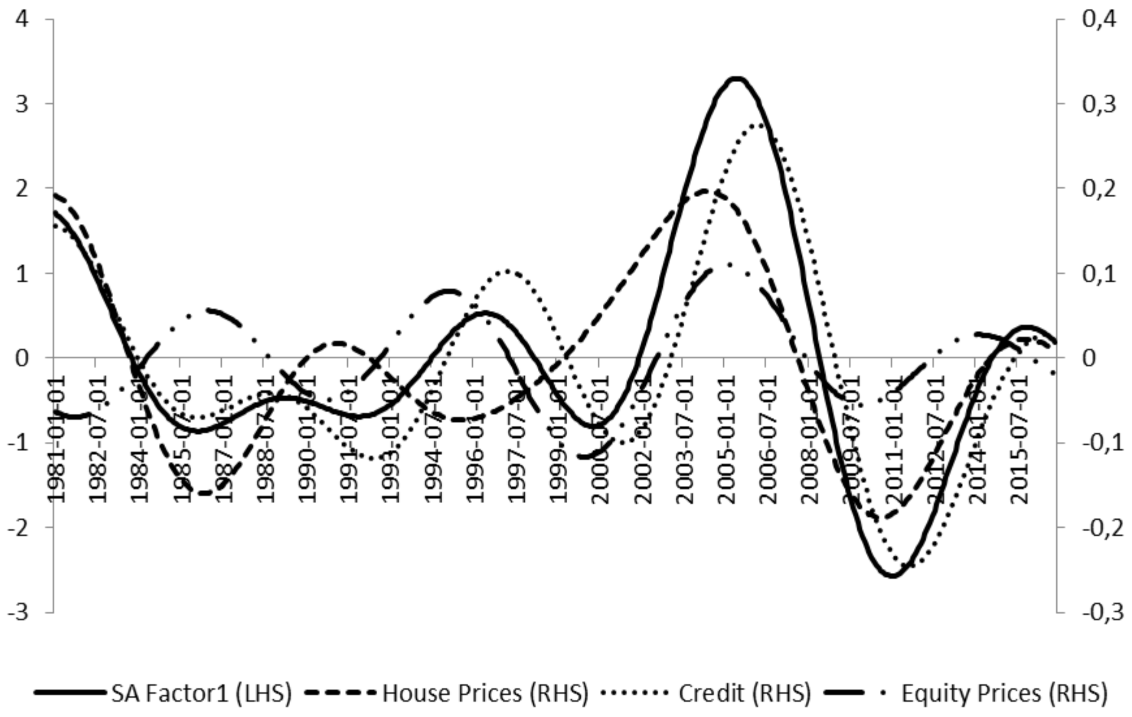
The question we ask in this section is how integrated is the South African financial cycle to the rest of the world. To answer this question, we analyse the relationship between the local and the global financial cycle. To do this, we construct two possible measures of the local financial cycle using a factor

[4]The code used for this analysis is by Haroon Mumtaz and can be obtained from https://sites.google.com/site/hmumtaz77/code.

analysis. For the first measure, we only use three variables t construct the cycle: domestic house and asset prices and credit growth. This is a measure used by the South African Reserve Bank (SARB). We follow their methodology so that we can compare our measure to theirs. First, we deflate the data using the consumer price index, then we take the first difference of the variables in logs and finally normalise the data. After this data transformation, we use the Christiano and Fitzgerald (2003) band pass filter with the financial cycle frequency band of 8 to 30 years (96 to 360 months with our monthly frequency) to extract the cyclical components of the three variables. And lastly, we extract the common factor between the cyclical components to get our first measure.

For our second measure, we follow Domanski et al. (2011) and Hatzius et al. (2010), depending on the availability of data. Here we extend the three variables in the first measure with commodity prices, real effective exchange rate, monetary policy aggregates (M1, M2 and M3), a measure of risk (spread of 10 year bonds and Eskom bond) and spread between short to medium term rates and medium to long-term rates. As in the first approach, we use the factor model to extract the financial cycle [5]. The first measure starts from January 1981 whereas the second measure only starts from December 1986, based on the availability of the data. In the end, the first and second measures of the financial cycle explains 61% and 28%[6] of the variance in the variables, respectively.

Figure 1: South African financial cycle



Note: Figure 1 shows the computed financial cycle for South Africa on the left hand scale and its components on the right hand scale. The components are: Absa House price index, Johannesburg All Share Prices and Total Credit to the private sector. The three variables are firstly deflated using the consumer price index, then first log differences and lastly normalised. All data is in monthly for the period January 1981 to November 2016. *Source*: Authors calculations.

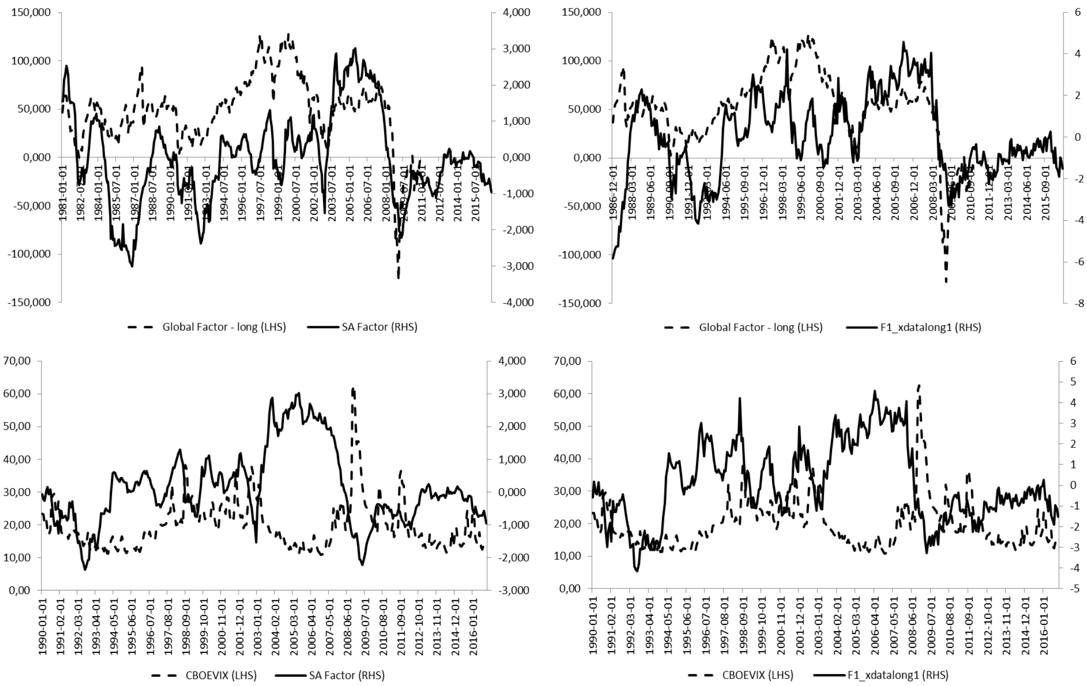
[5]We use the Alessi et al. (2008) criterion to determine the number of common static factors driving the data. This is a modified Bai and Ng (2002) estimator. The idiosyncratic components are allowed to be autocorrelated.

[6]Excluding the spreads and commodity prices increases the variance from 28% to 45%.

Figure 1 shows the computed first measure of the financial cycle for South Africa and its three components. The figure shows that there are three downturns during the sample period of January 1981 to November 2016. The first downturn is between first quarter of 1984 and third quarter of 1994. This downturn is consistent with the period of political instability during the Apartheid regime and the 1985 South African debt or financial crisis. A comparison with its components suggest that credit growth is the main driver of the persistence of the downturn, making it the longest during the sample period. The figure also suggest that house prices leads the cycle whereas credit growth lags it. The second downturn is between the period 1998 and 2002, which coincides with the Asian and technology crises. The last downturn is during the 2008 global financial crisis and lasts for almost 7 years.

In Figure 2, we compare the two computed measures of the local financial cycle to the global measures of the financial cycle and risk. We use the global factor by Miranda-Agrippino and Rey (2015) for the global financial cycle and the widely used VIX index for global risk. The starting dates for the global factor and the VIX dictates the starting dates of our comparison. In the left column, both the top and bottom panel, we use the three-variable measure of local financial cycle. This is just the unfiltered version of Figure 1. In the right column, both the top and bottom panel, we use the many-variables measure of the local financial cycle. Starting with the comparison with the global factor, the figure shows that there is a co-movement between of the local cycle with the rest of the world. The co-movement starts to be more in sync from 2002 onwards, as South African became a more open economy. Pre-2002, the relationship is sometimes not that obvious and in some cases suggest that the local cycle is lagging the global cycle. The comparison with the VIX in the bottom panel shows that both measures of the local cycle have a negative relationship with global risk. Therefore, there is strong evidence that increase in global risk reduces financial conditions in South Africa.

Figure 2: Global and Local Factors



Note: Figure 2 compares the two measures of local financial cycle to the measures of global financial cycle and global risk. We use the global factor by Miranda-Agrippino and Rey (2015) for the global financial cycle and the VIX for global risk. In the left column (both the top and bottom panel), we use the three-variable measure of local financial cycle. In the right column (both the top and bottom panel), we use the many-variables measure of the local financial cycle. *Source*: Authors calculations.

4.2 Data for the BVAR

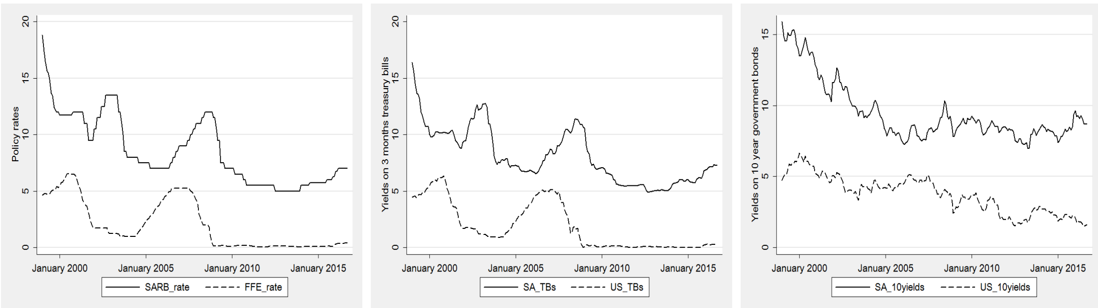
We use monthly data of US and SA variables for the period January 1990 to November 2016. The US variables are obtained from the Federal Reserve Bank and Federal Reserve Bank of St. Louis whereas the South African data is from the South African Reserve Bank. Table 3 provides the ordering, source, transformation and random walk prior assumptions of the variables. Following the medium scale BVAR model for the US by Bańbura et al. (2010), we include the following variables for the US in our analysis: industrial production, the Fed rate, inflation, producer price index, housing starts, unemployment, capacity utilisation, hourly rates, effective exchange rates, yields on 10 year bond, yields on 3-months treasury bills, Standard Poor's stock price index as proxy for asset prices, monetary aggregates - M1 and M2 money stocks, personal income and expenditure, commodity prices, total reserves and non-borrowed reserves. Similarly, we include the following variables for South Africa: effective exchange rates, yield on 10 year bond, monetary aggregates - M1, M2 and M3 money stocks, ABSA house price index, Johannesburg stock price index as proxy for asset prices. Since our goal is to analyse the risk-taking channel or credit channel, we add banks' balance sheet data for South Africa and measures of global risk and global and local financial cycles. The banks' balance sheet data is proxied by bank leverage and private sector credit. We use the VIX for global risk and the global factor by Miranda-Agrippino and Rey (2015) for the global financial cycle whereas the local cycle is proxied by our own calculated South African financial cycle discussed in section 4.1. We use the TED spread, as a measure of risk in South Africa. Lastly, we also include the purchase of shares and bonds by non-residents. All nominal values are deflated using the price deflators.

5 Benchmark results

5.1 Interest rate linkages

We start our results with a simple ordinary least squares regression. Figure 3 shows the correlation between policy rates for South Africa and the US, together with the short- and long-term rates for the period 1999M01 to 2016M09. Figure 3 (a) and (b) show that the policy rate and the short-term rates for South Africa co-move with that of the US with a lag. The relationship is not obvious for the long-term rates as shown in Figure 3 (c).

Figure 3: Short and long-term rates co-movements



Note: Figure 3 shows the co-movement between the US and South African short and long-term rates. Short-term rates are proxied by South African repo rate and 91-days Treasury bills, Fed Fund rate and yield on 3 months Treasury bills. Long-term rates are proxied by yields on 10 years and over bonds. *Source*: South African Reserve Bank and St. Louis Fed.

Following Hofmann and Takats (2015) and Obstfeld (2015), we estimate the following equation:

$$\Delta i_{sa,t} = \alpha + \beta \Delta i_{us,t} + \gamma X_{sa,t} + \mu_{sa,t} \tag{17}$$

where $\Delta i_{sa,t}$ and $\Delta i_{us,t}$ represent the period-to-period change in rates for South Africa and the US respectively and $X_{sa,t}$ controls for macroeconomic variables in South Africa - annual growth in inflation and output. Regressing the rates in differences rather than in levels avoids the spurious regression problem, Obstfeld (2015). We assume that the rates in the US can influence the rates in South African but not vice versa. For this analysis, we use the South African repo rate and the Fed funds effective rate for the policy rates, discount rates on 91-day Treasury Bills for South Africa and the market yield on U.S. Treasury securities at 3-month for the short-term rates, and the yields on the South African 10 years government bonds and 10 years U.S. Treasury securities for long-term rates. Inflation is year-on-year change in consumer price index whereas real gross domestic product growth is proxied by year-on-year change in manufacturing[7]. We use monthly data with lag length of 2.

We allow for the possibility that the short-term rates in the US affect local short-term rates with a lag. Therefore, we re-estimate the equation in both the first to the third lags of the short-term rates. Given that the results remain the same, we only report the results for the first and second lag. This only applied to the short-term rates (policy rate and the yield 3-months treasury bills) since long-term rates are mostly driven by market dynamics. We include the first lag of the dependent variable for short-term

[7]See Appendix 7.1 for details on the data.

rates to capture the central bank's interest rate smoothing[8]. Again this only applies to short-term rates since long-term rates are mostly driven by market dynamics. Estimations are for the period January 1990 to December 2007 due to the zero lower bound in the US and the use of unconventional monetary policy during and post the 2008 financial crisis.

The results are presented in Table 2 where: In columns (1) to (3) is the regression of the rates only. We control for local macroeconomic variables in columns (4) to (6) and control for global risk in columns (7) to (9). Lastly, we run the equation with interest rates in first lags in columns (10) and (11) and in second lags in columns (12) and (13). The results indicate that there is no evidence of policy spillovers for the short-term rates (policy rates and the yields on 3 months treasury bills), across all specifications. Contrary to the results for the short-term rates, the results show that long-term rates in the US has a positive effect on the long-term rates in South Africa. Lastly, the measure for global risk is only significant for the long-term rates equation. The overall results are consistent with Obstfeld (2015) who find policy spillovers for the long-term rates and not short-term rates. The author attributes the results to the fact that long-term rate, unlike short-term rates, are determined by markets and hence they tend to move together.

5.2 Results for the BVAR

We now present the results for the BVAR. To keep with the identification of monetary policy in Section 3.3, we separate our results by conventional and unconventional monetary policy. To save space, we only present selected variables relevant to our discussion. Results with all the variables are provided in the Appendix 7.2.

5.2.1 Conventional monetary policy

The results for monetary policy identification are obtained using a medium scale BVAR with 2 lags of the endogenous variables. The period under consideration is January 1990 to December 2007. We present the impulse response functions over 40 months. All figures show the response of the variables to a one-standard deviation to a monetary policy shock (100 basis points). The shaded area represents the posterior coverage intervals for the 84% confidence level. We start with the results for the identification of monetary policy in the US. To do this, we estimate the BVAR with only US variables. Our estimation is similar to the medium-scale model of Bańbura et al. (2010) which contains 20 variables. We add measures for global factors - global factor index by Miranda-Agrippino and Rey (2015) and the VIX, which makes it 21 variables in total. The impulse response functions for this specification are presented in Figure 4. A one standard deviation shock induces a contemporaneous 1 percentage increase in US policy rate. The response of the real variables is consistent with economic theory: Employment and capacity utilisation decline. And as shown in Figure 9 in the Appendix 7.2.1, other real variables such as personal income, industrial production, and housing starts decline whereas unemployment increases. Our results for inflation indicate a small price puzzle which is short-lived, with inflation declining and reaching a maximum almost after 20 months [9]. For the financial variables, a contractionary monetary policy increases the yield on long-term bonds whereas the returns on stock decline. Though insignificant, the US dollar initially appreciates. Lastly, consistent with Rey (2016), our additional measures of global factors show that global risk increase and the global factor declines.

[8]We exclude these lags from the results and the results are available on request.

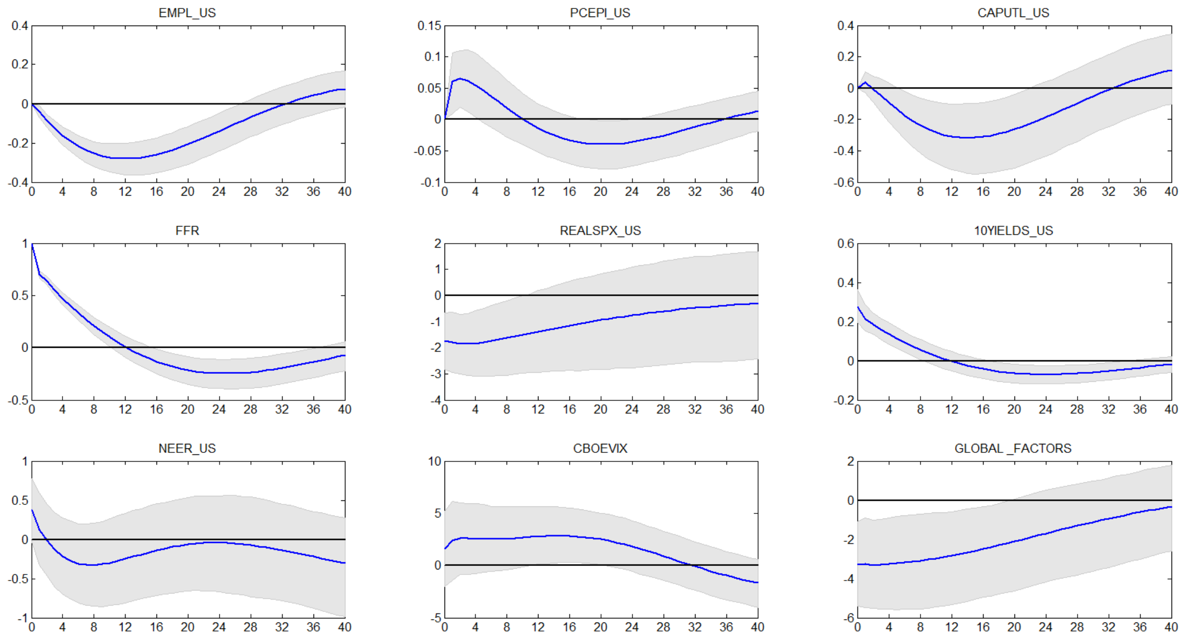
[9]Increasing the sample size improves the initial responses and the significance of the real variables. For example, the reduction in inflation, capacity utilisation and industrial production become more significant and the initial increase in commodity prices and personal income is dampened.

Table 2: Policy spillovers: 1990 - 2007

	Benchmark						Including the VIX			Lagged rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Dependent variable is:	Rate	TBs	LT	Rate	TBs	LT	Rate	TBs	LT	Rate	TBs	Rate	TBs
US policy rate	0.16			0.07	-0.05		0.07	-0.08					
	(0.17)			(0.19)	(0.21)		(0.19)	(0.19)					
US Treasury Bills		0.30			0.25			0.28					
		(0.21)			(0.24)			(0.25)					
US 10 year bond			0.38*			0.39*			0.40*				
			(0.15)			(0.16)			(0.16)				
L.US policy rate										0.05			
										(0.17)			
L2.US policy rate												-0.01	
												(0.17)	
L.US Treasury Bills											0.11		
											(0.14)		
L2.US Treasury Bills													-0.13
													(0.11)
SA Inflation				0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.00
				(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
SA output growth				0.03**	0.02**	0.00	0.03**	0.02**	0.00	0.03**	0.03**	0.03**	0.03**
				(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
VIX index							-0.05	0.15	0.48*				
							(0.27)	(0.21)	(0.23)				
Number of Obs.	214	214	215	214	214	215	214	214	215	214	214	213	213
R^2	0.11	0.24	0.04	0.15	0.27	0.04	0.15	0.27	0.06	0.15	0.26	0.15	0.26

Note: Table 2 presents the ordinary least square results for Equation (17) for the period January 1990 to December 2007. The frequency of the data is monthly. US policy rate is the Federal Fund rate and SA policy rate is the South African Reserve Bank's repo rate. South African treasury bills is the monthly averages of the weekly discount rates on 91-day treasury bills. US treasury bills is the market yield on US securities at 3 month constant maturity. All rates are in first difference. The first lags of the dependent variable for the short-term rates are excluded - all the own lags are significant. Inflation (South Africa) is the 12 months first difference of the log of consumer price index. Output growth (South Africa) is the 12 months first difference of the log industrial production. VIX is the first difference of the log of the VIX. Standard errors are in brackets and significance levels are presented as *, ** and *** for the 0.10, 0.05 and 0.01 p-values. *Source*: Authors calculations.

Figure 4: US conventional monetary policy identification - 1990 to 2007

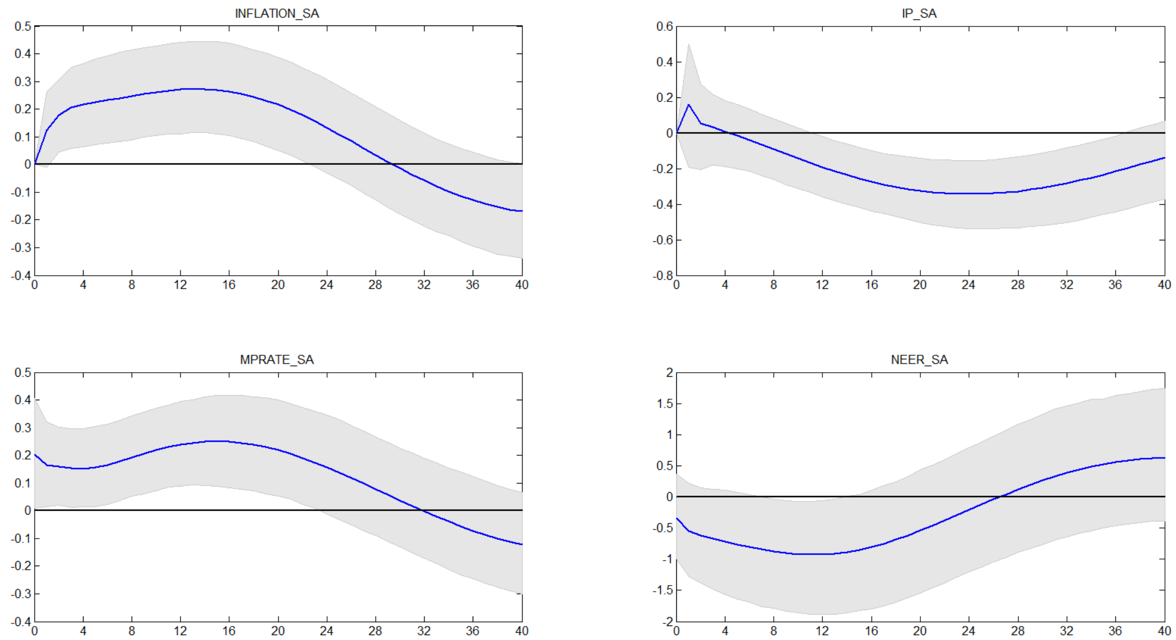


Note: Figure 4 shows the impulse responses of US variables to a 1% increase in the Fed Fund rate during the period 1990M01 and 2007M12.

We then extend our 21 variables BVAR model to include both real and financial variables for South Africa. This increases the number of variables in the model to 35. With the inclusion of the South African variables, we still find that our results for monetary policy identification in the US remain robust (see Figure 10 in the Appendix 7.2 for full results). The results including the South African variables are presented in Figure 5 for real economy and Figure 6 for the financial sector. The results in Figure 5 show that the South African Rand depreciate, though insignificant, after an unanticipated contractionary monetary policy shock in the US. The depreciation of the Rand is associated with an increase in inflation, which peaks at 0.27 percentages after 14 months before declining.

The depreciation of the Rand is inflationary since the currency does not seem to play the stabilisation role as discussed by Bernanke (2017). The increase in domestic monetary policy rate dampens industrial production, which declines with a 2 to 3 months lag before peaking at -0.34 after 25 months.

Figure 5: Response of SA real variables

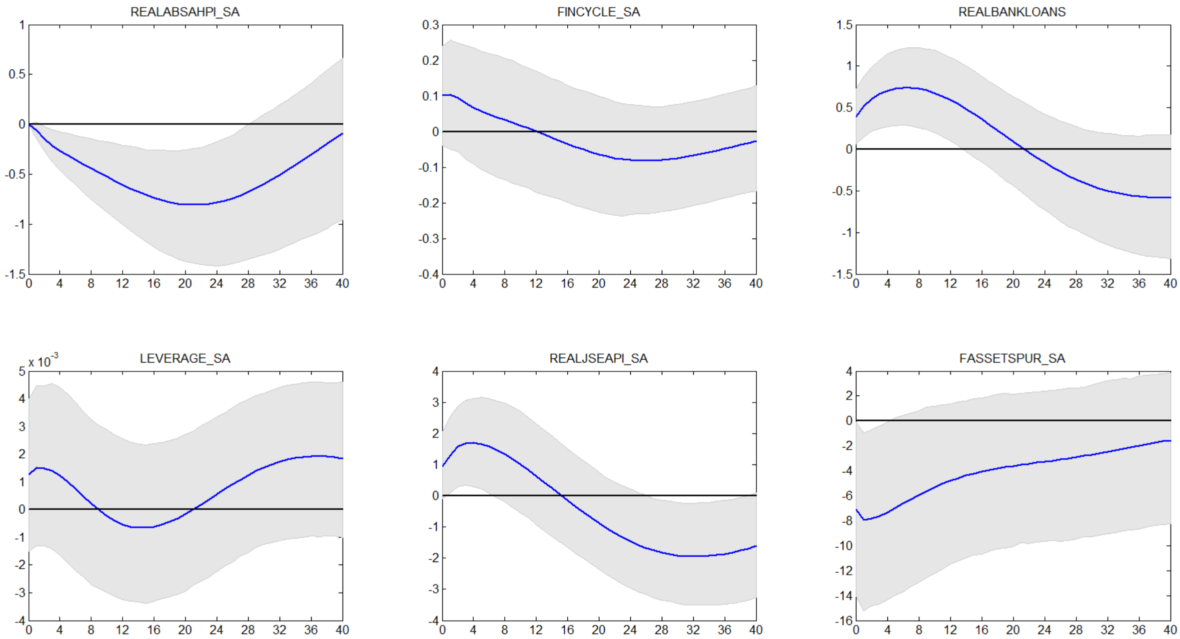


Note: Figure 5 shows the impulse responses of South African real variables to a 1% increase in the Fed Fund rate during the period 1990M01 and 2007M12.

Figure 6 shows the responses of the financial sector. The results show that the purchase of local shares by foreign investors contemporaneously decline by 7 percentage and reach its peak at -7.92 within two months. The yields on the 10 year bond increase[10]. The results for the risky assets, house prices and asset prices, are puzzling. Whilst house prices decline, as expected, asset prices surprisingly increase and only decrease after 12 months. Credit growth decline with a year lag, though the decline is insignificant. The overall impact of the US policy shock on the local credit cycle (asset and house prices and credit) is insignificant.

[10]The purchase of bonds by foreign investors is excluded because the data only starts in 1993.

Figure 6: Response of SA financial variables



Note: Figure 6 shows the impulse responses of South African financial variables to a 1% increase in the Fed Fund rate during the period 1990M01 and 2007M12.

From our results, we can make two implications about the structure of the domestic economy: Firstly, we find that our results for inflation, domestic monetary policy, and local currency are similar, though different in magnitude, to that of Canada (for all three variables) and New Zealand (excluding the local currency) in Rey (2016). Miranda-Agrippino and Rey (2015) also find similar results for the UK and the Euro area[11]. Therefore, similar to Miranda-Agrippino and Rey (2015), we interpret our results as being consistent with "fear of floating" arising from the pass-through of the exchange rate to domestic prices, Calvo and Reinhart (2002). Secondly, the weaker Rand should in theory increase trade competitiveness of domestic goods. However, there is no evidence of this trade competitiveness in our results for South Africa. Interpreting the results using Bernanke (2017)'s arguments, one possible reason could be the expenditure-augmenting effect. A contractionary monetary policy in the US reduces income of US economic agents and thereby reducing their demand for foreign goods like South Africa. This effect can either affect the South African industrial production directly if the US is a major export destination or indirectly through the effect of the US on South Africas major trading partners. Another possible reason could be based on the export composition of the domestic economy. South Africa is a big commodity exporter. Given the fixed demand for commodities, the weakness of the Rand will not necessarily increase this demand. This means that the competitive advantage from the weakness of the currency will depend on the competitiveness of the manufacturing sector exporters. Thus implying that the expenditure-switching effect channel is limited. Therefore, the reaction of the central bank can incorrectly be seen as leaning against the wind, whereas in fact, it is the structural issues of the domestic economy that make the objective of price stability and economic growth at odds.

[11] Miranda-Agrippino and Rey (2015) find that policy rates in both the UK and Euro area increase after a contractionary monetary policy shock in the US, which they view as consistent with the "fear of floating" monetary policy transmission.

In summary, the results indicate that the transmission of monetary policy from the US to South Africa is through the financial sector and not the real economy. The rigidities in the economy increase the importance of the financial sector. This in turn, makes the economy vulnerable to global investors sentiment.

5.2.2 Unconventional monetary policy

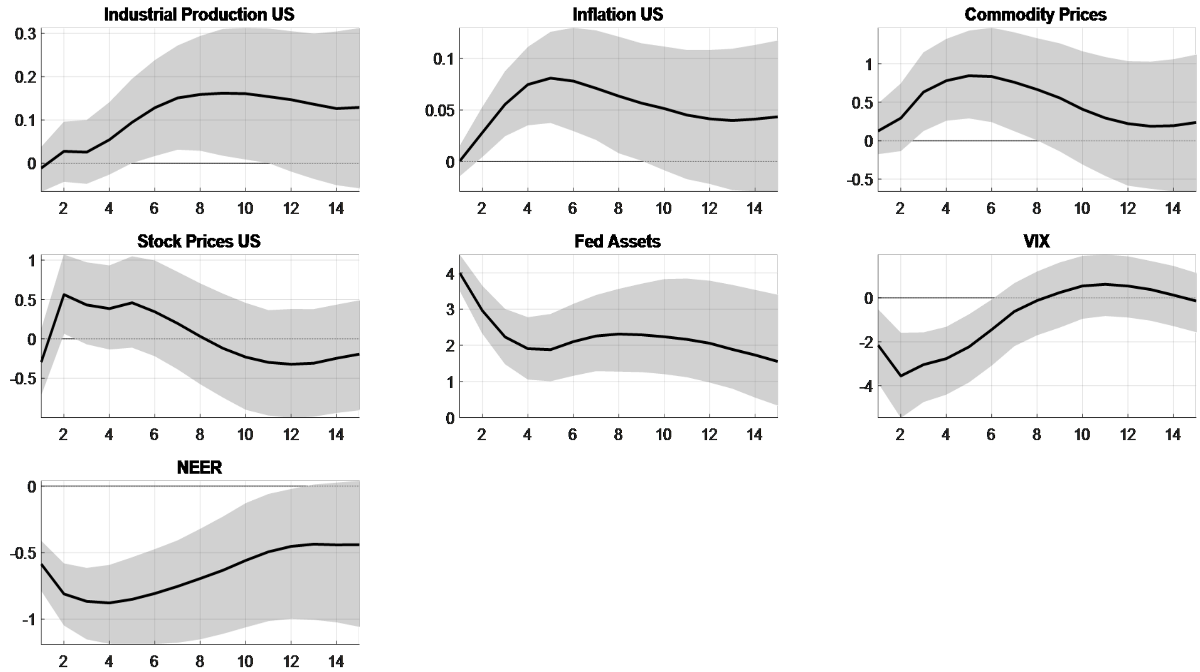
We now look at the response of South African variables to unconventional monetary policy in the US during the period January 2008 and November 2016. The results for monetary policy identification are obtained using a medium scale BVAR with 2 lags of the endogenous variables.

We start with the results for the identification of monetary policy in the US. To do this, we estimate the BVAR with only US variables. Here we only consider variables that are important since we have a much shorter sample. The US variables include employment, inflation, industrial production, Fed's assets, nominal effective exchange rate, and commodity prices. Again, we add measures for global risk, the VIX, which makes it 8 variables in total. We exclude the global factor due to its short sample size during this period. We extend this model to include South African variables. This increases the number of variables in the model to 22. With the inclusion of the South African variables, the results for the US still remain robust. Given the short-lived effect of the unconventional monetary policy on the US variables (Boeckx et al. (2014) and Swanson (2017)), we present the impulse response functions over 20 months. All figures show the response of the variables to a one-standard deviation to total assets of the US Federal Reserve Bank.

The impulse response functions for this specification are presented in Figure 7. A one standard deviation shock induces a contemporaneous 4 percentage increase in Fed's assets. Consistent with Boeckx et al. (2014), the results indicate that increase in the Fed's assets lowered risk in the financial markets, evidenced by the contemporaneous reduction in the VIX (and TED spread in South Africa). With lower risk, activity in both the real economy and the financial sector increase in the US. Output and inflation increase. Asset prices also increases whilst the US dollar depreciates.

The depreciation of the US dollar against its major trading partners indicates capital outflows from the US to other countries. This is supported by our results for South Africa in Figure 8.

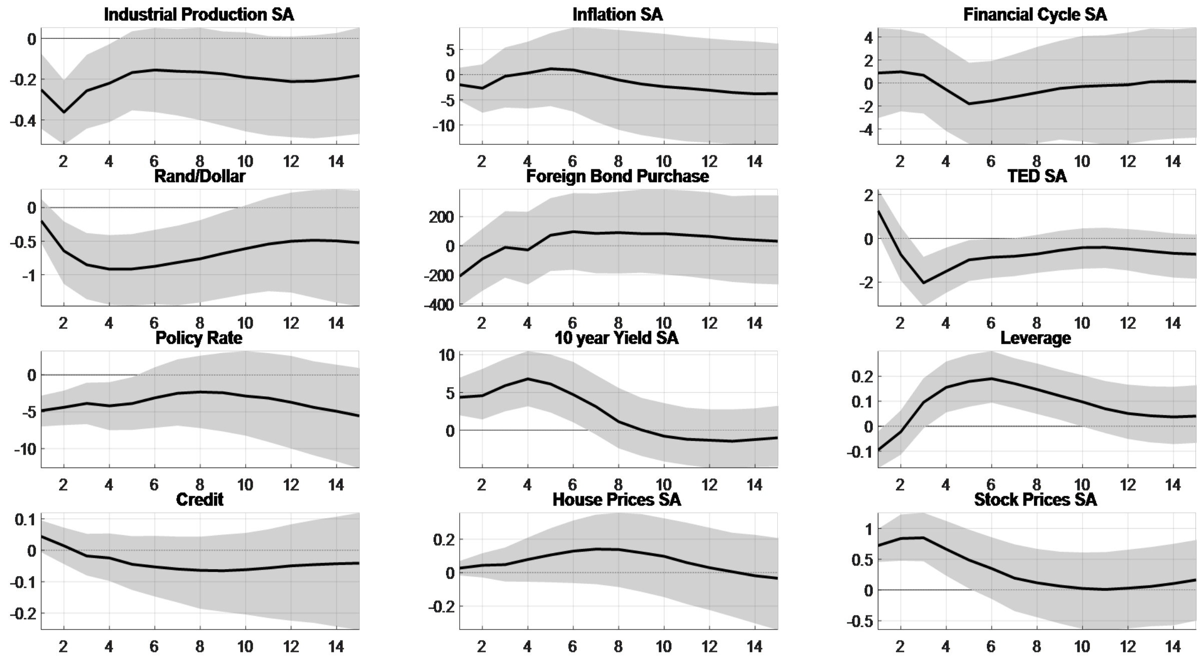
Figure 7: US unconventional monetary policy identification - 2008 to 2016



Note: Figure 7 shows the impulse responses of US variables to an increase in the Fed total assets during the period 2008M01 and 2016M11.

The results indicate that asset prices also increase in South Africa, causing an appreciation of the local currency against the US dollar. House prices also increase, though insignificant. The appreciation of the local currency puts downward pressure on inflation, due to cheaper imports. However, local products become uncompetitive - industrial production decrease. With lower demand, bank credit demand decreases, putting an upwards pressure on the banks leverage. Both the decrease in output and inflation reduces the policy rate. With lower policy rate, foreigners sell bonds, thus increasing the yield curve - long term yield increases and short run rate decreases. The overall effect on the South African financial cycle is insignificant.

Figure 8: Response of SA variables



Note: Figure 6 shows the impulse responses of South African variables to an increase in the Fed total assets during the period 2008M01 and 2016M11.

How does this link to the trilemma, dilemma? The results indicate that the policy rate in South Africa follows prices and output and is not affected by asset prices. Asset prices do not feed in an economic boom. Therefore monetary policy in South Africa is fundamentally independent because of this lack of transmission from asset prices to the economy. Again, our results are puzzling - foreign expansion has a contractionary effect on the real economy. Foreign expansion should increase the demand of our local goods whilst the cheaper imports should increase local consumption. These results further highlight the structural issues in the real sector.

In summary, we find strong evidence of monetary policy independence in South Africa in both out ordinary least square estimation and VAR analysis. The results for VAR analysis indicate a shift in the transmission of the US monetary policy shock from the financial sector during the period of conventional monetary policy to the real sector during the period of quantitative easing. However, due to structural issues in the real economy, South Africa is not able to take advantage of the local currency depreciation nor global economic recovery. This in turn makes monetary policy seem as anti-growth.

6 Conclusion

In this paper, we investigate the effect of US monetary policy on South Africa between January 1990 and November 2016. We start with a simple analysis of the South African financial cycle to global financial cycle by Miranda-Agrippino and Rey (2015) and global financial market risk. We find co-movement between of the local cycle with the rest of the world, especially from 2002 onwards, as South African became a more open economy. We also find that an increase in global risk reduce financial conditions in South Africa.

We then perform a simple ordinary least squares regression to analyse policy spillovers from the US to SA for both short and long-term rates. We restrict this analysis to pre-crisis period due to the change in monetary policy after the crisis. The overall results are consistent with Obstfeld (2015) who find policy spillovers for the long-term rates and not short-term rates.

Lastly, we assess the channels through the US monetary policy is transmitted to SA. To do this, we use a large Bayesian vector autoregressive (LBVAR) model with Minnesota priors, proposed by Bańbura et al. (2010) covering the period ranging January 1990 to November 2016. In the pre-crisis period, from January 1990 to December 2007, we identify monetary policy shock from the US based on the conventional monetary policy. We use the zero-restriction identification scheme with a 100 basis points rise in the Fed Funds rate. The post-crisis period, from January 2008 to November 2016, we identify monetary policy shock from the US based on the unconventional monetary policy due to the zero-lower bound during this period. Here, we use instead the sign-restriction identification scheme which captures closely the unconventional monetary policy consisting of LSAPs which prevails mostly during this period.

In both periods, we are able to identify monetary policy in the US. For the first period, we find that a contractionary monetary policy in the US reduces asset prices, causing the local currency to depreciate. The depreciation of the Rand is inflationary since the local currency does not seem to play any stabilisation role. The policy rate increase, which dampens industrial production. We interpret our results as being consistent with "fear of floating" arising from the pass-through of the exchange rate to domestic prices, Calvo and Reinhart (2002). The lack of responsiveness of exports to a weaker Rand means that Bernanke (2017)'s expenditure-switching effect channel is limited. Therefore, the reaction of the central bank can incorrectly be seen as leaning against the wind, whereas in fact, it is the structural issues of the domestic economy that make the objective of price stability and economic growth at odds.

For the unconventional monetary policy in the US, we find that the expansionary policy reduces global risk and stimulate the real and financial sector in the US. However, the expansionary foreign policy has a contractionary effect on the South African real economy - both output and inflation decrease. Contrary, we find that asset prices in South Africa increase, causing the local currency to appreciate. However, this expansionary effect does not feed into the real economy. In fact, we find that the South African policy rate becomes expansionary in response to the real economy. Therefore monetary policy in South Africa is fundamentally independent because of this lack of transmission from asset prices to the economy.

Overall, we find strong evidence of monetary policy independence in South Africa. The results indicate a shift in the transmission of the US monetary policy shock from the financial sector during the period of conventional monetary policy to the real sector during the period of quantitative easing. However, due to structural issues in the real economy, South Africa is not able to take advantage of the local currency depreciation nor global economic recovery. This in turn makes monetary policy seem as anti-growth.

7 Appendices

7.1 Data

Table 3: Large BVAR data transformation and ordering

BVAR name	Description	Unit	S/F	Log	RW	CMP	UMP
EMPL US	All Employees: Total Nonfarm Payrolls	Thousands of Persons	S	X	X	X	X
CPI US	Consumer Price Index for All Urban Consumers: All Items	Index 1982-1984=100	S	X	X	X	X
COMM PR	Total index; s.a. IP	Index: 2012=100	S	X	X	X	X
PI US	Personal Income - seasonally adjusted annual rate	Billions of Dollars	S	X	X	X	
PCE US	Personal Consumption Expenditures (s.a. annual rate) deflated by PCE deflator (1987=100)	Billions of Dollars	S	X	X	X	
IP US	Total index; s.a. IP	Index: 2012 - 100	S	X	X	X	X
Caputl US	Capacity Utilization: Manufacturing (SIC); s.a.	Percent of Capacity	S		X	X	X
UNRATE US	Civilian Unemployment Rate; s.a.	Percent	S		X	X	
HOUSING US	Number of New Private Nonfarm Housing Units Started for US	Thousands of Units Started	S	X	X		
PPI US	Producer Price Index by Commodity for Final Demand: Finished Goods	Index: 1982=100	S	X	X	X	
PCE US	Personal Consumption Expenditures: Chain-type Price Index	Index: 2009=100	S	X	X	X	
HOURLY EARNS	Average Hourly Earnings of Production and Nonsupervisory Employees	Dollars per Hour; s.a.	S	X	X	X	
FFR	Federal funds effective rate	Percent	MPV		X	X	
Fed's total assets	Total assets less eliminations from consolidation: Wednesday level	Millions of Dollars	MPV		X		X
DEFLATEDM2 US	M2 money supply; seasonally adjusted	Billions of Dollars	F	X	X	X	
TOTRESNS US	Total Reserves of Depository Institutions in 2000 prices	Billions of Dollars	F	X	X	X	
NONBORRES US	Reserves of Depository Institutions, Nonborrowed in 2000 prices	Millions of Dollars	F	X	X	X	
DEFLATEDM1 US	M1 money supply; seasonally adjusted	Billions of Dollars	F	X	X	X	
SPX US	Standard & Poor's share price index	Index	F	X	X	X	X
10YIELDS US	Market yield on U.S. Treasury securities at 10-year constant maturity, quoted on investment basis	Percent	F	X	X	X	X
NEER US	Nominal broad Dollar index	Index	F	X	X	X	X

Continued on next page

Table 3 – continued from previous page

BVAR name	Description	Unit	S/F	Log	RW	CMP	UMP
VIX	CBOE volatility index	Index	F	X	X	X	X
GLOBAL FACTOR	Miranda & Rey Global factor	N/A	F		X		
MPRATE SA	Bankrate (lowest rediscount rate at SARB)	Percent	MPV		X	X	X
CPI SA	CPI Headline	Index: 2016=100	S	X	X	X	X
IP SA	Manufacturing: Total volume of production; s.a.	Index: 2010=100	F	X	X	X	X
M1 SA	Monetary aggregates / Money supply: M1	Millions of Rand	F	X	X	X	
M2 SA	Monetary aggregates / Money supply: M2	Millions of Rand	F	X	X	X	
M3 SA	Monetary aggregates / Money supply: M3; s.a.	Millions of Rand	F	X	X	X	
JSEAPI SA	JSE All Share Index	Index: 2010=100	F	X	X	X	X
AbsaHPI SA	Absa house Price Index. New and existing homes, all sizes	Index: 2000=100	F	X	X	X	X
NEER- SA	Nominal effective exchange rate of the rand: Average for the period - 20 trading partners	Percentage	F	X	X	X	X
Purchase of shares - SA	Purchases of shares by non-residents on the JSE	Millions of Rand	F	X	X	X	X
Bank loans - SA	Assets of banking institutions: Total deposits, loans and advances	Millions of Rand	F	X	X	X	X
Bank leverage - SA	Ratio of deposits to assets for banking institutions	Ratio	F	X	X	X	X
Fincycle - SA	Own calculation. See section 4.1	N/A	F	X	X	X	X

Note: Table 2 provides the list of the variables included in the BVAR models. The variables in the model are in the same order as in the table. The first column shows the code of the data by the source. The second and third columns shows (respectively) the short names and description of the variables used n the BVAR model estimation. The fourth column shows the unit of measure where Dollars is the US dollars and the Rand is the South African currency. The fifth column indicate whether the variable is slow moving (S) or fast moving (F). Column six indicate if the variable is in logarithms and column seven if the variable is a Random Walk. Columns eight and nine indicate whether the variable is included in the conventional monetary policy (CMP) BVAR or the unconventional monetary policy (UMP) BVAR.

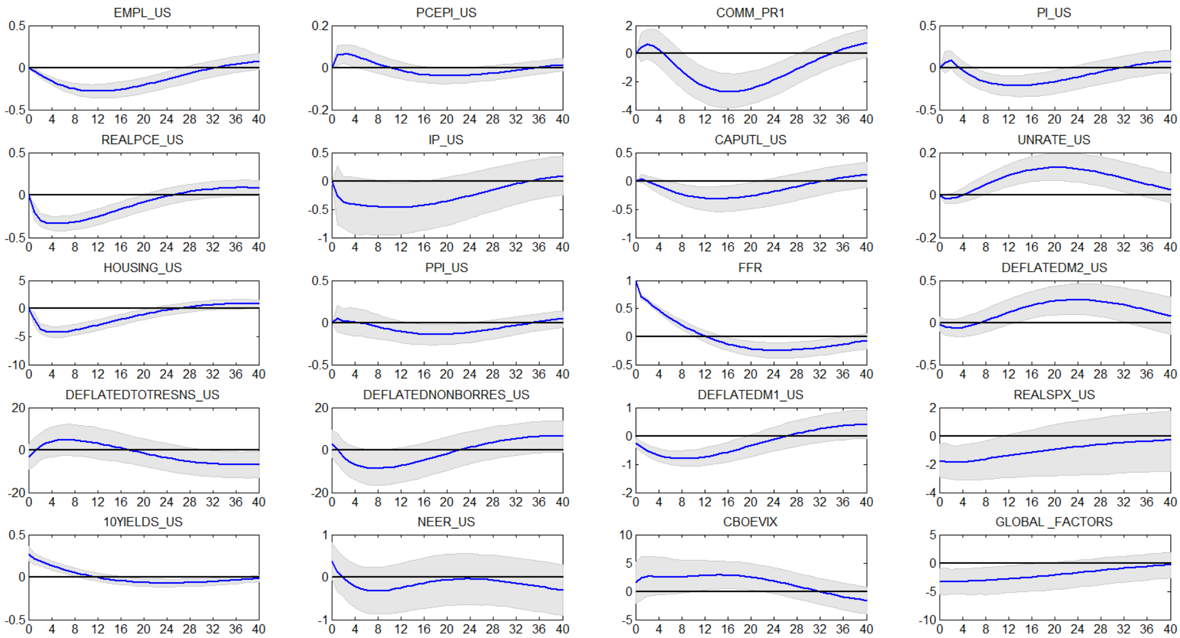
Table 4: Data for section 5.1 and 4.1

Data	Description	Source
OLS regression		
SA policy rate	Repo rate	SARB
SA short-term rates	Monthly averages of the weekly discount rates on 91-day Treasury Bills	SARB
SA long-term rates	Monthly yield on loan stock traded on the stock exchange: government bonds - 10 years and over	SARB
SA inflation	Total consumer prices (All urban areas)	SARB
SA industrial production	Total volume of production (Manufacturing)	SARB
US policy rate	Federal funds effective rate	Federal Reserve
US short-term rates	Market yield on U.S. Treasury securities at 3-month constant maturity quoted on investment basis	St. Louis Fed
US long-term rates	Market yield on U.S. Treasury securities at 10-year constant maturity quoted on investment basis	St. Louis Fed
US inflation	The Consumer Price Index for All Urban Consumers: All Items	St. Louis Fed
US industrial production	Seasonally adjusted total index - Industrial Production of major industries	St. Louis Fed
South African financial cycle		
Eskom bonds	Yield on loan stock traded on the stock exchange: Eskom bonds (State owned utility)	SARB
REER	Real effective exchange rate of the rand: Average for the period - 20 trading partners - Trade in manufactured goods	SARB
Medium-term rates	Yield on loan stock traded on the stock exchange: Government bonds - 3 to 5 years	SARB
Long-term rates	Yield on loan stock traded on the stock exchange: Government bonds - 5 to 10 years	SARB
House prices	Absa house Price Index (2000=100). New and existing homes - all sizes	N/A
Share prices	JSE All Share Index	IMF
Commodities	Platinum, gold, coal and crude oil prices	IMF
M1, M2 & M3	Monetary aggregates / Money supply	SARB

7.2 Additional results

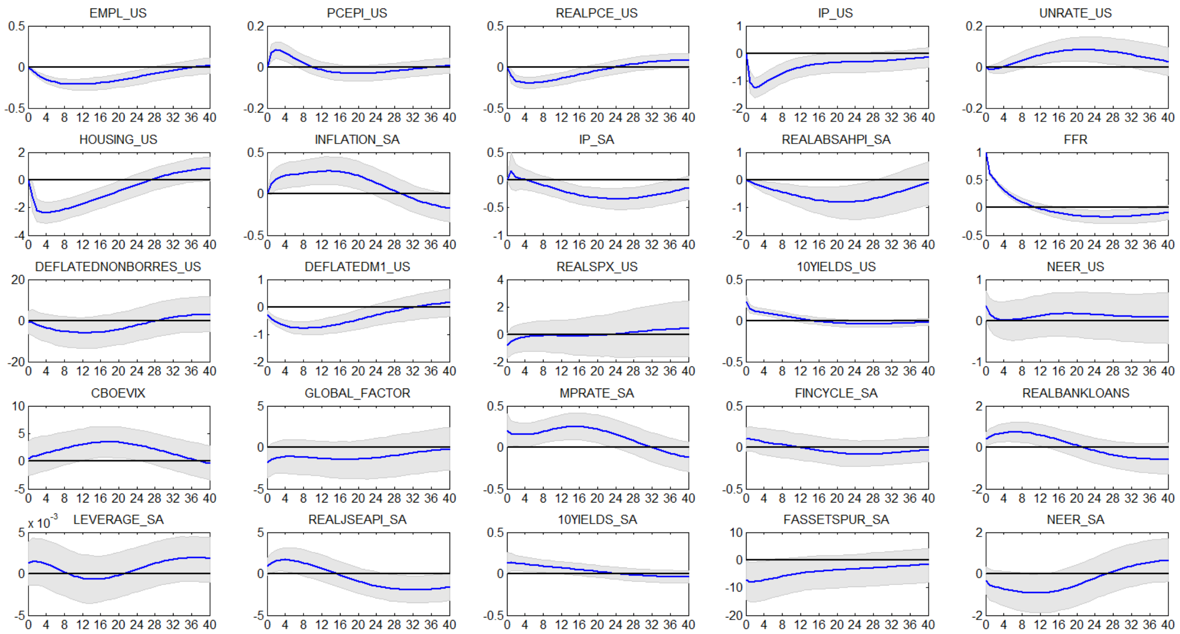
7.2.1 Conventional monetary policy

Figure 9: US Monetary policy identification (more variables)



Note: Figure 9 shows the impulse responses of South African real variables to a 1% increase in the Fed Fund rate during the period 1990M01 and 2007M12.

Figure 10: Response of SA variables (more variables)



Note: Figure 10 shows the impulse responses of South African real variables to a 1% increase in the Fed Fund rate during the period 1990M01 and 2007M12.

7.2.2 Unconventional monetary policy

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