A vector autoregression approach to the effects of monetary policy in South Africa

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TABLE OF CONTENTS

List of Figures

List of Figures in Appendices

List of Tables

List of Tables in Appendices

ABSTRACT

This dissertation applies vector autoregression approaches to assess the effects of the monetary policy in South Africa. First, the dissertation quantified declines in the consumption expenditure attributed to the combined house wealth and credit effects due to the contractionary monetary policy shocks. The results at the peak of interest rates effects on consumption on the sixth quarter provide little support that the indirect house wealth channel is the dominant source of monetary policy transmission to consumption. Second, the dissertation assessed how real interest rate reacts to positive inflation rate shocks, exchange rate depreciation shocks and the existence of Fisher effect over longer periods. Evidence confirmed the Fisher effect holds over longer horizons and the real interest rate reacts negatively to the inflation and exchange rate shocks. In addition, findings show that the strict inflation-targeting approach is not compatible with significant real output growth. The results show that only the real effective exchange rate is growth enhancing under flexible inflation targeting approach. Third, the dissertation investigated and compared the effects of contractionary monetary policy and exchange rate appreciation shocks on trade balance in South Africa. Evidence suggests that the exchange rate appreciation shocks worsen the trade balance for longer periods than contractionary monetary policy shocks in South Africa. In addition, the findings indicate that monetary policy operates through the expenditure switching channel rather than the income channel in the short run to lower net trade balance. Finally, the dissertation investigated the effect of contractionary monetary policy shocks on output in South Africa and Korea. The chapter compared what the estimated structural shocks suggested about policy shocks relative to bank systematic responses. Evidence shows that a contractionary monetary policy shock reduces output persistently in South Africa compared to transitory declines in Korea. The estimated monetary policy shocks suggest that Korean monetary policy was expansionary during the recession in 2009 unlike the South Africa counterparty. I attribute the differences to monetary policy intervention tools such as swap arrangement, in addition to interest rate reductions used to deal with recession in Korea.

CHAPTER 1 : INTRODUCTION

This dissertation focuses on monetary policy in South Africa using different forms of Vector Auto Regressions (VARs) in four essays. This investigation is motivated by policy discussions since 2010 in South Africa, occurring mostly in the absence of empirical evidence. The various ways of filling the gaps in the South African monetary policy empirical analysis are explained in the respective chapters. Each chapter explains the motivation for the study, the methodology applied, economic theoretical assumptions and the limitations of the assumptions in certain instances.

The South African Reserve Bank that conducts monetary policy has done little research using VARs on the monetary transmission mechanism in spite of improved research methodologies. This dissertation aims to enhance the understanding of transmission mechanism by applying VAR methodologies especially the structural VARs (SVAR) and Bayesian VAR sign restriction approaches to discuss monetary policy related questions. VAR identifications strategies range from the long run, short run or a combination of long and short run restrictions. The long run identification exploits information that some shocks have long run effects. In contrast, the short run identification exploits model assumptions about the timing of decisions relative to arrival of information.

The merits of these approaches in comparison to other methods for example, recursive approach, and simultaneous equations have been the deciding factor. As such, this thesis discusses the advantages and disadvantages of various models. Vector autoregressions are better than simultaneous equations for a variety of reasons. VARs use a number of convenient tools including impulse response functions, forecast error variance decompositions and historical decompositions. These tools can be applied to answer a host of questions concerning the effects of the shocks, and the importance in specific historical episodes (Gerlach and Smets, 1995). VARs also enable assessment of whether results are driven by different or implausible identifying assumptions.

This thesis begins the analysis by using the SVAR approach. SVARs have advantages compared to the recursive VARs approach. The restrictions imposed on SVARs are compatible with a large number of theories and allow discriminating between competing theories (Gottschalk, 2001). The identifying restrictions are based on uncontroversial assumptions and have an institutional context. SVARs are useful to explore what a theoretical view implies for the dynamic behavior of the variable of interest and allows taking a theory guided look at the data. Despite the stated advantages, the SVARs approach has certain weaknesses. The restrictions imposed in the SVARs models may give rise to undisciplined data mining, and findings are sensitive to ways in which the models are identified. The latter weakness suggests that little changes in the identifying assumptions can lead to substantial changes in the estimated effects of the shocks and in their relative importance over the sample period (Gerlach and Smets, 1995). However, this thesis tests the findings to different specifications and assumptions.

The structural vector error correction model (SVECM) is another form of SVAR useful when analyzing the speeds of adjustment to equilibrium, and recognizes the existence of cointegration between variables. This requires extra identifying restrictions in both short run and long run relationships. The identifying restrictions are either achieved through imposing restrictions in the long run or short run matrix, even on both. This thesis does not use the SVECM following Lucke (2010)`s argument that the identifying restrictions imposed on short and long run matrices are not necessarily independent and interact in a non-trivial manner with cointegrating properties of the system. A given set of restrictions may therefore fail to identify the structural shocks or may be inconsistent except on a parameter space of zero. Second, Lutkepohl (2008) argues that using long and short run restrictions requires some care in doing inference on impulse responses because certain identifying restrictions are not possible and require a singular residual covariance matrix, which is ruled out by assumption and is not plausible from a theoretical point of view. Moreover, if I impose false restrictions the inference would become incorrect.

There is also growing literature related to large datasets using factor analysis. Factor analysis uses more information, however, this approach is not appropriate, based on

merits of this study. Large datasets based on factor analysis follow the static factors approach in Bernanke et al. (2005). Recently the dynamic factors approach was applied by Forni and Gambetti (2010) and large Bayesian models by Banbura et al. (2010). However, Forni and Gambetti (2010) argue that static factors may not have any economic interpretation and there are often difficulties on the restrictions imposed on these factors according to theory. Forni and Gambetti (2010) criticised Bernanke et al. (2005)`s identification suggesting the static factors approach which consider factors that are linear combinations of slow-moving variables at the same time excluding fast-moving variables results in an efficiency loss.

The second VAR approach used in this thesis is the Bayesian sign restriction approach. The Bayesian VAR sign restriction approach imposes weak prior beliefs based on predictions of theoretical models and existing empirical findings in literature. Furthermore, the approach could be applied even when the variables are simultaneously determined making it harder to justify any parametric restrictions to resolve the identification problem. Fratzscher et al. (2010) argue that sign restriction gives results independent of a chosen decomposition of variance–covariance matrix, which implies that different ordering does not change the result, which is a weakness in recursive approaches. Granville and Mallick (2010) argue that the sign restriction method is robust to non-stationarity of series including structural breaks. In addition, Rafiq and Mallick (2008) suggest that restrictions imposed should happen irrespective of how variables are measured and their data idiosyncrasies, suggesting that definitions and measures of the same class of variables used are of secondary importance. A pure sign restriction approach makes explicit use of restrictions that researchers use implicitly and are therefore agnostic (Rafiq and Mallick, 2008). Fry and Pagan (2007) criticized the sign restriction approach arguing it leads to non-unique impulse responses. However, these authors admit identification issues affect all forms of VARs, not only those using sign restrictions. At the same time, this dissertation adopts the Scholl and Uhlig (2008) stance to reject the Fry and Pagan (2007)`s argument related to non-uniqueness of median impulse response in sign restrictions as an issue arising generally with all identification procedures.

Chapter 2 examines and quantifies the significance of an indirect channel of monetary policy transmission through combined house wealth and credit channel to consumption. Interest rate changes can affect consumption through the direct and indirect channel (HM Treasury, 2003). The direct channel suggests that changes in interest rates affect consumption directly. However, the indirect channel operates in two stages. First, changes in interest rates will affect housing demand and supply that will consequently lead to changes in house prices and house wealth. Second, changes in housing wealth would directly influence the current consumption through altering collateral required in accessing credit. This investigation uses the structural vector autoregressive (SVAR) methodology. The main analysis uses the South African Absa all-size (main segment) house price data. The robustness analysis uses house price data from three sub segments namely large, medium and small-size segments. In addition, the investigation compares the counterfactual and baseline scenarios to ascertain the extent of house wealth in propagating consumption changes.

Chapter 3 is motivated by the Minister of Finance`s clarification on the mandate of the South African Reserve Bank on February 2010, a decade since the country adopted an inflation-targeting framework. The clarification emphasized that when deciding on interest rates, the responsible members of the monetary policy committee should take a balanced approach, which considers economic growth. The chapter define shocks in a way that is consistent with strict and flexible inflation targeting framework in a lesser stricter way and is motivated by findings in recent literature evidence. The objective is to show that strict inflation targeting approach is not compatible with significant output growth. This Bayesian approach allows the analysis to incorporate that the South African Central Bank is accumulating foreign exchange reserves and a high oil price environment during the investigation. The analysis investigates three questions using VAR sign restriction method. (i) To what extent does the real interest rate react to both the exchange rate and the inflationary shocks? (ii) To what extent do these two shocks affect the output growth performance? (iii) Can monetary policy play a simulative role in mining output?

Chapter 4 uses the sign restriction approach to investigate how contractionary monetary policy and exchange rate appreciation shocks influence contribution of net exports to South African gross domestic product. In addition, the analysis examines whether contractionary monetary policy shocks affect the net exports through the expenditure-switching channel or income absorption channel using VAR sign restriction method. Various robustness tests are applied to facilitate a coherent policy recommendation based on the dominant channel.

Chapter 5 revisits the debate on whether monetary policy has effects on output focusing on the South African and Korean economies. The investigation relies on a VAR sign restriction specification as postulated by Rafiq and Mallick (2008) to assess the effect of monetary policy on output. The chapter concludes by examining the extent to which the estimated monetary policy shocks describe the true monetary policy activities during the major and recent real-time macroeconomic shocks, including the policy stance after global recession in 2008.

The dissertation has six chapters, four that conduct empirical analysis, the introduction and the conclusion. The empirical analysis is organized such that Chapter 2 focuses on monetary policy effects via the real house prices to general consumption expenditure. Chapter 3 deals with the inflation targeting, monetary policy and the exchange rate shocks. Chapter 4 compares the effects of the monetary policy and exchange rate shocks on trade balance. Chapter 5 compares the effects of the contractionary monetary policy shocks on output in South Africa and Korea. Chapter 6 provides the conclusions.

CHAPTER 2 : MONETARY POLICY TRANSMISSION, HOUSE PRICES AND CONSUMER SPENDING

2.1 Introduction

Chapter 2 estimates a SVAR to quantify the percentage decline in consumption expenditure, attributed to the combined house wealth and credit effects, due to a contractionary monetary policy shock in South Africa. The analysis captures the house wealth and credits effects using the South African Absa`s all-size house segment price data.[1]

Interest rate changes can affect consumption through indirect and direct channels (HM Treasury, 2003). The indirect effects operate in two stages. First, changes in the interest rates will affect housing demand and supply, which will consequently lead to changes in house prices and house wealth. Second, declines in housing wealth directly reduce current consumption. The direct link occurs when changes in the interest rates affect consumption directly and these changes have an income or cash flow effect. A monetary policy decision, which raises the interest rate, would increase the burden of the mortgage interest payments, which directly reduce the current consumption. HM Treasury (2003) suggests that the direct effects of the interest rates on consumer spending are stronger when individual households have net exposure on the interest-bearing debt, when a large proportion of the contracts use the variable interest rates, when consumers are credit constrained and when the link between the base rate and mortgage rate is strong. An increase in the interest rates reduces the current consumption through lowering the after-mortgage payments' household disposable income available for current spending.[2]

Elbourne (2008), using an eight-variable SVAR approach, deduced that in the United Kingdom (UK) about 15 per cent of the decline in consumption following an interest rate shock could be explained by a combined effect of the house wealth and the credit effects

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[1] The Absa bank provides price data for the three other segments namely small, medium and large. and we use them in robustness section.
[2] Both ways of transmission of interest rates to consumer spending predict inverse relationship between both house prices and consumption and prevailing level of interest rate.

associated with the house price changes. Two South African studies discussed the impact of monetary policy on the disaggregated house price inflation, which is the first stage in the indirect channel in Figure 2-2. Gupta and Kabundi (2010) uses a factor augmented vector autoregressive (FAVAR) to conclude that South African house price inflation declined in response to the contractionary monetary policy shocks. Kasai and Gupta (2010), using a SVAR found interest rate shocks had relatively stronger effects on house price inflation, irrespective of the house segments in South Africa, under financial liberalisation. This chapter fills the gap by estimating and quantifying the combined role of house wealth and credits effects in explaining consumption declines in South Africa using the two stages in the indirect channel in Figure 2-2.[3]

To ensure comparability of results to the literature, this analysis adopts the specification of SVAR model in Elbourne (2008). The main analysis uses the all-size house segment while three sub segments (namely small, medium and large segment) are used in the robustness analysis. In addition, the chapter discusses the results at the peak of the interest rate effects on consumption at the sixth quarter. The latter approach ascertains whether house wealth under indirect channel in Figure 2-2 is a dominant source of monetary policy transmission to consumption.

This chapter is motivated by four reasons. First, this chapter is motivated by changes in composition of bank finances. Figure 2-1 shows the composition of South African bank finances in percentages according to three main financing categories namely the loans and advances, installment lease and mortgages. Mortgage`s proportion in commercial bank finances exceeded loans and advances since 2003 and reached about 53 per cent around 2008. The rise in mortgages proportion and value coincided with rising house prices since 2003 in South Africa. The large contributions of mortgages category in banks` finances, is very important for monetary policy authorities concerned about the wealth effects associated with rising house prices. Hence, it is important to quantify the indirect effects of consumption through housing market channel associated with interest rate changes.

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[3] We could not get the figures indicating the extent of mortgage equity withdrawals in South Africa and hope that this study will stimulate relevant data collection.

Figure 2-1 Components of commercial bank finances in per cent
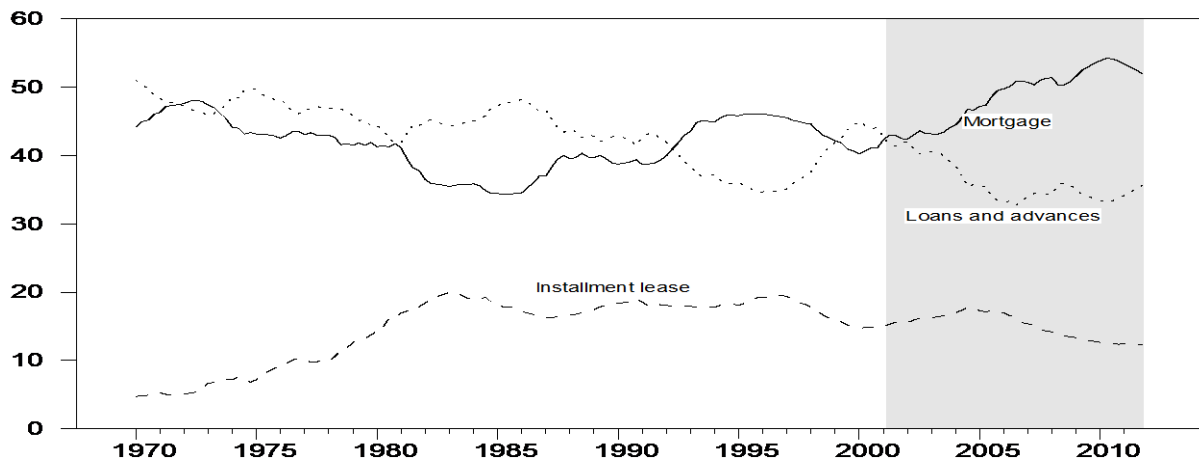
Second, there is little information known about the significance of housing segmentation and wealth effects in monetary transmission in South Africa. Despite, Gupta and Kabundi (2010) assessing the impact of monetary policy on segmented house price inflation in South Africa, they did not extend the analysis to a two stage transmission mechanism which incorporates consumption. The purpose of this chapter is to make monetary policy authorities understand the importance of the direct versus indirect channel.

Third, this chapter`s findings will give additional information to monetary authorities in complementing the importance of loan to value ratios in policy making. To my knowledge, no study in South Africa has looked at this transmission channel and attempted to link the results to patterns of loan to value ratios according to income groups. Finally, the chapter contributes not only to the policy perspectives but derives mathematically the formulas used to calculate the indirect effects to ascertain Elbourne (2008) `s intuitive formula of the indirect effects.

The rest of the analysis is organised such that Section 2.1 describes the monetary policy transmission and literature review. Section 2.3 describes the methodology and the data description is in Section 2.4. Section 2.5 presents and explains the results and Section 2.6 gives the conclusions followed by four Appendices.

2.2 Literature review and theory

The level of household consumption spending depends on house wealth, which changes with the house prices and interest rates. Monetary policy decisions, which change the short-term interest rates, affect the housing market and the whole economy, both directly and indirectly through a number of channels. The direct effects of the interest rates work through the costs of capital, expectations of the house price movements and house supply. The indirect effects work via the wealth effect from the house price changes and balance-sheet effects through the credit channel on consumption spending and housing demand. Figure 2-2 shows the direct and indirect channels of monetary policy transmission adopted from Elbourne (2008).

Figure 2-2 Relationship between interest rate, housing and consumption
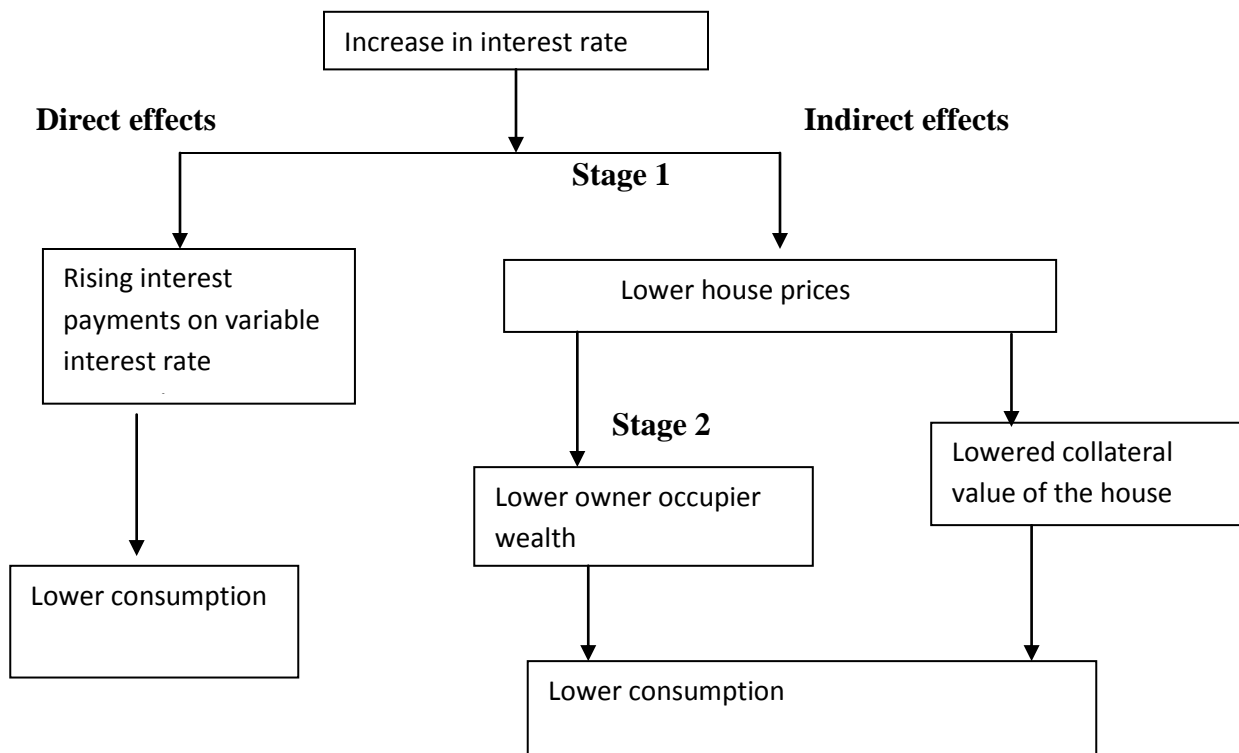
Source : Elbourne (2008)

The direct effect occurs through the income or cash flow effect, in which a higher interest rate increases the burden of any outstanding variable interest debt payments. An increase in the debt's interest payments reduces the cash flow and a decrease in the after-housing costs disposable income, prompting households' expenditure to decline in the shorter

9

term. When the cash-flow effects are greater, the closer the households are to spending the entire income budget. In addition, these effects tend to be greater, the more constrained households become to access credit and the more responsiveness the variable or fixed rates to changes in the base rates set by the central bank.

The indirect channel in Figure 2-2 operates through the wealth and credit effects (Elbourne, 2008). The indirect channels of an interest rate increase operate in two stages. First, asset-pricing theory suggests an inverse relationship between the interest rates and house prices. Second, house price declines reduce the owner-occupier wealth and cash flow, and lower the collateral value of the house. Declining house prices reduce the value of the house collateral and limit the credit constrained consumers' access to credit, leading to a reduction in the consumption expenditure.

Lacoviello and Minetti (2007) argue that house prices play an important role in the transmission of monetary policy through the credit-supply shifts and the determination of the lender's net worth, which constrains the amount of credit made available. Households that depend on credit finance find that higher interest rates reduce the collateral value linked to the house prices, lowering the household's likelihood of access to credit. The credit channel of monetary transmission suggests that credit-constrained households are more likely to reduce their consumption spending following a decline in house prices (Elbourne, 2008).[4]

The wealth effects linked to the life-cycle hypothesis suggest that consumers should increase their consumption following an increase in the wealth. Elbourne (2008) suggests that the existence of an imperfect substitutability between mortgages and other forms of finance for households is a necessary condition for the existence of a credit channel of monetary policy through the housing market. Lacoviello and Minetti (2007) suggest that tight monetary conditions cause an inward shift of credit supply which specifically affects borrowers with limited access to non-bank sources of external funding.

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[4] Moreover, households are likely to be more affected than firms due to the weakened balance sheets leading to the tighter lending sub-channels of the credit channel (Lacoviello and Minetti, 2007).

2.2.1 The effect of monetary policy on house prices

The demand for houses varies inversely with interest rates. In addition, interest rate payments represent a major portion of the house payment decision (Elbourne, 2008). According to Maclennan et al. (2000), interest rates represent the overall costs of investing in a house relative to other assets. House prices are sensitive to the investment return on the other financial assets, such as bonds. This substitution effect of an interest rate increase causes a portfolio switch by households into those less liquid assets and a shift away from the non-interest rate-bearing bank deposits into the interest rate-bearing deposits (Maclennan et al., 2000).

High interest rates are relevant at the beginning of a new interest rate payment period and influence the interest rate payments on the new housing loans. Hence, the amount an individual is willing to pay is linked to the affordability of the initial interest rate payments. Alternatively, higher interest rates lower the house prices by increasing the burden of the variable interest rate to such an extent that houses will be sold to pay back the principal or the house is repossessed (Elbourne, 2008).[5] Moreover, the speed, at which the house prices constrain consumption, after a monetary policy contraction, depends on the rate of adjustment of the mortgage interest rate, mortgage structure and interest rate period.

Calza, Monacelli and Stracca (2006) find that the sensitivity of consumer spending to monetary policy shocks increases with the lowering of the down payment and lowering of the mortgage repayment rate, and becomes larger under the variable rate mortgage structure. For instance, the correlation between consumption and house prices increases with the degree of flexibility or the development of mortgage markets. The shorter the duration of the interest rates, the faster these changes will affect the household disposable income (Elbourne, 2008). In addition, the more the variable rates respond to the official interest rates, the greater the probability that spending will react quickly to the changes in the interest rates.

HM Treasury (2003) suggests that the direct effects on consumption are strongest where the level of interest rate-bearing debt is high in relation to the interest-bearing assets, in the presence of the strong link between the base and mortgage rates, and when the consumers are credit constrained. The two South African studies mainly assessed the direct relationship between the interest rate increase and house price inflation, a first stage in the indirect channel in Figure 2-2 (see Gupta and Kabundi, 2010; Kasai and Gupta, 2010). This chapter extends this approach and uses both stages in Figure 2-2.

2.2.2   The effects of house prices on consumption

According to Elbourne (2008), it is important to show an indirect housing market channel of the monetary policy working through the house prices to influence the consumption variable. However, not all the house wealth derived from the increase in house prices is consumed, but is affected by other factors. For instance; the institutional differences, which lower real house price volatility, tend to lessen the sensitivity of the house prices to consumption, and weaken the role of the real house prices in the interest rate transmission mechanism (Maclennan et al., 2000). Factors such as high transaction costs, a low loan-to-value ratio, a lower level of the owner-occupier sector, a larger proportion of the households in the private-rented sector and a large proportion of the fixed-interest mortgage loans weaken the sensitivity of consumption to the house price changes.

Another transmission channel argues that rising house prices have negative effects on the rented sector (Maclennan et al., 2000; Elbourne, 2008). In these instances, the rent payers expect to pay higher future rental rates and a large down payment when purchasing a house. When the wealth effects become smaller for the institutional investors owning rental housing than owner-occupiers, *ceteris paribus*, the higher proportion of owner occupier and the lower proportion of households in the market-rented sector make the response of consumption to the house price increase to be large. Households can use capital gains from the house price increase to fund their current consumption. The low transaction costs make the housing market liquid (Elbourne, 2008). Elbourne (2008) found the positive effect of increases in house prices on consumption. Maclennan et al.

12

(2000) suggests that where housing is regarded as excellent collateral, housing is in fact more spendable and house prices impact much stronger on consumer spending.

2.2.3 Evidence from counterfactual studies

Various counterfactual simulation studies examine the importance of the wealth channel during the monetary policy transmission to the consumption. Giuliodori (2005)'s VAR evidence indicates that the peak response of consumption to a monetary contraction is about 0,5 per cent in the unrestricted setting and about 0,2 per cent in the restricted model. Elbourne (2008)'s counterfactual approach attributes about 12 per cent of the consumption fall to the combined wealth and credit effects. He estimates a SVAR to infer that about 15 per cent of the fall in consumption was due to the combined role of the housing wealth effect channel and housing credit channel. In addition, the impulse responses from the counterfactual model were similar to those under the baseline scenarios and within the error bands of the baseline model.

Ludvigson et al. (2002) estimate VARs and find the impulse responses of consumption expenditure to monetary policy shock virtually identical under the baseline and counterfactual scenarios. This evidence indicates that the wealth channel was relatively an unimportant one in transmitting the effects of monetary policy to consumer sector. Aoki et al. (2002) developed and calibrated the dynamic general stochastic equilibrium model with frictions in the credit markets used by households. After switching on the financial accelerator channel in the model, the impulse responses of consumption and house price increased significantly in line with the results from the VAR evidence. Table 2-1 and Table 2-2 summarise and separate all the evidence.

Table 2-1 Survey of empirical studies

Authors	Method and period	Main findings	Shocked variable	Responses
a)	**The effects of house price on consumption**			
Case et al. (2005)	Panel data yearly (1975–1999)	House wealth effects more important than stock market effect in influencing consumption in 14 developed countries	10% house price shock	Consumption rose by 1% for panel of western countries
Chirinko et al. (2004)	SVAR (1979Q4–1998Q4)	House price shocks have bigger effects than equity shocks	1,5% House price shock	Consumption rose in 8 of 13 countries
b)	**The effect of monetary policy on house prices**			
Giuliodori (2005)	VAR-choleski (1979Q1–1998Q4)	House price enhances effects of monetary policy on consumption where housing and mortgage markets are relatively developed and competitive	100 Basis point money	House price fell by 0,7%−1.8%
Lacoviello and Minetti (2007)	VAR * (1978Q1–1999Q4)	In UK, evidence of bank lending channel and possible balance sheet channel in VAR (model 1)	About 70 basis points money rate	Real House price fell by 1,4%
Lacoviello (2002)	VAR** (1973Q1–1998Q3)	Monetary policy had a significant effect on house effect on house prices	A normalized 50 basis points interest rate shock	House price fell by1,5% in UK
Aoki et al. (2002)	VAR-Choleski (1975Q2–1999Q4)	Based on aggregate effects of financial innovations size of house price responses fell relative to interest rate consumption responses	50 basis points short term	House price fell by 0.8% Non-durable Consumption fell by 0,1%
Gupta and Kabundi (2010)	FAVAR (1980Q1–to 2006Q4)	Monetary policy reduced house price inflation across different house segments	0,25% treasury bill shock	All house prices inflation fell
Kasai and Gupta (2010)	SVAR*** (1967Q4–1983Q3) (1983Q4–2006Q4)	Monetary policy reduced house price inflation under financial liberalization in 1983Q1-2006Q4	One standard deviation	House price fell

*Notes. Combination of short and long run combination; ** Adopted King, Plosser, Stock, Watson (1991) approach,*** implies two sample periods were used.

Table 2-2 Counterfactual studies

b.1) Combined role of housing wealth and credit channel

Authors	Method and period	Main findings	Shocked variable	Responses
Elbourne (2008)	SVAR (198M1-2003M5)	House price explains about one-seventh of fall in consumption after interest rate hike	100 basis points interest rate shock	house price fell by 0,75%. Retail sales fell by 0,4%
c) Counterfactual studies				
Elbourne (2008)	SVAR (198M1-2003M5)	12% of consumption decline attributed to falling house price following interest rate hike	100 basis point s interest rate	house price fell by 0,75%. Retail sales fell By 0, –4%
Giuliodori (2005)	VAR-choleski (1979Q3–1998Q4)	Excluding role of house price, consumption fell from 0.5% to 0.2%	100 Basis point money market interest shock	House price fell by 0,7%–1,8%
Ludvigson et al. (2002)	SVAR (5 variables) (1966Q1–2003Q3)	Absence of wealth channel to consumption had a small impact on the responses of consumption to federal funds rate Total PCE was one-tenth of percentage point less at its trough when wealth channel is shut off than under the baseline model	One standard deviation (81 basis point)	Nondurable & services consumption fell by -0.23% Total PCE fell by -0,25 to–0,5%
Ludvigson et al. (2002)	SVAR (6-variables) (1966Q1-2003Q3)	Wealth channel is relatively unimportant in transmitting the effects of monetary policy to consumer sector. Very little support for view that wealth channel is dominant source of monetary transmission to consumption. Both nondurable and total PCE under baseline model virtually not distinguishable from model when wealth channel was shut off.	One standard deviation (81 basis points)	Both nondurable & total consumption fell by -0,2% and -0,23% respectively
Aoki et al. (2002)	Calibrated DSGE to VAR (1975Q2-1999Q4)	The DSGE model fitted data when the financial accelerator through housing market is switched on	50 basis points short term interest rate	House prices and consumption rose under financial

2.3 Methodology

This section describes the structural VAR methodology. The reduced form VAR model is given by equation (2.1)

[2.1] $$X_t = \sum_{s=1}^{n} \beta_s X_{t-s} + u_t$$

where X_t is a vector of endogenous variables. β_s is matrix of parameters, X_{t-s} for s=1,2,...,n is a vector of lagged X variables. u_t is a vector of white noise with mean $E(u_t) = 0$, variance–covariance matrix $E(u_t u_t') = \Sigma$. The reduced form disturbance, u_t are linear combinations of all structural shocks e_t in form $G_0 u_t = e_t$. Pre-multiplying equation [2.1] by G_0 leads to a structural VAR model

[2.2] $$G_o X_t = \sum_{s=1}^{n} G_s X_{t-s} + e_t$$

where $G_s = G_0 \beta_s$, $G_0 u_t = e_t$ and $E(e_t e_t') = \Lambda$ hence $\Sigma = G_0^{-1} \Lambda (G_0^{-1})'$. The model has eight structural shocks. The structural form of the model is identified through imposing additional restrictions on the contemporaneous restrictions on the G_0 matrix or Σ. Since diagonals are normalised to 1`s at least $n \times (n-1)/2$ restrictions are needed to overidentify G_0 (Kim and Roubini, 2000). I discuss the reason for using SVAR compared to other VARs. Gottschalk (2001) argues that SVAR approaches are useful for taking a theory-guided look at the data and restrictions are compatible with a large number of theories, which allows the use of this methodology to discriminate between competing theories. These advantages make the recursive VAR approaches less ideal for this analysis.

In addition, this chapter does not focus on the speed of adjustment to equilibrium and consequently does not apply SVECM. This does not mean SVECM is not useful, but its weaknesses make it a less preferred method. The SVECM recognizes the existence of cointegration between variables. This requires extra identifying restrictions in both short

run and long run relationship. The identifying restrictions are either achieved through imposing restrictions in the long-run or short run matrix, even on both. There are problems related to identifications of SVECM. According to Lucke (2010), the identifying restrictions imposed on short and long run matrices are not necessarily independent and interact in a non-trivial manner with cointegrating properties of the system. This suggests that a given set of restrictions may therefore fail to identify the structural shocks or may be inconsistent except on a parameter space of zero.

Second, Lutkepohl (2008) argues that using long and short run restrictions requires some care in doing inference on impulse responses. This arises because certain identifying restrictions are not possible because they imply a singular residual covariance matrix, which is ruled out by assumption and is not plausible from a theoretical point of view. This means some over identifying restrictions may not be possible because they are outside the admissible parameter space. In these instances, the t-ratios cannot be interpreted in the usual way, and it is not always obvious which overidentifying restrictions are possible and which ones are not admissible. Hence, the interpretation of confidence bands intervals around the impulse response function needs some care. Moreover, if I impose false restrictions the inference would be incorrect.

The SVAR model adopted from Elbourne (2008) is divided into blocks representing the external sector, money-market equilibrium, goods markets equilibrium, exchange rates and housing sector. The baseline model's identification given in equation [2.3] incorporates the behaviour of agents.

Baseline model

$$[2.3] \quad \begin{bmatrix} \varepsilon_{OIL} \\ \varepsilon_{FFR} \\ \varepsilon_{PCE} \\ \varepsilon_{P} \\ \varepsilon_{MD} \\ \varepsilon_{MS} \\ \varepsilon_{R/\$} \\ \varepsilon_{h} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & 0 & 0 & 0 & 0 & a_{38} \\ a_{41} & 0 & a_{43} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & a_{53} & a_{54} & 1 & a_{56} & 0 & 0 \\ a_{61} & a_{62} & 0 & 0 & a_{65} & 1 & a_{67} & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 & 0 \\ 0 & 0 & 0 & 0 & a_{85} & a_{86} & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{OIL} \\ u_{FFR} \\ u_{PCE} \\ u_{P} \\ u_{M} \\ u_{R} \\ u_{R/\$} \\ u_{h} \end{bmatrix}$$

where u_{OIL}, u_{FFR}, u_{PCE}, u_P, u_M, u_R, $u_{R/\$}$ and u_h are the residuals from the reduced form equations. ε_{OIL}, ε_{FFR}, ε_{PCE}, ε_P, ε_{MD}, ε_{MS}, $\varepsilon_{R/\$}$ and ε_h are the structural disturbances. The shocks are oil price (OIL) shocks, federal funds rate (FFR) shocks, consumption expenditure (PCE) shocks, consumer price index (P) shocks, money demand (MD) shocks, interest rate (R), exchange rate (R/$) shocks and real house price (h) shocks respectively.

The first two rows in equation [2.3] measure the external pressure on the domestic economy from the oil price and the foreign interest rates. Row [1] assumes that the oil price is the main factor driving its own changes, which captures the current systematic responses to the negative supply-shock and inflationary pressures.[6] In addition, the US federal funds rate (FFR) captures the changes in the global business cycle, which is also an important driver of domestic activity.[7] Federal Funds rate depends on the oil price and itself in row [2].

The model includes the aggregate demand and the aggregate supply equations to ensure the domestic goods market equilibrium. The aggregate demand in row [3] allows consumption to vary contemporaneously with the house prices and the oil prices. Zero restrictions in the domestic goods market equilibrium equations reflect a model showing

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[6] This is similar to the justification given by Elbourne (2008). Kim and Roubini (2000) included oil prices to resolve price puzzle. On the contrary, Brischetto and Vos (1999) used it to capture the anticipated inflation for G-6 countries.
[7] Elbourne (2008) follows Grilli and Roubini's (1996) argument that for G-7 countries, the US acts as a leader and other countries are followers in setting monetary policy.

nominal rigidities (Elbourne, 2008).[8] The prevalence of better mortgage terms may magnify the impact of the house price on consumption. The oil price variable captures the effect of the mark-ups on the production costs, contains information about the world business cycle and control for the policy-makers' expectation of the future inflation. The consumer price index in row [4] depends on the oil price and consumption, and an increase from both variables exerts a positive impact on the price level.

The demand for the real money in row [5] is in the standard form and depends contemporaneously on the consumer prices, interest rates and consumption. M3 is the monetary aggregate variable. In addition, the identification eliminates the contemporaneous portfolio adjustments from monetary aggregate to the house prices and assumes these to be negligible (consequently treating them as zero). At equilibrium, the money supply equals the money demand. Furthermore, we assume, in row [6] the money supply equation to be a reaction function of the monetary authority, which sets interest rate after observing the current values of oil prices, domestic monetary aggregates, US federal funds rate and nominal exchange rates.

The policy reaction function excludes prices variables because they are available with a delay when the interest rate is set. Monetary policy reaction function does not respond contemporaneously to consumption, simply because data is not available contemporaneously (Elbourne, 2008) as monetary policy committee meets six times in a year while consumption data is available quarterly. South Africa is an open economy with open capital markets, suggesting that the domestic interest rates respond to US interest rates developments. In addition, the federal funds rate acts as proxy for the return in the international economy. The oil price level is included as a measure for an anticipated inflation.[9]

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[8] Elbourne (2008) uses a high number of zero restrictions and suggests that the identification strategy is consistent with a model exhibiting nominal rigidities. He further argues that nominal rigidities of this nature are common in DSGE models.

[9] Elbourne (2008) argues that there is a problem of forecasting current consumption and price level from available data and use it as a policy guide rule. Furthermore, he suggests that the inclusion of actual price level and consumption values contemporaneously in the reaction function is equivalent to assuming that the central bank forecasts these variables accurately. Therefore, using the oil price can be a good proxy for prices.

The model uses the nominal exchange rate to allow monetary authorities to consider the depreciation effects of the currency on the inflation rates.[10] The use of nominal interest rate suggests monetary authority is implicitly concerned about effects of depreciation of the currency on inflation rates. The use of nominal interest rates controls for components of interest rate movements that are systematic responses to depreciation of the currencies. Doing so, means the specification is more likely to identify the interest rate innovations that are exogenous contractions in monetary policy and that should lead to currency appreciation (Kim and Roubini, 2000). As documented in Elbourne (2008), the specification assumes that the central bank does not respond contemporaneously to the house prices movements.

The identification in row [7] assumes that the exchange rates depend contemporaneously on all the other variables except the real house prices. This reflects that the exchange rate is set in active competitive markets and responds to all the disturbances in the economy. In addition, the exchange rate equation is an arbitrage equation that describes the financial market equilibrium. Since the exchange rate is forward looking asset price, the specification assumes all variables have contemporaneous effects on exchange rate in this equation (Kim and Roubini, 2000). House prices react contemporaneously to the domestic monetary variables and interest rates as in row [8].

2.3.1 Quantifying declines in consumption

The mathematical derivation of the main formulas is in the Appendix A 2. The formula used in Elbourne (2008) uses equation [2.4] to calculate the proportions of the consumption declines because of the combined house wealth and credit changes from the positive interest rate shock.

[2.4]
$$Q = \frac{dc_t}{d\varepsilon_{ht}} * \frac{dh_t}{d\varepsilon_{rt}} \Big/ \frac{dc_t}{d\varepsilon_{rt}}$$

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[10]   To those components of the interest rate movements that have a systematic response to the domestic currency depreciation. These two purposes of including the exchange rate are explained in Elbourne (2008).

where the $\dfrac{dc_t}{d\varepsilon_{ht}}$ denotes the impulse responses of the consumption to the house price

shocks, the $\dfrac{dc_t}{d\varepsilon_{rt}}$ and $\dfrac{dh_t}{d\varepsilon_{rt}}$ are the impulse responses of consumption and house price to

the interest rate shocks respectively. In addition, $\dfrac{dh_t}{d\varepsilon_{ht}}$ denotes the impulse responses of

the house price to the own shocks. However, the derivations based on the definition of the house-wealth effect suggest a need to modify the Elbourne (2008)`s formula by dividing the impact of the house prices on consumption by the impact of house price shocks on itself as done in equation [2.5] to give a house wealth equation.[11]

$$[2.5] \qquad \dfrac{\dfrac{dc_t}{d\varepsilon_{ht}}}{\dfrac{dh_t}{d\varepsilon_{ht}}} = w$$

This wealth effect (w) of the house price increase on consumption is incorporated into equation [2.6] to get the modified Elbourne (2008)`s formula for quantifying the consumption decline due to house wealth and credit changes.

$$[2.6] \qquad Q^m = w \dfrac{dh_t}{dc_t} = w * \dfrac{\dfrac{dh_t}{d\varepsilon_{rt}}}{\dfrac{dc_t}{d\varepsilon_{rt}}}$$

Equations [2.4] and [2.6] quantify the combined wealth and credit effects arising from a change in the interest rates increase.

2.4 Data

The analysis uses quarterly (Q) data for eight variables in the period 1975Q1 to 2009Q4 to examine the transmission of monetary policy via real house prices to consumer spending in South Africa. Domestic variables are the consumer price index, consumption expenditure,[12] money-market interest rate, money supply, real house price, nominal

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[11] Our mathematical derivation of the above formula indicates that it is incorrect to estimate the house-wealth effect on consumption by the impact of house shocks on consumption only.

[12] The consumption is the final consumption expenditure by households: Total (PCE) variables from the South African Reserve Bank with code KBP6007D at constant 2005 prices and seasonally adjusted at the annual rate.

exchange rate and the oil index. The consumption expenditure data was extracted from the South African Reserve Bank. The FFR captures the influence of the foreign interest rate on South Africa's open economy. The money-market interest rate represents the South African monetary policy instrument and M3 aggregate denotes the money supply. These variables were extracted from the IMF International Finance Statistic database excluding the house prices from South Africa's Absa Bank. The Absa house prices are calculated from data pertaining to total buying prices of the all-size house segment covering the area defined by the range 80–400 m^2. The area is further divided into three segments namely the small (80–140 m²), medium (141–220 m²) and large (221–400 m²). For the estimation process, all variables are converted into the logarithms except the money-market interest rate and FFR.

Table 2-3 Descriptive statistics

Variable	Mean	Minimum	Maximum	Std error
All-size house price (rands)	450476.80	283737.00	833733.10	153317.00
Large-sized house price (rands)	628178.50	408316.00	1190426.00	212310.10
Medim-sized house price (rands)	434063.00	274434.70	818241.70	147273.10
Small-sized house price (rands)	335333.90	213796.80	581153.60	105672.90
Consumer price index	50.26	4.58	136.25	38.97
US Federal funds rate (%)	6.24	0.16	17.78	3.59
Consumption (trillion rands)	0.69	0.40	1.16	0.22
M3 (trillion rands)	0.42	0.01	1.94	0.52
Money market rate (%)	11.70	4.00	22.50	4.45
Oil price index	28.67	11.17	121.10	19.84
Rand per US dollar (R/$)	3.93	0.67	12.13	2.82

Notes. The real four house prices were obtained from Absa bank. I converted the monthly house price into quarterly averages. Std refers to standard

Table 2-3 shows the descriptive statistics of all variables. Only the interest rates and federal funds rates have the largest standard deviation, while house prices display the same magnitude of variations excluding the large house segment. Both money-market interest and federal funds rates display nearly an equal standard deviation. Among the four house price segments, the real large house segment has the largest mean price of R628 178,5 and the real small house segment has the least value of R335 333,9. Figure 2-3 shows the time paths of all variables used for analysis over the period 1975Q1 to 2009Q4. All prices of the four house segments display a similar trend, reaching a peak

after 2005. The interest rates and oil price index show some volatility over the period. The consumer price index, consumption and M3 show an upward movement.

Figure 2-3 Plots of variables
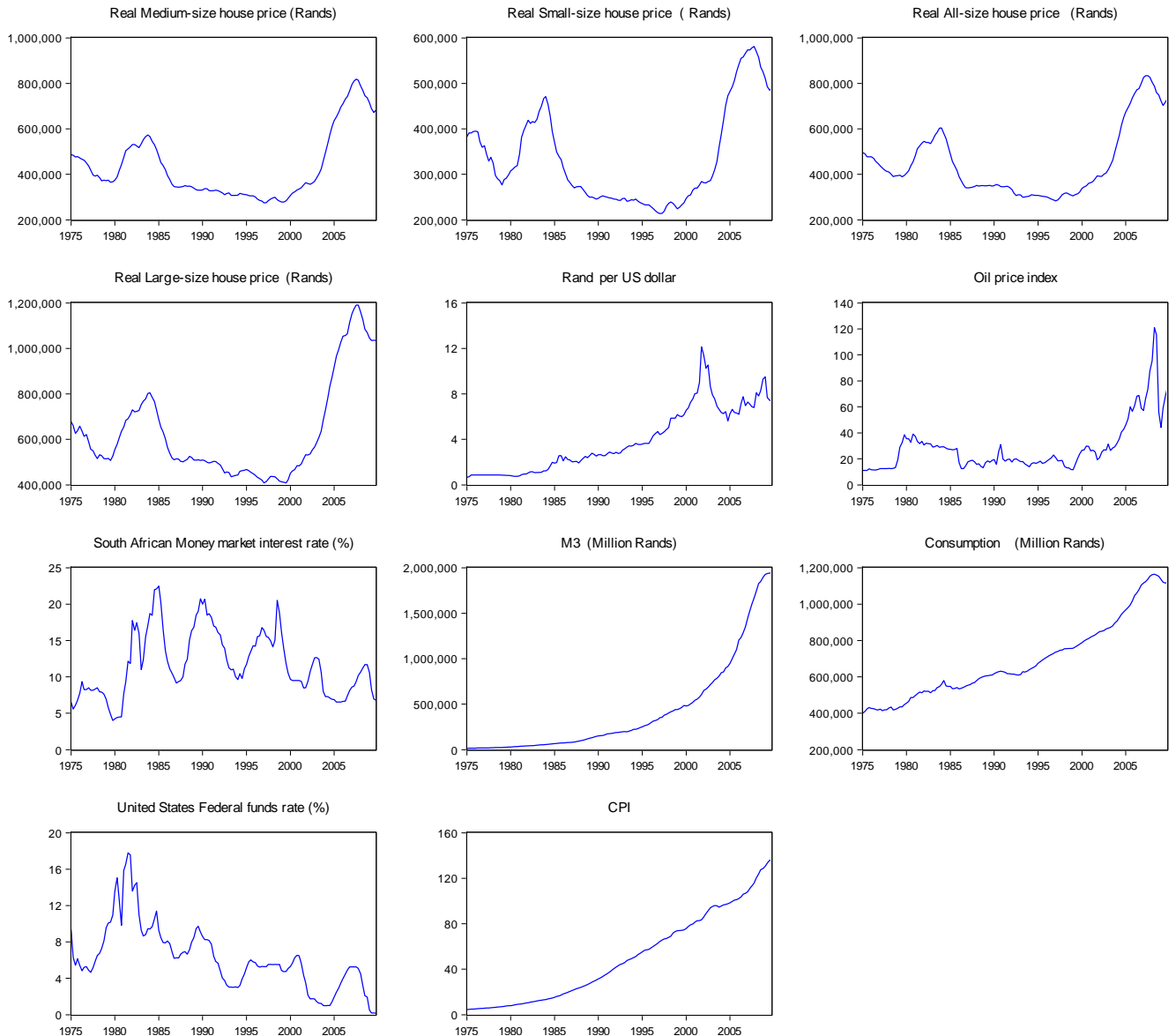
This subsection conducts various unit root tests to determine the order of integration of the variables. The various unit roots tests in Table 2-4 are the Augmented Dickey Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and Phillips-Person test (PP). The ADF rejects the null hypothesis that the variables examined have unit roots against the

alternative hypothesis of stationarity. Furthermore, the KPSS rejects the null hypothesis that the variables being tested are stationary. These tests find that most variables have unit roots.

Table 2-4 Unit root test

Variable	ADF	PP	KPPS
Real all-size house price	-1.70	-1.11	1.14
Real medium-size house price	-1.87	-1.22	1.12
Real small-size house price	-1.79	-1.32	1.15
Real large-size house price	-1.39	-1.11	1.13
Consumer price index	3.40	-0.51	1.47
Federal funds rate	-1.35	-2.65	0.89
Consumption	-0.92	-1.23	1.39
M3	2.38	2.37	1.17
Money-market rate	-3.27	-2.56	0.23
Oil price index	-1.87	-2.12	0.63
Rand	-3.41	-2.84	1.36

Notes. The Augmented Dickey-Fuller test statistic (ADF) used 13 lags selected by Schwarz Information Criterion, and included the trend and constant. ADF test-statistic values at 1 per cent; 5 per cent and 10 per cent are -4.03, -3.44; and -3.15 respectively. The Kwiatkowski-Phillips-Schmidt-Shin test statistic (KPSS) test statistics at 1 per cent; 5 per cent and 10 per cent are 0.74; 0.46 and 0.35 respectively. Phillips-Perron (PP) test statistics at 1 per cent; 5 per cent and 10 per cent are -4.03, -3.44 and -3.15 respectively.

2.5 Results

The SVARs are estimated using four lags selected by the Akaike Information Criteria using the price data of the all-size house segment including an intercept, time trend[13] and various dummies of the known structural breaks.[14] Except the interest rates, all other variables are expressed in logarithmic form. The preceding section explained advantages of using SVAR in comparison to other VARs, hence I explain the reasons now, for using data in levels than differencing it based on literature. The SVAR is estimated using data in levels form[15] because differencing produces no gain in an asymptotic efficiency in a vector autoregressions analysis even if it is appropriate (Rats, 2007). In addition, Sims (1991) noted that while there is a possibility of efficiency losses, there is no penalty in terms of consistency of the estimated parameters. Furthermore, differencing throws away

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[13] Elbourne (2008) included the trend.

[14] The various dummy variables are the adoption of inflation targeting framework in 2000Q1, the recession between 1991Q1–1992Q2, recession in 2009Q1–Q3, Asian crisis in 1997Q3-1998Q3, period in which interest and credit controls were removed starting in 1980Q1 and includes the period of exchange rate liberalization after 1979Q1, debt standstill in 1985Q2-1989Q3 and post financial liberalisation in which bank liquidity ratios were removed in 1985Q1.

[15] This is consistent with the approach used in Kim and Roubini (2000), Brischetto and Vos(1999) , Elbourne (2008). Brischettos and Vos (1999) caution against the possibility that standard inference may not be correct, even though the estimated model in levels should provide consistent parameter estimates. This implies that in the presence of such cointegration, there is a set of cointegration restrictions which when imposed would improve the efficiency of the estimation.

information hence a VAR estimated on differences cannot capture cointegration relationship and produces almost no gain. Hence, any potential cointegration relationship between the variables will be determined in the model. The SVAR is estimated by a maximum likelihood method and standard errors computed using the Monte Carlo Integration technique. The 16 and 84 percentiles are the error bands.[16] The quantifications follow Lacoviello (2002)'s approach to normalise the initial impact of interest to 0,5 per cent (50 basis points) and house prices to 0,5 per cent but leaving the error bands unaffected.

This analysis focuses on the interest rate and house price shocks to assess the importance of the indirect channel in Figure 2-2. These are key shocks in order to use equations [2.4] and [2.6] and focuses on South African variables only. Hence, Figure 2-4 shows the various impulse responses to the interest rate and house price shocks. As predicted by economic theory, both consumption and all-size house price declined in response to a contractionary interest rate shock. The U-shaped significant declines in consumption and real house price due to a contractionary monetary policy shock, are consistent with findings in VAR literature. However, the decline in M3 is not significant suggesting that the liquidity effect is weak.

A 0,5 per cent increase in all-size house prices has a positive impact on consumption, house price and M3 for nearly 10 quarters whereas the interest rate rises significantly after four quarters. The rise in consumption in response to positive house price shock suggests the wealth effect. Moreover, the rand appreciates significantly by nearly 1 per cent in the second, quarter after a positive house price shock. The consumer price inflation remains muted.

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[16] The variables were multiplied by 100 for all impulse responses to represent percentage deviations from their trend. The estimated models passed the over-identification test at the 1 per cent significance level.

Figure 2-4 Impulse responses
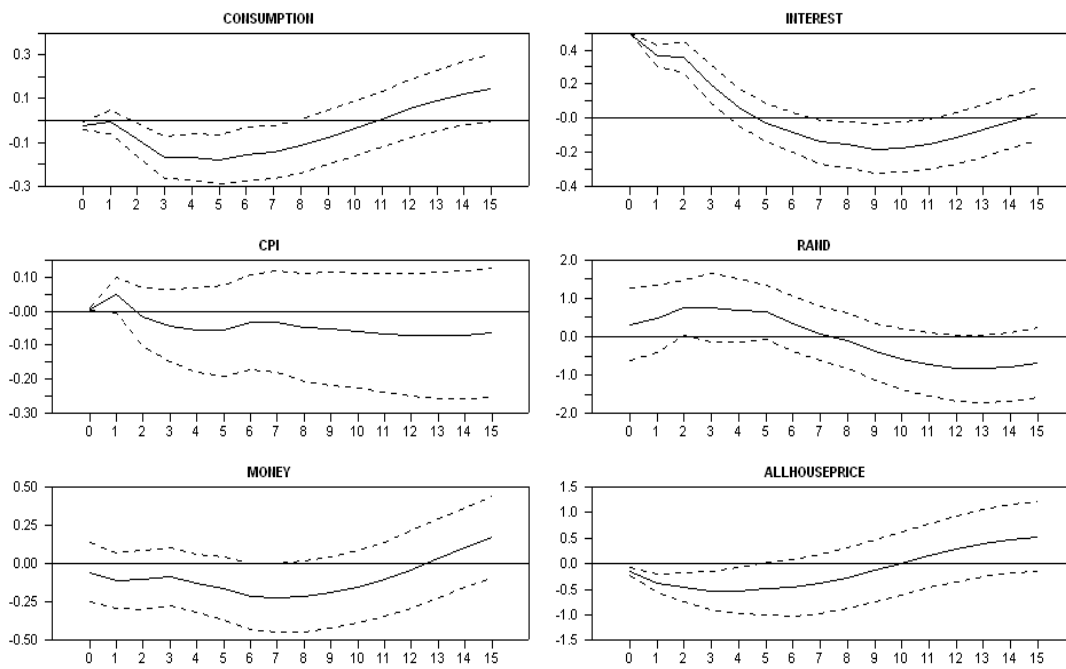
Responses to 0.5% Interest rate increase
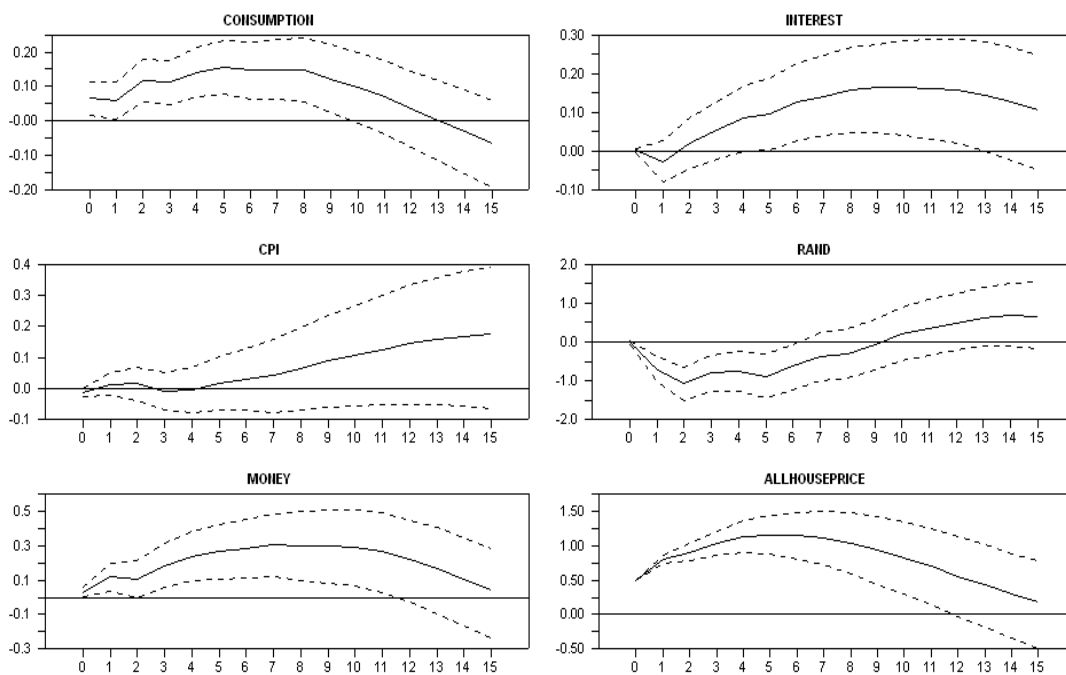
Responses to 0.5% allsize house price increase

2.5.1 Forecast error variance decomposition

Table 2-5 Variance decomposition in per cent

Quarters ahead		Oil	FFR	PCE	CPI	M3	R	Rand	RHPI
a) Consumption									
	1	0.5	0.3	99.2	0	0	0	0	0
	2	1.8	0.5	92.9	2.6	0.3	0.4	1.4	0.1
	3	1.8	0.5	81.9	4.1	0.6	0.3	6.8	3.8
	4	1.5	2.9	65	4.8	4.6	0.5	14.8	5.9
	8	0.6	10.5	36.1	3.8	4	0.5	29.2	15.2
	12	3.5	11.3	28.2	3	4.5	3.6	30	15.9
	16	4.6	11.8	28.3	3.4	3.9	7.8	25.4	14.8
b) Interest rate									
	1	1.2	0	0	3.1	0.2	95.4	0	0
	2	0.6	5.5	3.1	7.4	2.8	76.1	1.1	3.5
	3	0.6	10.3	4.6	11.6	3.7	58.5	1.5	9.1
	4	0.6	11.4	11.2	9.4	8.2	48	1.4	9.8
	8	0.6	9.1	31.9	5.9	9.9	27.9	5.8	8.9
	12	0.8	10.4	32.6	4.7	8.8	19.9	8.2	14.8
	16	4.3	9.9	28.1	5.3	10	19.7	8.4	14.4
c) All-size house price									
	1	0.1	0.6	4.8	35.4	0.5	1.9	1.4	55.4
	2	0.9	3.5	3.9	19.9	0.7	4.3	7.1	59.7
	3	1.5	12.3	3.5	12.7	0.8	2.6	12.4	54.2
	4	1.1	19.1	3.7	9	0.6	1.4	14.2	50.8
	8	2.1	20.2	3.2	3.6	2.7	3.2	21.3	43.6
	12	8.5	12.4	1.9	3.1	8.4	3.6	23.3	28.9
	16	10.7	11.1	2.5	4.3	9.8	19.9	20.2	21.4

Notes. The variables are oil price (Oil), federal funds rates (FFR), consumption expenditure (PCE), Consumer price index (CPI), money (M3), interest rate(R), exchange rate (R/$) and house price (HP)

Table 2-5 shows the variance decompositions of the consumption, the interest rate and all-size house prices variables respectively. Table 2-5(a) shows the variance decomposition of consumption variable. The consumption variability is driven mainly by its own variation for nearly two years. After eight quarters, the foreign interest rate, rand and real house price levels became more important. Interest rates, price levels, M3 and oil price variables account for less than 5 per cent in 12 quarters respectively. Real house price accounts for nearly 15 per cent of the variation in consumption in the long run (i.e. over 8 quarters).

The variance decomposition for the interest rate variable in Table 2-5 (b) indicates the variables in the model, which the policy setters consider when setting the interest rates.[17] Almost all variability in the money-market interest rate in the first 4 quarters arises from

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[17] This refers to the variables in this model. However, the central bank use more variables than these.

own innovations. After 8 quarters, consumption explains nearly 30 per cent, which is greater than variations from the FFR, the rand, real house prices and M3 variables.

In Table 2-5 (c), real house prices are largely self-determined even though the importance of other variables increasingly becomes significant as the horizon increases. The importance of the consumer price level in explaining the house price variability declines with the increase in forecast horizons. The interest rate variable introduces more variability to the real house prices in the long run. Overall, the variance decomposition confirms the findings in Elbourne (2008) that the proportion of house price variation attributable to the aggregate demand shocks represented by consumption is low.[18]

2.5.2   Robustness analysis

The analysis further conducts three robustness tests namely the counterfactual approach, alternative model and three house segments (i.e. small, medium and large).

This counterfactual approach further ascertains the importance of the house wealth effect on consumption,[19] by shutting off the effects of the house prices on consumption.[20] All coefficients of a_{38} in each B_s matrix in equation [2.1] are set to zero suggesting that wealth effect has no effect in the indirect channel in Figure 2-2 (this excludes house wealth on consumption in stage 2). The difference between the consumption responses from the baseline model (both stages in the indirect channel included) and the counterfactual model (indirect channel excluding house wealth) is a measure of the contribution of the consumption wealth channel in the transmission channel of monetary policy (Ludvigson et al., 2002).

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[18] We do not report variance decompositions for other house categories as they show similar patterns. The analysis for other house segments shows similar trends.

[19] This is adopted from the Elbourne (2008) counterfactual approach. This involves a comparison of the direct effects of monetary policy shocks on consumption using the baseline model to those from the counterfactual model. The baseline model allows consumption to respond to monetary policy shocks and it includes the endogenous response of house wealth and its influence on consumption.

[20] A set of the cross-correlation between consumption and house prices is set to zero in the consumption equation of the structural model.

The counterfactual analysis is subject to Lucas (1976) critique and different interpretations have been put forward. Counterfactual analysis is subject to the Lucas (1976) critique because deep parameters underlying the reduced form estimates are likely to be different under the counterfactual scenario. However, Poirson and Weber (2011) argued that change in deep parameters may be too small to have a major implication for the reduced form estimates of the VAR in the context of various policy changes. In context of similar study to this chapter, Elbourne (2008) argues that the critique is less severe since consumption does not depend on the house price, suggesting that the central bank would have reacted differently and the monetary policy shocks would be different. Thus, the Lucas critique would not be strong because these results form part of circumstantial evidence (Elbourne, 2008; Giuliodori, 2005).[21]

The second, robustness analysis uses additional restrictions to check the role of the house wealth on consumption using equation [2.7]. The restrictions suggest that house prices respond to both the aggregate demand and supply in the baseline model.

$$[2.7] \quad \begin{bmatrix} \varepsilon_{OIL} \\ \varepsilon_{FFR} \\ \varepsilon_{PCE} \\ \varepsilon_P \\ \varepsilon_{MD} \\ \varepsilon_{MS} \\ \varepsilon_{R/\$} \\ \varepsilon_h \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & 0 & 0 & 0 & 0 & a_{38} \\ a_{41} & 0 & a_{43} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & a_{53} & a_{54} & 1 & a_{56} & 0 & 0 \\ a_{61} & a_{62} & 0 & 0 & a_{65} & 1 & a_{67} & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 & 0 \\ 0 & 0 & a_{83} & a_{84} & a_{85} & a_{86} & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{OIL} \\ u_{FFR} \\ u_{PCE} \\ u_P \\ u_M \\ u_R \\ u_{R/\$} \\ u_h \end{bmatrix}$$

The third robustness test, extends the analysis to assess the sensitivity of the findings using three house segments by splitting the area range defined in the all-size house segment.[22] Absa bank provides data for three house sub segments namely the small-size (80–140 m²), medium-size (141–220 m²) and large-size (221–400 m²). The impulse

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[21] However, this particular analysis is not looking at what would happen if the consumption did not depend on the house prices but focuses on the proportion of the consumption response estimated to come through the house prices.

[22] Absa house prices are calculated from data pertaining to total buying prices of three house segment with all-size house segment determined by 80–400 m².

responses are in Appendix B 2 and mostly resemble those from the All-size house segment.

2.5.3 Discussion of results

The results from the preceding estimations are presented in tables. This is followed by a graphical comparison of responses from the counterfactual and baseline models. The results in Table 2-6 show the various consumption declines calculated from the Elbourne formula and its modified version, separated into the baseline and alternative models. The impulse responses from the alternative models in Appendix B are similar to their counterparts in the baseline models. This suggests there is a high chance to have similar trends between the results.

Table 2-6 Consumption declines in the sixth quarter in per cent

House size	Elbourne	Modified Elbourne
a) **Baseline model**		
All-size	9.8	6.3
Large-size	5.3	5.2
Medium-size	4.7	4.2
Small-size	3.7	4.0
b) **Alternative model**		
All-size	11.5	7.2
Large-size	5.6	5.4
Medium-size	5.1	4.4
Small-size	3.5	3.7

Notes. These percentages refer to effects in the sixth quarter from corresponding house segment. Additional detailed information about these calculations is available in the Table Appendix C2-1 to C2-4 under four r house segments.

These percentages of the consumption declines attributed to the combined effects of the house wealth and credit channel refer to the peak of interest rate effect on the consumption variable in the sixth quarter. These results are calculated using equation [2.4] and [2.6]. About nearly 9,8 per cent and 6,3 per cent of the consumption declines in the baseline model are attributed to the combined role of the housing wealth and a credit channel using the Elbourne approach and its modified version respectively.[23] A similar

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[23] The aim is show how the values are calculated using formulas defined in equation [2.7] and equation [2.9]. For example, the calculation for the all-size house price category using the Elbourne approach is 9,8 per cent = ((-0.18/-0,49) x0.27) x100. The modified Elbourne approach values of 6,3 per cent =((-0,18/-0,49)x(0,27/1.54))x100. These values have been rounded to the two decimal points. The detailed calculations of these values are available in tables in the Appendix. The tables in the appendix give only information of selected impulse responses used specifically in the calculations using both the Elbourne and Modified Elbourne versions. The impulse responses under the baseline line models and the alternative are exactly, from figures 3–6 and figures B1–B4 in

pattern, despite slightly increased magnitudes is visible from the alternative model leading to a similar conclusion as in the baseline model. A similar trend is visible using the modified version in both models. These findings further suggest that the house wealth (or stage 2) in the indirect channel shown in Figure 2-2 explains nearly one-tenth (or less) of the consumption declines in response to the interest rate increase. Perhaps this is due to the response of the house wealth to its own innovation, which does not appear either highly transitory or persistent.

The analysis further examines whether the preceding findings are influenced by aggregation in the all-size house segment, possibly overstating the consumption declines. Hence, the reason to use the three sub segments namely the small, medium and large segments. The results presented in Table 2-6 confirm that using the all-size house segment tends to overestimate the declines in consumption related to the combined effect of house wealth and credit channel following a positive interest rate shock. The findings suggest less than or nearly one-twentieth (one-half of a tenth) of the consumption declines is due to the indirect channel in Figure 2-2. These findings suggest that the substantial portions of the effects of the interest rate shocks on consumption are attributable to the effects operating through other channels and not the house wealth channel.

The analysis concludes by graphically examining the effect of house wealth in propagating consumption. This involves a comparison of consumption impulse responses from the baseline and counterfactual models amongst the four house segments. Figure 2-5 shows the consumption impulses for the baseline and the counterfactual models from four house segments in response to 0,5 per cent interest rate increase. The Baseline model shows the total effect of interest rate shocks on consumption, including those simulated by the endogenous responses of house wealth.

In contrast, the counterfactual models simulate the effects of the interest rate shock on consumption by shutting off the wealth effect to consumption as described in the

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the appendix for alternative model. The full impulse responses of counterfactual are not attached as they are similar to those in baseline and alternative model.

preceding section. All the consumption responses from the baseline models are close to those under the counterfactual models and are within the 16 and 84 percentile error bands of the former models. The insignificances of the small gaps between the impulse responses suggests a little role of house wealth in the propagation of the consumption declines after an interest rate increase amongst the four house segments.

These findings suggest that the substantial portions of the effects of the interest rate shocks on consumption are attributable to the effects operating through other channels and not the house wealth channel. The findings do not imply that the house wealth has no effect on the consumption variable, but that the endogenous changes in the house wealth driven by innovation in the interest rates have little marginal effects on consumption.[24] The insignificant gaps between the baseline and counterfactual models provide little support for the view that the wealth channel is the dominant source of the monetary policy transmission to consumption.

Perhaps this is linked to the transitory effect of the interest rate shock on real house, which significantly dies out in 5 quarters or 15 months, and interest rate shocks on its movements are highly transitory. According to Ludvigson et al. (2002), transitory changes in wealth would have little influence on consumer spending. When movements in the consumption occur only in response to the permanent changes in the asset values, the wealth channel of monetary policy transmission to consumption would probably be quite small (Ludvigson et al., 2002).[25]

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[24] In addition, the interest rate shock is highly transitory and significant for only five quarters in both the counterfactual and the baseline models.

[25] We also found that the response of wealth in relation to its innovation looks not entirely transitory (Appendix B 2). This means that it is a mixture of permanent shocks to which consumption may be responding, whereas the transitory shock has little influence on consumption spending. The impulse responses from the alternative model in Appendix B 2 lead to a similar conclusion, strengthening the credibility that these conclusions are robust to the restrictions imposed.

Figure 2-5 Baseline and counterfactual consumption impulses
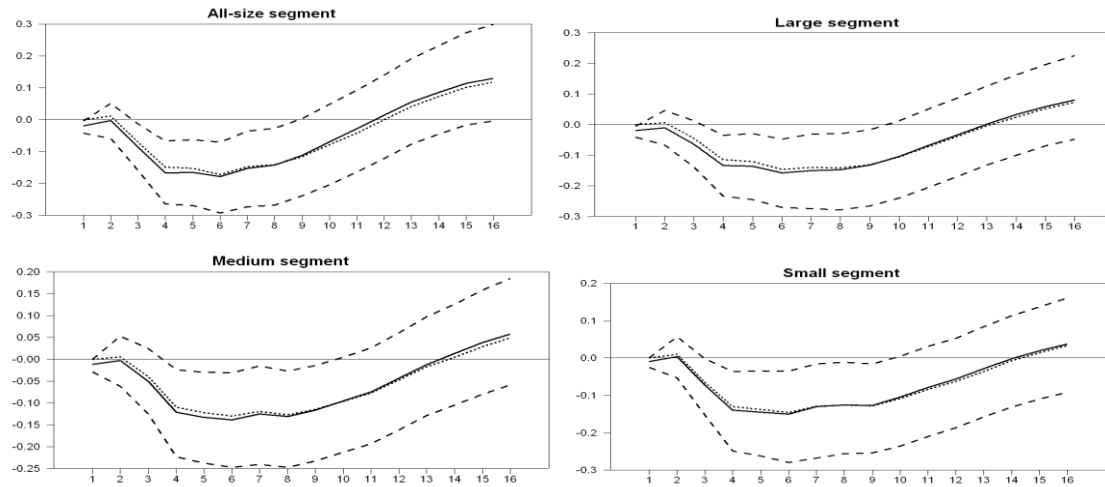
Notes. The solid line denotes the impulse response of consumption in response to interest rate shock under the baseline model whereas the dotted line refers to the impact under the counterfactual model. The vertical axis represents the percentage deviation from the underlying path. The bands represent the 16 and 84 percentile bands

The results in preceding sections can be explained by patterns in loans to value ratios shown in Figure 2-6 for five housing segments according to house prices between 2004 and 2009. [26]The loan to value ratio is one of many variables which explains why indirect housing segment channel was not important and why is the effect becoming weaker the smaller the housing segment. The smallest house segment with a price below R0,25 million is the affordable segment while largest segment costing above R3 million is the super wealthy segment. These house segments reflect the income groups in South Africa, with affordable segment for low-income groups and super luxury for high-income category.

The loan to value ratios exceeds 75 per cent amongst all income groups.[27] In addition, the loan to value ratios are higher in the affordable segment, which is the cheapest, and decline as house price increase to super luxury segment. This means interest rate charges and payments are relatively higher in lower income groups or affordable house segments than in higher income groups. The smaller house segments should be relatively more indebted and spend more money on servicing debt, with little income remaining for

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[26] Affordable has price less than R0.25 million, mid value price are R0.25-0.7million, high value price is R0.7-R1.5million,luxury price are R1.5-R3 million and super luxury prices are above R3 million.

[27] Second, the loan to value ratios rose between 2004 and 2008, in affordable segment (98,3-103 percent), mid value (95,9-98,5 per cent), high value (91,3-94 per cent), luxury (87,3-90,6 per cent) and super luxury (82,5-85,4 per cent).

33

consumption. Alternatively, these higher loan to value ratios mean the smaller house segments have little claim on equity which they can withdraw to spent on consumption and other purposes.

Figure 2-6 Loan to value ratios in per cent
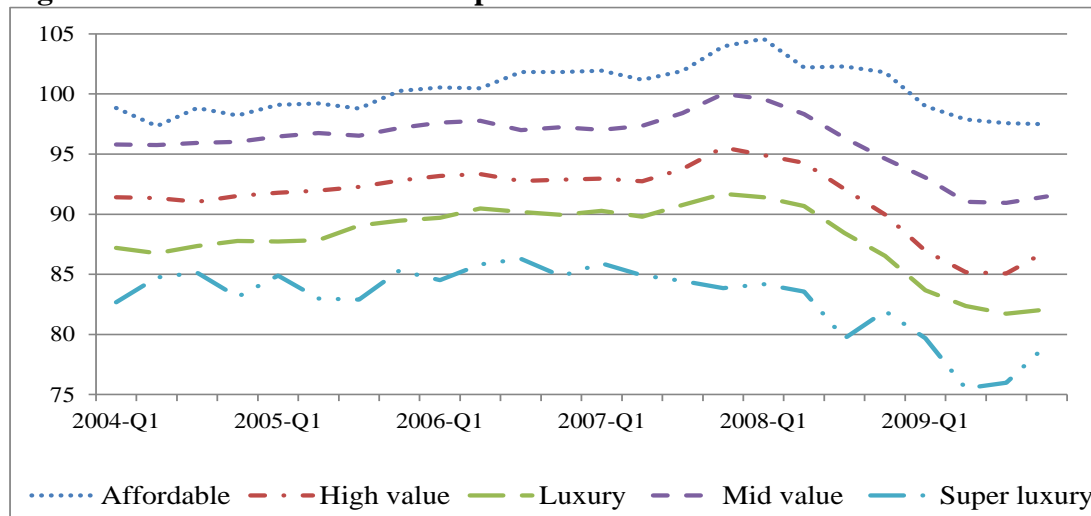
2.6 Conclusion

This analysis provides an assessment on the importance of the indirect channels through which monetary policy influences real variables by focusing on the transmission to consumption through house prices. The results at the peak of the interest rate effects on consumption suggest that the proportion of consumption declines as a result of the combined effect of house wealth and credit changes following monetary policy tightening is nearly one-tenth (or 9,8 per cent). The findings suggest less than or nearly one-twentieth (one-half of a tenth) of the consumption declines is due to the changes in the house wealth in the indirect channel using the small, medium and large segments respectively. While these results suggest heterogeneous interest rate effects operating through house wealth and the credit channel, they confirm that house wealth accounts for very little consumption declines. Moreover, the differences between the consumption impulse responses from the counterfactual and baseline scenarios provide little support that combined house wealth and credit effect channels are the dominant sources of

monetary policy transmission to consumption. These findings suggest that the direct effects of high interest rates on consumption appear to be more important in transmitting monetary policy changes to the economy than through the indirect effects. Hence, monetary policy tightening can marginally weaken inflationary pressures arising from excessive consumption operating through house wealth and the credit channel compared to the direct impact on consumption.

Appendix A 2 Deriving formulas

This section mainly highlights how to derive the Elbourne and its modified formulas and relies on the Vector moving averages (VMA) representation. I specifically focus on the consumption and house price equations.

First, I denote the vector $M_t = \begin{bmatrix} c_t \\ h_t \end{bmatrix}$ where c_t is the consumption and h_t is the real house price variables. The structural form equation can be written as

[A2.1] $BM_t = \psi_0 + \psi_1 M_{t-1} + \varepsilon_t$

were $B = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}$ $\qquad \psi_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}$ $\qquad \psi_1 = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$ $\qquad \varepsilon_t = \begin{bmatrix} \varepsilon_{ct} \\ \varepsilon_{ht} \end{bmatrix}$

Then normalizing [A2.1] by B to get the reduced form equation [A2.2]

[A2.2] $M_t = A_0 + A_1 M_{t-1} + e_t$

were $A_0 = B^{-1} \psi_0 = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix}$, $A_1 = B^{-1} \psi_1 = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$ and $e_t = B^{-1} \varepsilon_t = \begin{bmatrix} e_{ct} \\ e_{ht} \end{bmatrix}$

After some mathematical manipulation following the derivations in Enders (2004) which uses a bivariate equation expressed in VMA with reduced form error

[A2.3] $\qquad \begin{bmatrix} c_t \\ h_t \end{bmatrix} = \begin{bmatrix} \bar{c} \\ \bar{h} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{ct-i} \\ e_{ht-i} \end{bmatrix}$

35

Replacing reduced from error in [A2.3] by structural innovations leads to [A2.4]

[A2.4]
$$\begin{bmatrix} c_t \\ h_t \end{bmatrix} = \begin{bmatrix} \bar{c} \\ \bar{h} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{ct-i} \\ \varepsilon_{ht-i} \end{bmatrix}$$

The above form allows derivations of the impact multipliers in tracing the impact of a one-unit change in structural innovation. For example the impact effect of ε_{ht-i} on c_{t-i} and h_{t-i}

[A2.5]
$$\frac{dc_{t-i}}{d\varepsilon_{ht-i}} = \phi_{12}(i) \quad , \quad \frac{dh_{t-i}}{d\varepsilon_{ht-i}} = \phi_{22}(i)$$

Using the above impact multipliers, I trace the wealth effects of house price increases on consumption, and combined wealth effects and credits effects of interest on reducing consumption expenditure. I use a simplified consumption equation below. In equation [A2.6] consumption c_t depends upon real house prices h_t

[A2.6] $c_t = wh_t + u_t$ were w is house wealth coefficient and u_t is the error term. The wealth effect or effect of house price on consumption given by equation [A2.7]

[A2.7]
$$\frac{dc_t}{dh_t} = w$$

Mathematically, equation [A2.7] can be expressed in a form, which introduces the impact multiplier effects after adjusting for specific shocks effects which leaves equation [A2.7] mathematically unchanged. This mathematically correct transformation gives the numerator and denominator an economic meaning. Hence, I express the effects of house price increases on consumption in equation [A2.7] with the numerator representing the impact of house price shock on consumption and the denominator denoting the impact of house shock on house prices as in equation [A2.8]

[A2.8]
$$\frac{dc_t}{d\varepsilon_{ht}} \Bigg/ \frac{dh_t}{d\varepsilon_{ht}} = w$$

The $\dfrac{dc_t}{d\varepsilon_{ht}}$ and $\dfrac{dh_t}{d\varepsilon_{ht}}$ denote the impact of house price shocks on consumption and

house price respectively. Similarly, I can introduce the effects of interest rates, with

the $\dfrac{dc_t}{d\varepsilon_{rt}}$ and $\dfrac{dh_t}{d\varepsilon_{rt}}$ representing the interest rate effects on consumption and house price

respectively. I divide equation [A2.6] by consumption to quantify the separate

contributions from the combined wealth coefficient and house price terms (wh_t/c_t) from

those associated with the residual term (u_t/c_t). Subsequently using (wh_t/c_t), we can

express the proportion of declines in consumption, linked to combined house wealth and

credits effects associated with interest rates increases using equation [A2.9] to get the

modified Elbourne approach denoted by Q^m. I use this to trace the wealth and credits

effects arising from an interest rate increase.

[A2.9] $\quad Q^m = w \, dh_t \Big/ dc_t = w * \dfrac{\dfrac{dh_t}{d\varepsilon_{rt}}}{\dfrac{dc_t}{d\varepsilon_{rt}}}$

The preceding approach differs from Elbourne's (2008) approach denoted by Q in

equation [A2.10] which ignores the denominator in equation [A2.8].

[A2.10] $\qquad\qquad Q = \dfrac{dc_t}{d\varepsilon_{ht}} * \dfrac{\dfrac{dh_t}{d\varepsilon_{rt}}}{\dfrac{dc_t}{d\varepsilon_{rt}}}$

Appendix B 2 Impulse response under the Baseline model

Figure Appendix B 2-1 Impulse responses under Large house segment (Baseline model)
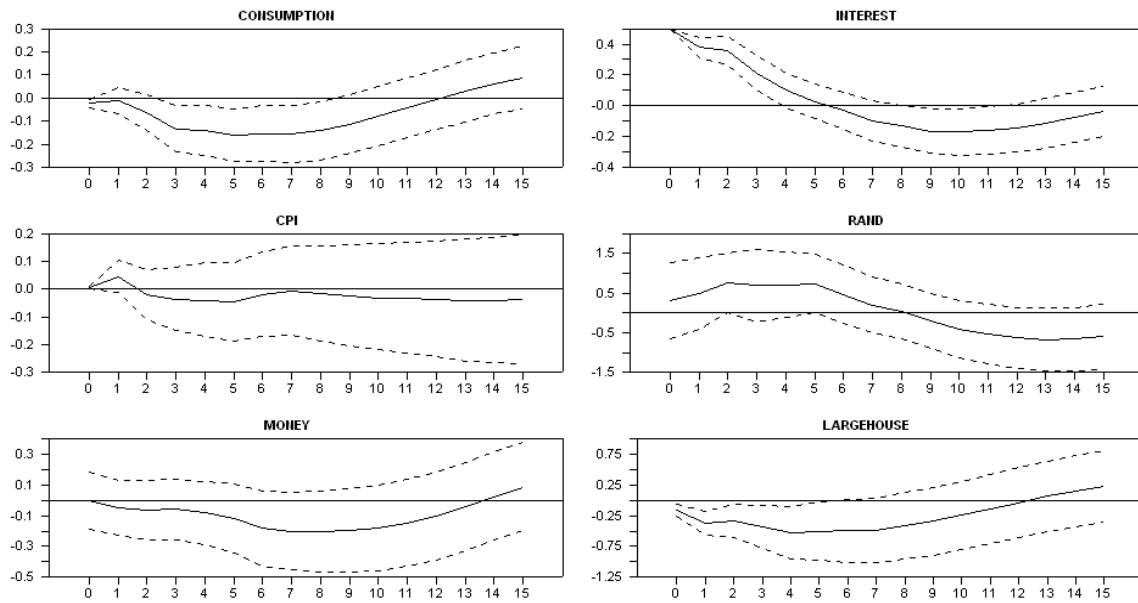
Responses to 0.5% Interest rate increase
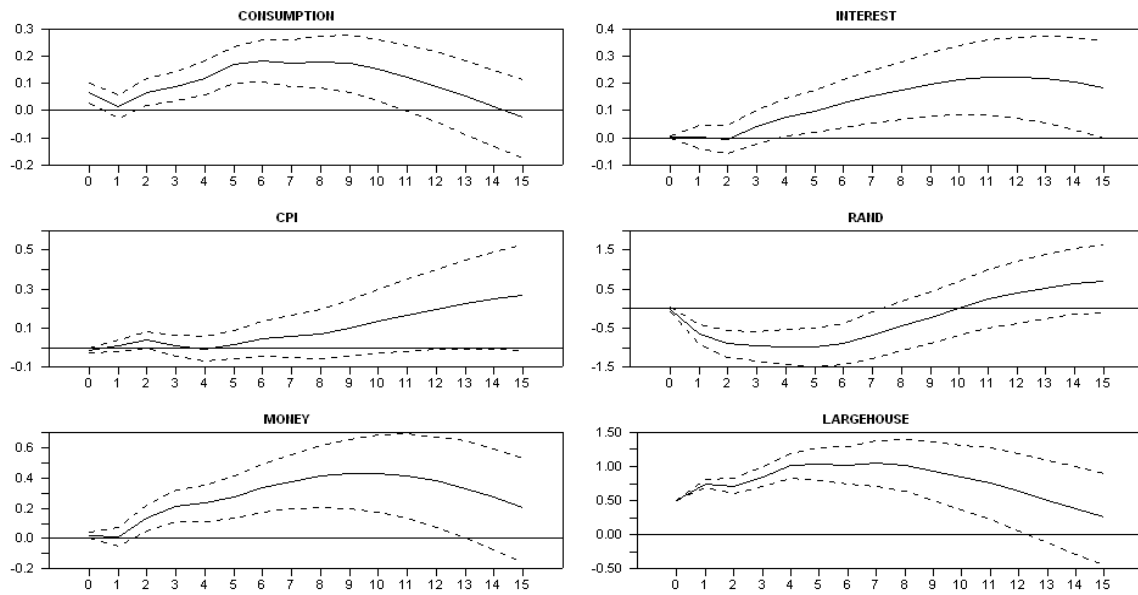
Responses to 0.5% Large size house price increase

Figure Appendix B 2-2 Impulses responses under Medium house segment (Baseline model)

CONSUMPTION

INTEREST

CPI

RAND

MONEY

MEDIUMHOUSEPRICE

Responses to 0.5% Interest rate increase

CONSUMPTION

INTEREST

CPI

RAND

MONEY

MEDIUMHOUSEPRICE

Responses to 0.5% medium house price increase

39

Figure Appendix B 2-3 Impulse responses under Small house segment (Baseline model)
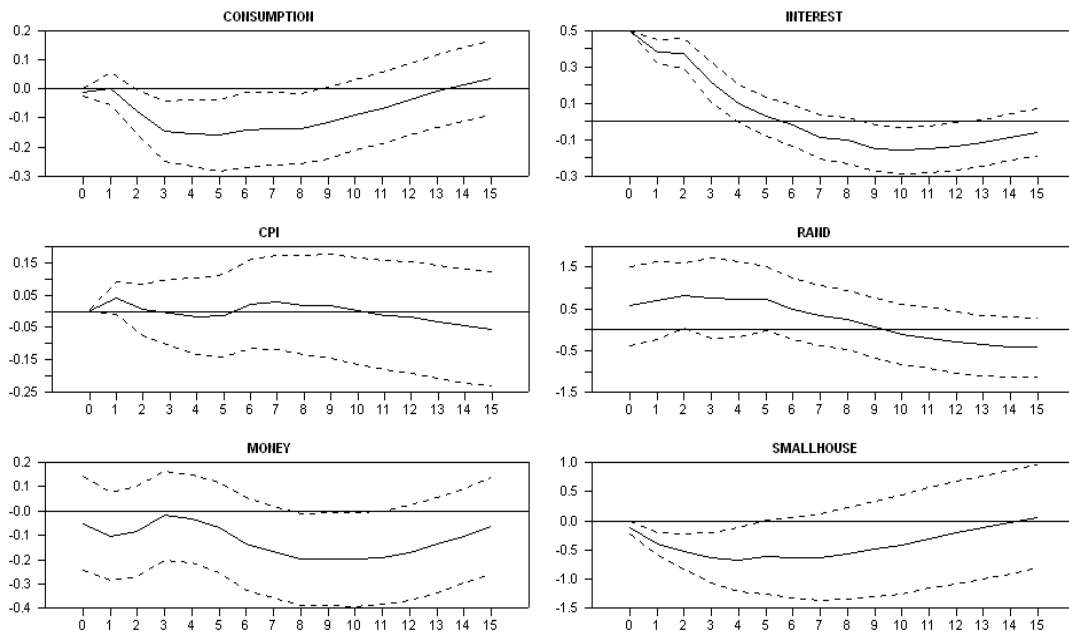
Responses to 0.5% Interest rate increase
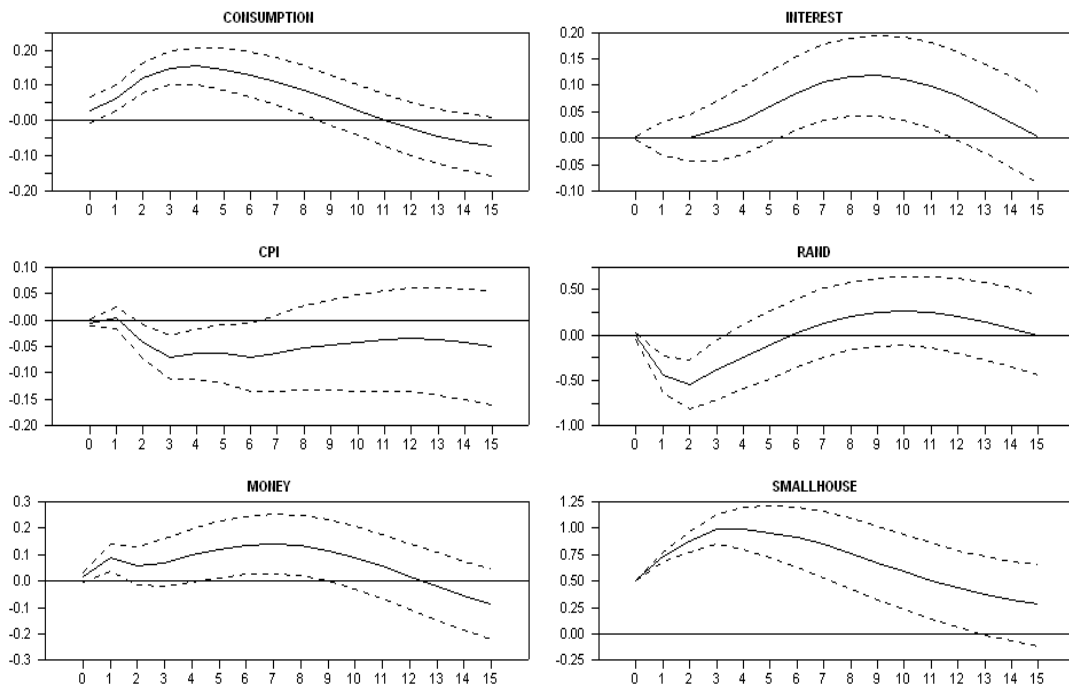
Responses to 0.5% Small size house price increase

Appendix C 2 Impulse response under the Alternative model

Figure Appendix C 2-1 Impulse responses under All-size house segment (Alternative model)
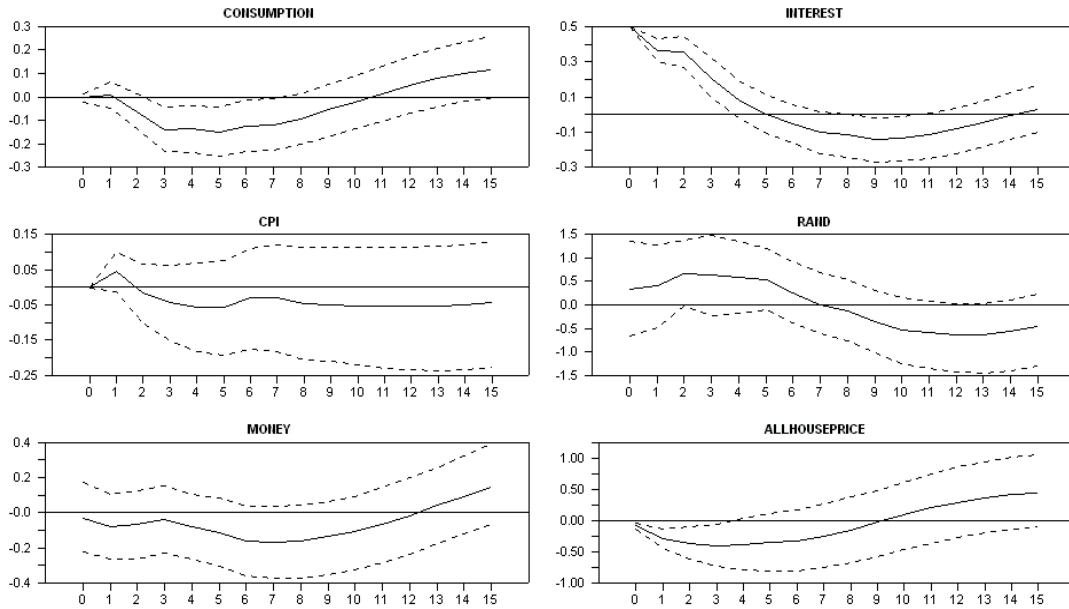
Responses to 0.5% Interest rate increase
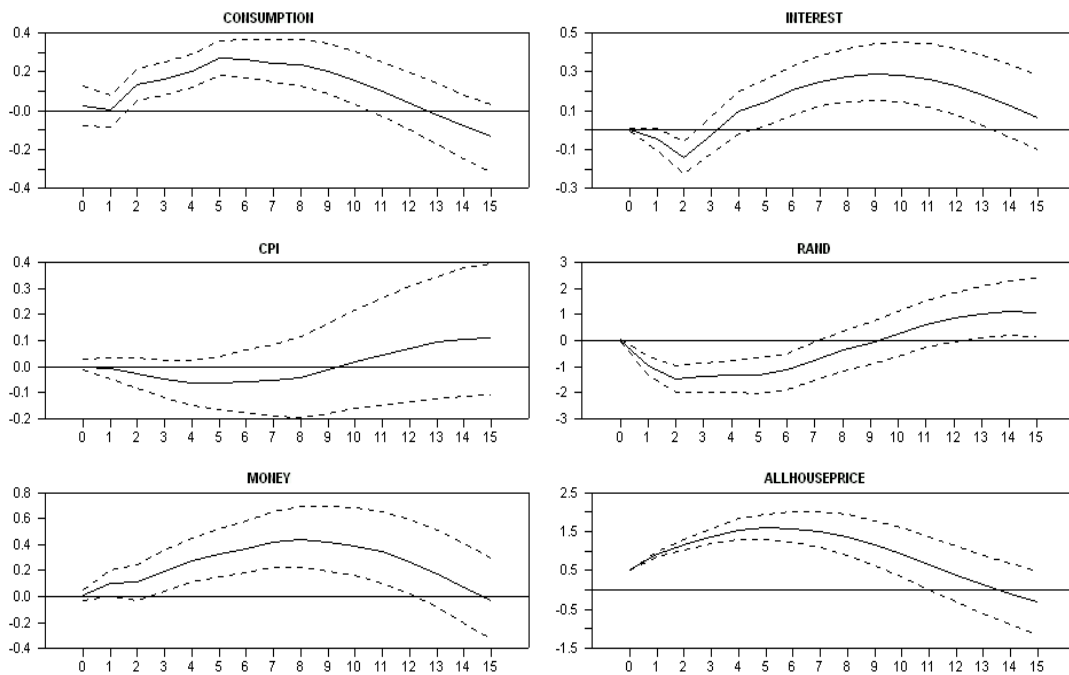
Responses to 0.5% Allsize house price increase

Figure Appendix C 2-2 Impulse responses under Large house segment (Alternative model)
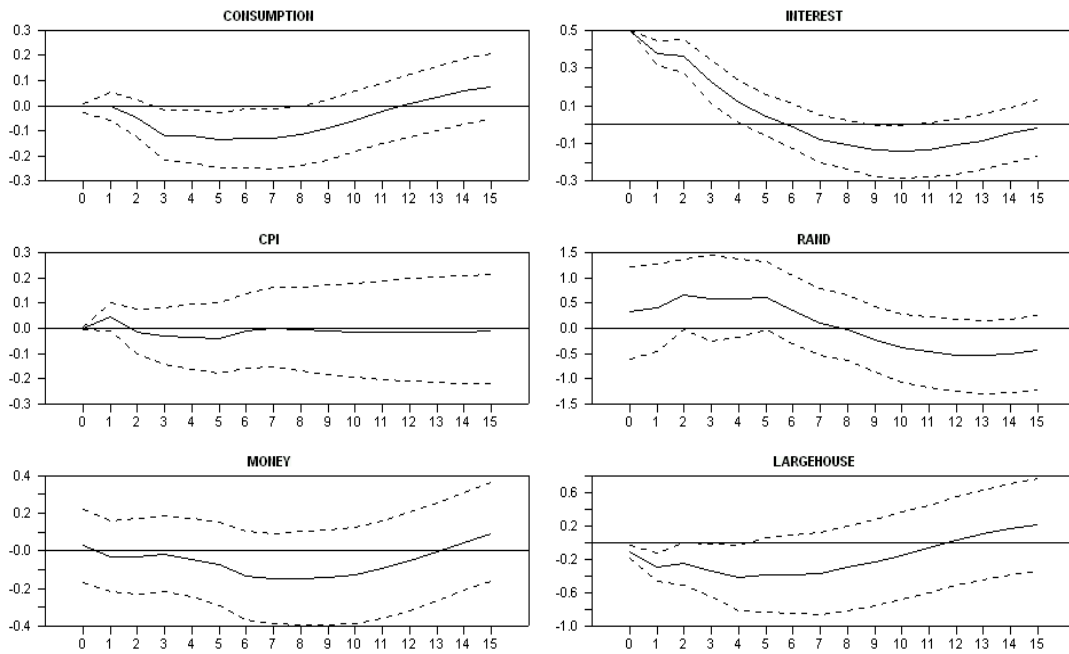
Responses to 0.5% Interest rate increase

Responses to 0.5% Large size house price increase

42
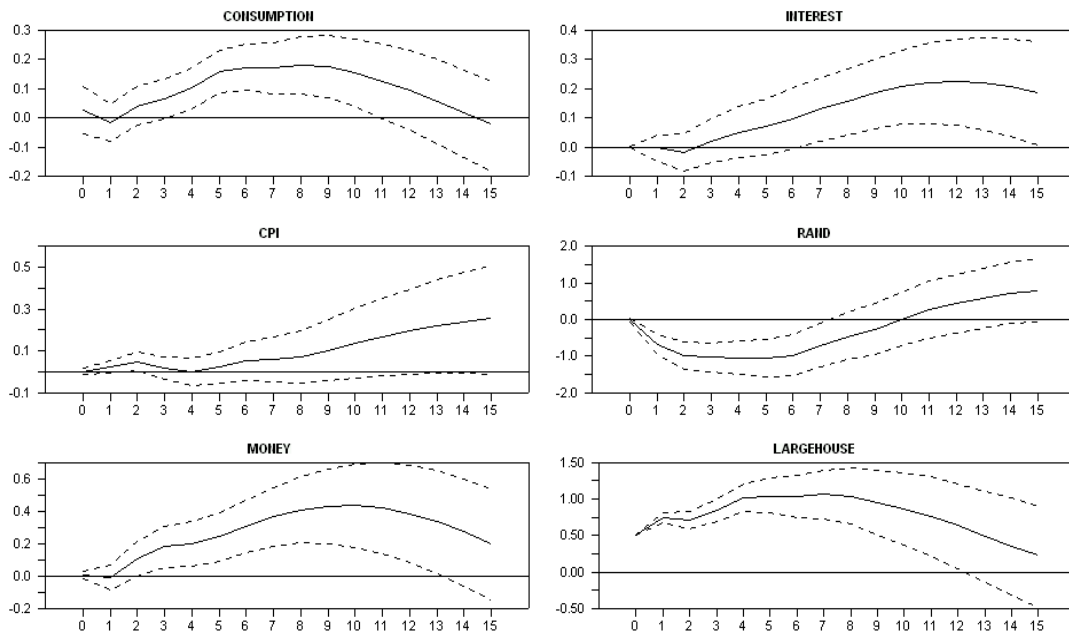
Figure Appendix C 2-3 Impulse responses under Medium house segment (Alternative model)
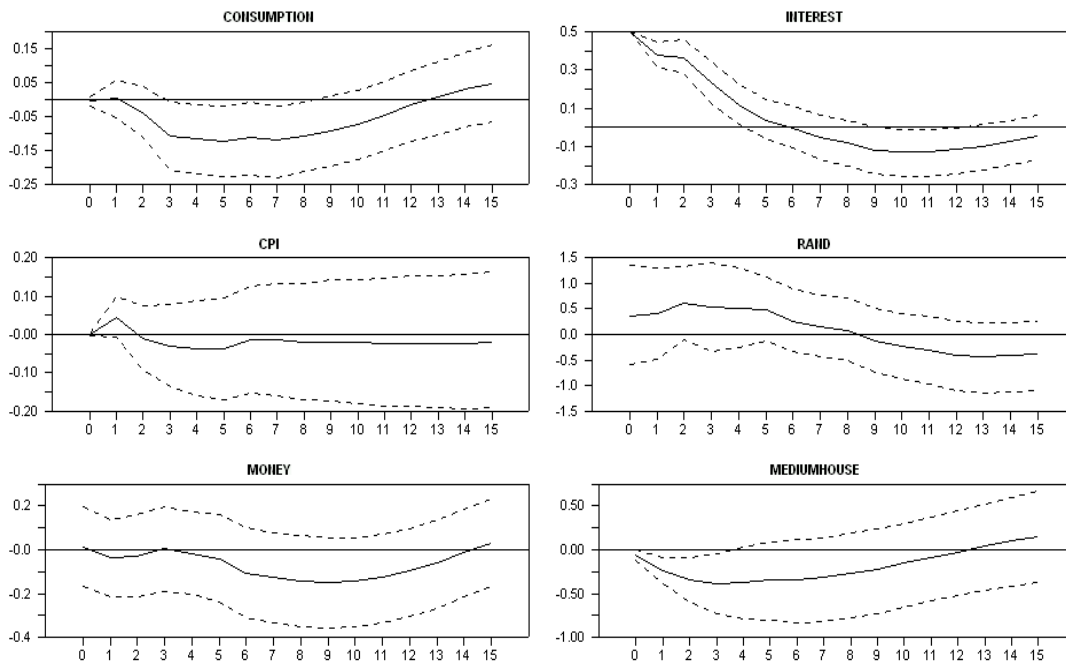
Responses to 0.5% Interest rate increase
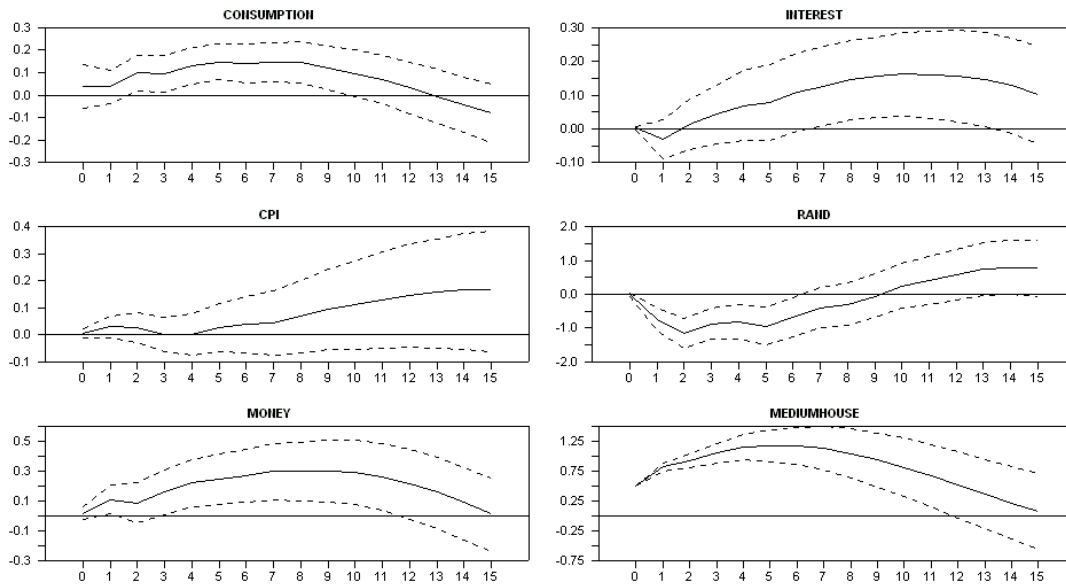
Responses to 0.5% medium house price increase

Figure Appendix C 2-4 Impulse responses under Small house segment (Alternative model)

Responses to 0.5% Interest rate increase

Responses to 0.5% Small size house price increase

44

Appendix D 2 **Consumption declines in percentage for all house segments**
Table Appendix D 2-1 Percentage consumption declines under All-size house segment

	a) Baseline model						Alternative model					
	$i \rightarrow c$	$i \rightarrow h$	$h \rightarrow c$	$h \rightarrow h$	Elbourne	Mod. Elbourne	$i \rightarrow c$	$i \rightarrow h$	$h \rightarrow c$	$h \rightarrow h$	Elbourne	Mod. Elbourne
1	-0.02	-0.14	0.08	0.50	1.1%	2.2%	0.00	-0.09	0.02	0.50	0.1%	0.1%
2	0.00	-0.38	0.04	0.91	0.0%	0.0%	0.01	-0.29	0.00	0.93	0.0%	0.0%
3	-0.09	-0.47	0.17	1.12	3.1%	2.7%	-0.06	-0.36	0.14	1.15	2.4%	2.1%
4	-0.17	-0.53	0.19	1.33	5.9%	4.4%	-0.14	-0.41	0.16	1.38	5.6%	4.1%
5	-0.16	-0.53	0.22	1.49	6.8%	4.6%	-0.14	-0.39	0.20	1.55	7.2%	4.6%
6	-0.18	-0.49	0.27	1.54	9.8%	6.3%	-0.15	-0.35	0.27	1.61	11.6%	7.2%
7	-0.15	-0.46	0.26	1.51	8.7%	5.8%	-0.12	-0.32	0.26	1.58	10.2%	6.5%
8	-0.14	-0.37	0.24	1.42	9.1%	6.4%	-0.12	-0.25	0.25	1.50	11.7%	7.8%
9	-0.11	-0.25	0.22	1.28	9.8%	7.7%	-0.09	-0.14	0.24	1.36	15.3%	11.2%
10	-0.07	-0.12	0.19	1.08	10.8%	10.0%	-0.05	-0.03	0.20	1.15	40.9%	35.6%
11	-0.03	0.03	0.14	0.85	-13.4%	-15.7%	-0.02	0.09	0.15	0.90	-3.7%	-4.1
12	0.01	0.16	0.09	0.61	0.8%	1.3%	0.02	0.20	0.10	0.64	0.8%	1.2%

NB. $i \rightarrow c$, $i \rightarrow h$ refers to impact of a 0.5% (50 basis points) interest rate i increase on consumption c and house price h. $h \rightarrow c$, $h \rightarrow h$ refers to impact of 0.5% house price h increase on consumption c and house price h. Mod. Elbourne refers to the modified Elbourne approach from equation [9] in the main text. The shaded parts represent the maximum impact of inte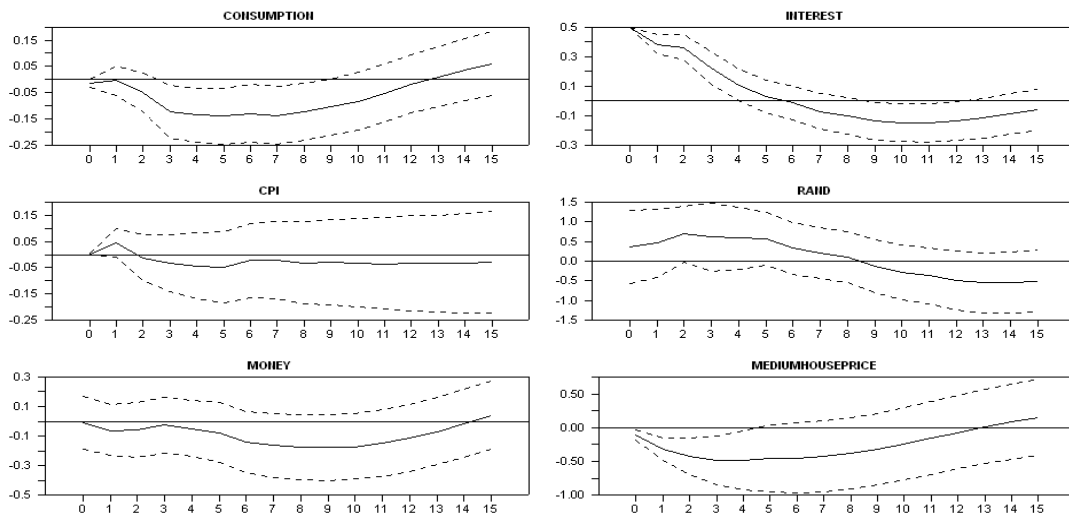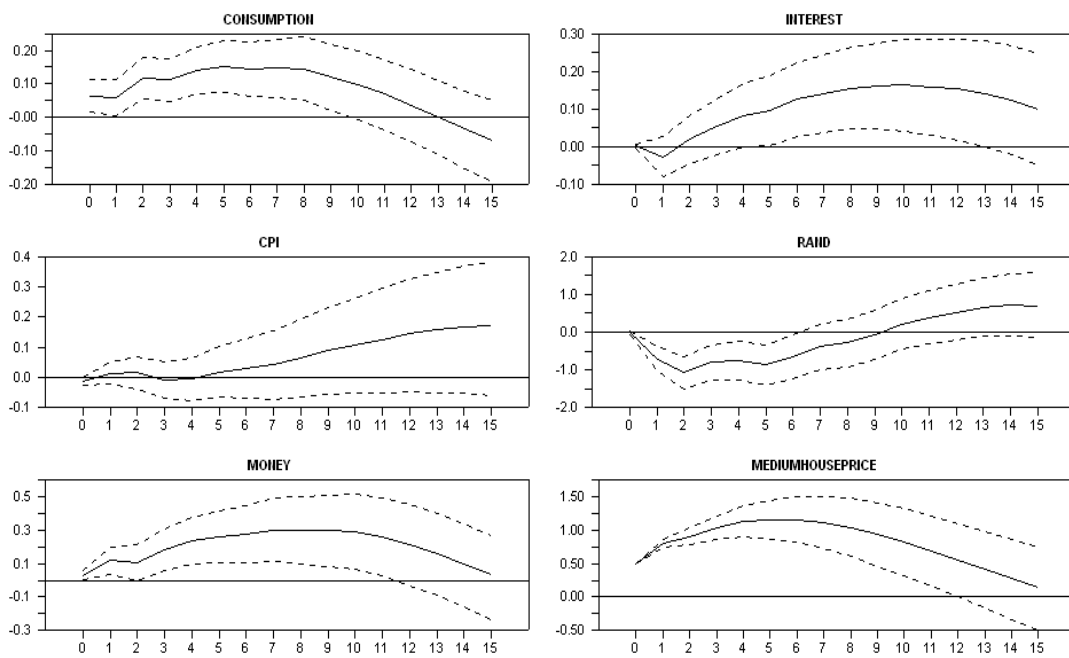rest rate increase on consumption. For example the percentage of consumption decline due to combined role of house-wealth and credit effects at this point baseline model using Elbourne formula is 9.8% i.e ((-0.18/-0.49)x0.27)x100; Using the modified Elbourne approach gives 6.3% i.e ((-0.18/-0.49)x(0.27/1.54))x100. Similarly all calculations are done the same way.

Table Appendix D 2-2 Percentage consumption declines under large house segment

	Baseline model						Alternative model					
	$i \rightarrow c$	$i \rightarrow h$	$h \rightarrow c$	$h \rightarrow h$	Elbourne	Mod. Elbourne	$i \rightarrow c$	$i \rightarrow h$	$h \rightarrow c$	$h \rightarrow h$	Elbourne	Mod. Elbourne
1	-0.02	-0.16	0.07	0.50	0.8%	1.5%	0.00	-0.12	0.03	0.50	0.1%	0.2%
2	-0.01	-0.38	0.01	0.75	0.0%	0.0%	0.00	-0.30	-0.01	0.75	0.0%	0.0%
3	-0.06	-0.33	0.07	0.71	1.3%	1.8%	-0.05	-0.25	0.04	0.71	0.9%	1.2%
4	-0.13	-0.43	0.09	0.84	2.7%	3.3%	-0.12	-0.33	0.07	0.84	2.3%	2.8%
5	-0.14	-0.52	0.12	1.00	3.1%	3.1%	-0.12	-0.42	0.10	1.00	2.9%	2.9%
6	-0.16	-0.49	0.16	1.01	5.3%	5.2%	-0.14	-0.38	0.15	1.02	5.6%	5.4%
7	-0.15	-0.47	0.18	0.99	5.6%	5.6%	-0.13	-0.38	0.17	1.01	5.8%	5.7%
8	-0.15	-0.46	0.17	1.00	5.3%	5.3%	-0.13	-0.36	0.16	1.03	5.9%	5.7%
9	-0.13	-0.39	0.17	0.96	5.7%	5.9%	-0.12	-0.29	0.17	1.00	6.8%	6.8%
10	-0.10	-0.30	0.16	0.86	5.5%	6.4%	-0.09	-0.22	0.16	0.90	6.8%	7.6%
11	-0.07	-0.22	0.13	0.76	4.2%	5.5%	-0.06	-0.14	0.14	0.80	5.6%	7.1%
12	-0.03	-0.11	0.10	0.66	3.0%	4.6%	-0.02	-0.05	0.11	0.69	5.0%	7.3%

NB. $i \rightarrow c$, $i \rightarrow h$ refers to impact of a 0.5% (50 basis points) interest rate i increase on consumption c and house price h. $h \rightarrow c$, $h \rightarrow h$ refers to impact of 0.5% house price h increase on consumption c and house price h. Mod. Elbourne refers to the modified Elbourne approach from equation [9] in the main text. The shaded parts represent the maximum impact of interest rate increase on consumption. For example the percentage of consumption decline due to combined role of house-wealth and credit effects at this point baseline model using Elbourne formula is 5.3% i.e ((-0.16/-0.49)x0.16)x100; Using the modified Elbourne approach gives 5.2% i.e ((-0.16/-0.49)x(0.16/1.01))x100. Similarly all calculations are done the same way.

Table Appendix D 2-3 Percentage consumption declines under Medium house segment

a)	Baseline model						Alternative model						
	$i \to c$	$i \to h$	$h \to c$	$h \to h$	Elbourne	Mod. Elbourne	$i \to c$	$i \to h$	$h \to c$	$h \to h$	Elbourne	Mod. Elbourne	
1	-0.01	-0.11	0.06	0.50	0.7%	1.3%	0.00	-0.06	0.03	0.50	0.1%	0.2%	0.0%
2	0.00	-0.31	0.06	0.80	0.0%	0.1%	0.00	-0.24	0.04	0.81	-0.1%	-0.1%	
3	-0.05	-0.43	0.12	0.90	1.3%	1.5%	-0.04	-0.35	0.10	0.92	1.1%	1.1%	
4	-0.12	-0.48	0.11	1.02	2.8%	2.7%	-0.11	-0.39	0.09	1.04	2.6%	2.5%	
5	-0.13	-0.47	0.14	1.11	3.9%	3.5%	-0.12	-0.37	0.13	1.14	4.0%	3.6%	
6	-0.14	-0.44	0.15	1.12	4.7%	4.2%	-0.12	-0.35	0.15	1.15	5.1%	4.4%	
7	-0.12	-0.44	0.14	1.10	4.0%	3.6%	-0.11	-0.35	0.14	1.15	4.3%	3.7%	
8	-0.13	-0.41	0.14	1.06	4.5%	4.3%	-0.12	-0.32	0.14	1.11	5.2%	4.7%	
9	-0.12	-0.36	0.14	0.97	4.4%	4.6%	-0.11	-0.28	0.14	1.01	5.4%	5.4%	
10	-0.09	-0.29	0.11	0.85	3.6%	4.2%	-0.09	-0.23	0.12	0.91	4.5%	5.0%	
11	-0.08	-0.21	0.09	0.74	3.1%	4.2%	-0.07	-0.15	0.09	0.78	4.1%	5.2%	
12	-0.04	-0.12	0.06	0.60	2.1%	3.4%	-0.04	-0.09	0.06	0.64	3.1%	4.8%	

NB. $i \to c$, $i \to h$ refers to impact of a 0.5% (50 basis points) interest rate i increase on consumption c and house price h. $h \to c$, $h \to h$ refers to impact of 0.5% house price h increase on consumption c and house price h. Mod. Elbourne refers to the modified Elbourne approach from equation [9] in the main text. The shaded parts represent the maximum impact of interest rate increase on consumption. For example the percentage of consumption decline due to combined role of house-wealth and credit effects at this point baseline model using Elbourne formula is 4.7% i.e ((-0.14/-0.44)x0.15)x100; Using the modified Elbourne approach gives 4.2% i.e ((-0.14/-0.44)x(0.15/1.12))x100. Similarly all calculations are done the same way.

Table Appendix D 2-4 Percentage consumption declines under Small house segment

a)	Baseline model						Alternative model					
	$i \to c$	$i \to h$	$h \to c$	$h \to h$	Elbourne	Mod. Elbourne	$i \to c$	$i \to h$	$h \to c$	$h \to h$	Elbourne	Mod. Elbourne
1	-0.01	-0.11	0.03	0.50	0.2%	0.5%	-8.77E-05	-0.07	-0.01	0.5	0.0%	0.0%
2	0.00	-0.38	0.06	0.73	-0.1%	-0.1%	0.01	-0.33	0.04	0.73	-0.1%	-0.2%
3	-0.07	-0.51	0.12	0.87	1.7%	2.0%	-0.06	-0.44	0.10	0.87	1.2%	1.4%
4	-0.14	-0.61	0.15	0.98	3.3%	3.4%	-0.12	-0.52	0.12	0.98	3.0%	3.0%
5	-0.15	-0.64	0.15	0.98	3.4%	3.5%	-0.13	-0.54	0.13	0.99	3.1%	3.1%
6	-0.15	-0.57	0.14	0.93	3.7%	4.0%	-0.14	-0.49	0.13	0.95	3.5%	3.7%
7	-0.13	-0.58	0.12	0.88	2.8%	3.2%	-0.12	-0.49	0.11	0.91	2.9%	3.2%
8	-0.13	-0.57	0.10	0.80	2.3%	2.8%	-0.12	-0.48	0.10	0.83	2.4%	2.9%
9	-0.13	-0.50	0.08	0.71	2.0%	2.8%	-0.12	-0.41	0.07	0.74	2.1%	2.9%
10	-0.10	-0.42	0.05	0.61	1.2%	2.0%	-0.10	-0.33	0.05	0.65	1.4%	2.2%
11	-0.08	-0.34	0.02	0.52	0.5%	1.0%	-0.08	-0.26	0.02	0.56	0.6%	1.1%
12	-0.06	-0.23	0.00	0.43	-0.1%	-0.2%	-0.06	-0.16	0.00	0.47	-0.1%	-0.2%

NB. $i \to c$, $i \to h$ refers to impact of a 0.5% (50 basis points) interest rate i increase on consumption c and house price h. $h \to c$, $h \to h$ refers to impact of 0.5% house price h increase on consumption c and house price h. Mod. Elbourne refers to the modified Elbourne approach from equation [9] in the main text. The shaded parts represent the maximum impact of interest rate increase on consumption. For example the percentage of consumption decline due to combined role of house-wealth and credit effects at this point Baseline model using Elbourne formula is 3.7% i.e ((-0.15/-0.57)x0.14)x100; Using the modified Elbourne approach gives 4.0% i.e ((-0.15/-0.57)x(0.14/0.93))x100.   Similarly   all   calculations   are   done   the   same   way

CHAPTER 3 : INFLATION TARGETING, EXCHANGE RATE SHOCKS AND OUTPUT

3.1 Introduction

South African monetary policy authorities have in several occasions managed to bring the inflation rate within the target band of 3-6 per cent after adopting inflation-targeting framework in February 2000. After a decade, in February 2010, the Minister of Finance clarified the mandate of the South African Central bank and emphasized the need for monetary policy authorities to take a balanced approach that privileges economic growth when setting interest rates. Economic growth in these periods was not significant enough to reduce unemployment rate and the market forces determined the exchange rate.

This chapter investigates the responses of output and real interest rate to exchange rate and inflation shocks using a Bayesian sign restriction VAR under weak assumptions of strict and flexible inflation targeting approaches. The questions are posed as follows: To what extent, do the exchange rate, and inflation shocks affect real interest rate and output growth performance in South Africa, assuming strict and flexible inflation targeting approaches? This investigation controls for the high foreign reserves accumulation and high oil price inflation using Bayesian VAR sign restriction approach. The chapter defines the real interest rate as the difference between nominal interest rate and expected inflation rate. The literature often defines the expected inflation as forecasted inflation rate. While this may sound to be trivial questions, the real interest, captures the behavior of monetary authorities and I argue it would show those periods when Taylor principle holds if policy makers increase nominal rates by a bigger magnitude immediately or when monetary authorities may smooth interest rate over time or Fisher effect.[28]

Inflation targeting is either strict or flexible, depending on the perceived loss function of the central bank. Under strict inflation targeting, the central bank is only concerned about keeping inflation close to an inflation target over the shorter horizon (Svensson, 1997b). This requires very vigorous activist policies, which involve dramatic interest and exchange rate

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[28] In addition, the real interest rate shows the periods when the differences are statistical significantly big, where differences are not statistically significant, when nominal interest rate increased by more than expected inflation rate and when the fisher effect appears. It might sound obvious that in small open economies the exchange rate plays a significant role in inflation dynamics thereby affecting the Phillips curve the exchange rate shocks will affect the real interest. However, the extent to which real interest rate responds to exchange rate shocks is not known. In addition, Aizenman et al. (2009) argues that real exchange is not robust predictor of future inflation in emerging markets.

changes. This happens with considerable variability of the exchange rates, interest rates, output, employment and domestic component of inflation. To some extent, the activism probably stabilizes inflation around the inflation target. Flexible inflation targeting occurs when the central bank gives some weight to the stability of interest rates, exchange rates, output and employment to bring inflation to the desired long run target over the longer horizon. It requires less policy activism, which gradually returns the inflation back to the target over a longer horizon. Flexible inflation targeting successfully limited not only the variability of inflation but also the variability of the output gap and the real exchange rate (Svensson, 1997b). Immediately after adopting inflation-targeting approach, applying a stricter approach clearly demonstrates the commitment to the inflation target, builds credibility more quickly, and is more appropriate at the initial phase of disinflation. However, after the central bank has demonstrated commitment and established credibility to a reasonable degree, there may be more scope for flexibility without endangering credibility.

The investigation of whether central banks follow pure inflation targeting or mixed approach has received wide coverage recently. A few empirical studies reviewing whether central banks practice flexible inflation targeting used standard Taylor rules augmented with exchange rate. Aghion et al. (2009) tested whether emerging markets follow the pure inflation targeting rules or try to stabilize real exchange rates. Their findings indicated that inflation targeting emerging markets practiced a mixed inflation targeting strategy. Inflation targeting central banks responded to both the inflation and real exchange rates when setting the interest rates. In addition, Aizenman et al. (2008) found the strongest response to the real exchange rate in countries following the inflation targeting policies, and these countries were relatively intensive in exporting basic commodities. The literature applied the Taylor rule to examine whether central banks practice pure and mixed inflation targeting approaches using the output gap, inflation gap and exchange rate gap as explanatory variables.

This chapter is motivated by five reasons based on institutional mandates and literature findings. First, the analysis is motivated by institutional changes in South African Reserve Bank where the oversold forward book was expunged in the inflation-targeting era. However, after 2010 the South African Reserve bank started an overbought forward book when the currency appreciated more than anticipated. During this period the executives alluded that exchange rate interventions was being less effective. This initiative shows the bank considers the importance of exchange rate movements.

Second, this analysis is motivated by Aghion et al. (2009)`s argument that pure inflation targeting is appropriate for underdeveloped economies. They argue that high exchange rate volatility reduces productivity but the impact is less severe for economies with relatively well-developed financial sectors. This argument means that exchange rate appreciation or volatility should constitute a big constraint for growth orientated programmes suggesting pure inflation targeting (fixed exchange rate) maybe appropriate for South Africa. Financial deepening has increased in South Africa with the share of private credit to GDP rising from 35 per cent in 1980Q1 to 80 per cent in 2008Q1. These numbers show that South African financial sector is relatively developed according to emerging market standards, hence the analysis would tell whether pure or flexible IT approach is good for the country. In addition, the South African`s private credit to GDP share is comparable to numbers reported for Chile.[29] According to Aghion et al. (2009), such drastic changes in financial depth decrease the negative impact of exchange rate volatility on Chilean growth by a factor of five.

Third, the study contributes to discussions that inflation targeters specializing in commodity exports tend to adopt a flexible inflation targeting or mixed approach regime by allowing interest rate to respond to real exchange rate fluctuations. Nonetheless, South Africa is a mineral exporting country. Aizenman et al. (2008) argues that commodity exporting countries impacted by real exchange rate shocks showed that a modified version of inflation targeting dominated the pure inflation targeting strategy. Evidence concluded that inflation targeting emerging markets do not follow pure inflation targeting strategies. In mixed inflation targeting practices, external variables play an important role in the central bank's policy rule as monetary authorities systematically respond to real exchange rate. They found that Inflation targeting groups with a high concentration in commodity exports change real interest rate much more proactively to real exchange rate changes than non-commodity exporting countries. Hence, the study articulates this issue in the case of South Africa by analyzing the impact of the behaviour of South African Reserve Bank to mining output in a flexible inflation targeting approach.

Fourth, the analysis is motivated by developments in 2010, which include high oil price and the South African Reserve Bank`s indication to increase reserves accumulation. During this

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[29] Chile`s financial depth ranged from 10 per cent in 1975 to 70 per cent in 2000.

period, the Minister of Finance suggested that monetary authorities should take a balanced approach that privileges the economic growth when setting interest rates. Finally, the analysis fills the gap in the literature on emerging markets such as South Africa, by using a Bayesian VAR sign restriction method to search the type of monetary policy for the central bank to support significant economic growth. In addition, the investigation shows that strict inflation-targeting approach has different output growth implications compared to the path under the flexible inflation-targeting framework.

Section 3.2 reviews the literature evidence showing that other variables including the inflation rate matter for the central banks. Section 3.3 focuses on methodological issues including derivations of a theoretical model and describes the sign restriction approach. Section 3.4 presents the data. Sections 3.5 gives the results from pure sign restriction approach, and summarizes the robustness of findings. Section 3.6 gives the conclusion and additional graphs in the four Appendices.

3.2   Literature review

Certain studies found that variables other than the inflation rate are important for the policy makers, especially in the commodity exporting nations including the inflation targeting countries. Strict inflation targeting suggests that the only concern of the central bank is to stabilize the inflation rate. Flexible inflation targeting happens when the central bank gives some weight to the stability of interest rates, exchange rates, output and employment (Svennson, 1997b).[30] Aghion et al. (2009) showed that exchange rate volatility reduces productivity in developing countries, attributing it to the financial channels. In addition, the evidence confirmed that adverse effects of exchange rate volatility were larger for the less financially developed countries, and significant for all the emerging markets and developing countries.

Cecchetti and Ehrmann (2000) compared the central bank behaviours in twenty-three industrialized and developing economies including nine that explicitly target inflation. The findings showed that inflation targeters exhibited increasing aversion to the inflation variability and decreasing aversion to the output variability. Moreover, the inflation targeting countries were able to reduce inflation volatility at the expense of an increase in output variability. The findings by Aghion et al. (2009) indicated that inflation targeting emerging

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[30] In addition, the inflation forecast equals the inflation target at a longer horizon.

markets practiced a mixed inflation targeting strategy. Inflation targeting central banks responded to both the inflation rate and real exchange rates when setting the policy rates. In addition, the findings revealed the strongest response to the real exchange rate in countries following inflation targeting policies, which are relatively intensive in exporting basic commodities.

Pavasuthipaisit (2010) developed a DSGE model that also concludes that inflation targeting regimes should respond to the exchange rate shocks under certain conditions that the study outlines. Findings from the tests showed that the policy rule adopted by the inflation targeting commodity-intensive developing countries differed from that of the inflation targeting non-commodity exporter. These findings give support to the greater sensitivity of commodity inflation-targeting countries to exchange rate changes.

A few studies estimated explicitly the Taylor rule equations for individual countries. Aizenman et al. (2008) suggest that emerging markets that adopted inflation targeting were not following pure inflation targeting strategies. They found evidence showing that external variables played a very important role in the central bank's policy reaction functions including the real exchange rate. In addition, inflation targeters with high concentration in commodity exports, change interest rate in a proactive manner in response to real exchange rate than non-commodity intensive group. Corbo et al. (2001) found mixed evidence from seventeen OECD countries estimated individually. Results showed that inflation targeters exhibited the largest inflation coefficients compared to those of the output gap. Lubik and Schorfheide (2007) estimated Taylor type rules in which authorities reacted to output, inflation and exchange rates. The findings reveal mixed responses indicating the Australian and New Zealand central banks changed interest rates in response to exchange rate movements. In contrast, the Canadian central bank did not respond to exchange rates.

De Mello and Moccero (2010) estimated interest rate policy rules for Brazil, Chile, Colombia and Mexico under the inflation-targeting and floating exchange rates in 1999. They formed the interest rate policy rule in the context of the new Keynesian structural model with inflation, output and interest rate variables. Findings suggest a stronger and persistent response to expected inflation in Brazil and Chile in the post 1999 inflation-targeting period. In Colombia and Mexico, monetary policy has become less counter-cyclical. Minella et al. (2003) estimated a reaction function for the central bank of Brazil, and showed that the coefficient on output gap is not statistically significant in most of the specifications.

After deriving the inflation equation in context of an open economy in the next section, the analysis will proceed to estimating the entire structural model using a VAR sign restriction approach.

3.3 Methodology

3.3.1 Theoretical model

This chapter extends the small open economy model in Granville and Mallick (2010) to incorporate the net changes in net trade balance and capital flows. The monetary sector requires at equilibrium changes in money supply (ΔMS_t) to equal changes in money demand (ΔMD_t). The changes in money supply (ΔMS_t) are decomposed into changes in international reserves (ΔIR_t) and domestic assets (ΔDA_t) shown in equation [3.1]

[3.1] $$\Delta MS_t = \Delta IR_t + \Delta DA_t$$

In addition, changes in the international reserves are separated into changes in net exports (ΔNX_t) and capital account (ΔK_t). However, the capital account depends on the difference between domestic interest rate, foreign interest rate, and expected exchange rate changes given by equation [3.2].

[3.2] $$\Delta IR_t = \Delta NX + \Delta K_t$$

Positive changes in trade balance and capital account suggest that the Central Bank is accumulating more international reserves. However, the net effect on reserves accumulation is unclear since currency appreciation lowers exports and make it cheap to the purchase foreign currency *ceteris paribus*. The changes in money demand (ΔMD_t) in equation [3.3] depends on the changes in level of real output (Δy_t), exchange rate (Δe_t) and real interest rate (r_t).

[3.3] $$\Delta MD_t = \alpha \Delta y_t - \gamma r_t - \eta \Delta e_t + v_t \quad \text{and} \quad \alpha, \gamma, \eta > 0$$

[3.4] $$r_t = i_t - \pi_t^e$$

The real interest rate equation [3.4] is the difference between the nominal interest rate (i_t) and expected inflation (π_t^e). Assuming equilibrium in the money market ($\Delta MD_t = \Delta MS_t$) holds continuously, we can write the capital flow reaction given by equation [3.5].

[3.5] $$\Delta DA_t = \alpha \Delta y_t - \gamma r_t - \eta \Delta e_t - \Delta IR_t + \nu_t$$

The open economy Phillips curve suggests the aggregate inflation (π_t) equation [3.5] depends on changes in output, exchange rate, domestic assets, and oil price inflation (π_t^0) expressed in domestic currency.

[3.6] $$\pi_t = \psi \Delta y_t + \kappa \Delta e_t + \lambda \Delta DA_t + \rho \pi_t^0 + \mu_t$$

Therefore substituting equation [3.5] into equation [3.6] gives

[3.7] $$\pi_t = (\psi + \lambda \alpha)\Delta y_t - \gamma \lambda r_t + (\kappa - \lambda \eta)\Delta e_t - \lambda \Delta IR_t + \rho \pi_t^0 + (\lambda \nu_t + \mu_t)$$

Substituting equation [3.2] into equation [3.7] to include changes in net trade and capital account in the inflation equation [3.8]

[3.8] $$\pi_t = (\psi + \lambda \alpha)\Delta y_t - \gamma \lambda r_t + (\kappa - \lambda \eta)\Delta e_t - \lambda(\Delta NX_t + \Delta K_t) + \rho \pi_t^0 + (\lambda \nu_t + \mu_t)$$

The monetary authorities` reaction equation [3.9] is the standard open economy Taylor rule linking nominal interest rate to inflation, exchange rates, and output.

[3.9] $$r_t = \pi_t + \delta \Delta y_t + \phi(\pi_t - \pi^*) + \beta \Delta e_t$$

Taking inflation rate to the right hand side leads to equation [3.10]. The reaction function suggests that real interest rate is increasing in the excess of the inflation rate over the inflation target, in current output gap and exchange rate depreciation.

[3.10] $$r_t = \delta \Delta y_t + \phi(\pi_t - \pi^*) + \beta \Delta e_t$$

This chapter assesses questions, which are different from those explored in Svensson and Rudebusch (1998) approach. These authors derived optimal monetary policy rules for inflation targeting framework. The approach in this chapter is very different in three ways. First, it relies on weaker prior beliefs or understanding of the economy given that no central bank in reality follows the loss function specified in theoretical literature. Second, the importance of variables in loss function are time varying. In order to capture South African economic concerns prevailing in 2010, the chapter applies the Bayesian approach that captures real time monetary authorities emphasis on important variables, *ceteris paribus*.

Third, the selection of variables is motivated by variables in equation [3.7], [3.8] , [3.9] and [3.10].

3.3.2 Econometric model

The estimation focuses on the inflation shocks and three exchange rate depreciation shocks in South Africa in the framework of Bayesian sign restriction VAR, which are estimated separately. The sign identification starts with the estimation of a reduced-form VAR equation [3.11].[31]

[3.11] $Y_t = BY_{t-1} + u_t$

where Y_t is an $n \times 1$ vector of data series at date $t = 1,2,....,T$ where B=[B$_1$, B$_2$, ...B$_p$] is the vector of matrix of lagged coefficients and u_t is the one-step ahead prediction error and the variance-covariance matrix is Σ. Assuming independence of fundamental innovations, I need to find matrix A which satisfies $u_t = A\varepsilon_t$. The jth column of A, that is α_j represents the immediate impact on the variables of the jth fundamental shock equivalent to one standard deviation in size on the n-endogenous variables in the system. Hence the variance–covariance is given by $\Sigma = E(u_t u_t') = AE(\varepsilon_t \varepsilon_t')A' = AA'$. To identify A, we need at least *n(n-1)/2* restrictions on A. The reduced form disturbance are orthogonalised by Cholseky decomposition, which uses recursive structure on A making it lower triangular matrix.

The Bayesian sign restriction approach (see Uhlig, 2005; Mountford and Uhlig, 2009; Fratzscher et al., 2010)) identifies the VAR model through imposing sign restrictions on the impulse responses of a set of variables. The shocks are estimated separately and then in pairs between inflation and various exchange rate shocks. The identification here searches over the space of possible impulse vectors $A_i \varepsilon^i$ to find those impulse responses, which agrees with the sign restrictions. The aim is to find impulse vector a where $a \in R^n$, given that there is an *n*-dimensional vector q of unit length so that $a = \tilde{A}q$ where $\tilde{A}\tilde{A}' = \Sigma$ and $\tilde{A}$ is a lower triangular Cholesky factor of Σ.

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[31] For simplicity we omitted the intercept term and dummies.

These results are presented in two separate sections. The first part of Section 3.5 reports results of individually identified fundamental shocks. I show that the impulse responses for n-variables up to horizon S can be calculated for a given impulse vector a_j, after estimating coefficients in B using the ordinary least squares. The impulse response functions are given by equation [3.12] as done in Fratzscher et al. (2010).

[3.12] $r_s = [1 - B]^{-1} a_j$

The r_s denotes the matrix of impulse responses at horizon S. The sign restrictions are imposed on a subset of the n-variables over horizon $0, 1, \ldots, S$ such that the impulse vector a_j identifies the particular shock of interest. The impulse responses are estimated by simulation. Given the estimated reduced form VAR, we draw q vectors from the uniform distribution in R^n divide it by its length to obtain a candidate draw for a_j and calculate its impulse responses while discarding any q where the sign restrictions are violated. The estimation and inferences are done as explained below. In the sign restriction approach a prior is formed for the reduced form VAR model. Using the Normal-Wishart in (B, Σ) as the prior implies the posterior is the Normal-Wishart for (B, Σ) times the indicator function on $\tilde{A}q$. The indicator function separate draws, which satisfies the sign restriction from those which fail to do so. A joint draw from the posterior of the Normal-Wishart for (B, Σ) and draws from the unit sphere are drawn from posterior distribution to get a candidate q vectors. I use the draws from the posterior to calculate the Cholskey decomposition as an important computational tool rather than shocks identification tool. From each q draw I compute the associated a_j vectors and impulses responses and these impulses are subject to further selection. For those impulse responses that satisfy the sign restrictions, the joint draws on (B, Σ, a) are stored otherwise they are discarded. Then error bands are calculated from draws kept from 10 000 draws, which satisfy the sign restrictions. Hence, this first part focuses on estimation of one shock.

The second, part of Section 3.5 reports the impulse responses of two identified fundamental shocks, that is, $k = 2$. This is an extension of the above approach to include two shocks. As such, I characterize the impulse matrix $[a^{(1)}, a^{(2)}]$ as of rank 2 rather than all of A in robustness test. Restrictions imposed are based on economic prior's expectations on the impulse responses together with restrictions that ensure orthogonality of the fundamental

shocks. By construction, the covariance between fundamental shocks $\varepsilon^{(1)}{}_t, \varepsilon^{(2)}{}_t$ corresponding to $a^{(1)}, a^{(2)}$ is zero meaning that these fundamental shocks are orthogonal.

Hence any impulse matrix $[a^{(1)}...a^{(k)}]$ can be written as product $[a^{(1)}...a^{(k)}]q = \tilde{A}Q$ of the lower triangular Cholesky factor $\tilde{A}$ of Σ with k x n matrix $Q = [q^{(1)}...q^{(k)}]$ of orthonormal rows $q^{(j)}$ such that $QQ' = I_k$. This is a consequence of noting that $\tilde{A}^{-1}\tilde{A}$ must be an orthonormal matrix for any decomposition $\tilde{A}\tilde{A}' = \Sigma$ of Σ. Denoting $a = a^{(s)}$ where $s \in \{1,2,....n\}$ represents a column of the impulse matrix. I also denote $q = q^{(s)} = \tilde{A}^{-1}q^{(s)}$ as the corresponding column of Q. Therefore, the impulse responses for the impulse vector a can be written as a linear combination of the impulse responses to the Cholesky decomposition of Σ in a way described below. Denoting $r_{ij}(s)$ to be the impulse response of the jth variable at horizon s to the ith column of $\tilde{A}$, and the n-dimensional column vector $r_i(k) = [r_{1i},...,r_{ni}]$. The n-dimensional impulse response r_{as} at horizon s of impulse vector $a^{(s)}$ is given by equation [3.13].

$$[3.13] \qquad r_{as} = \sum_{i=1}^{n} q_i r_{is}$$

where q_i is the ith entry of $q = q^{(s)}$. I identify $a^{(1)}, a^{(2)}$ using the appropriate sign restrictions $a^{(1)} = \tilde{A}q^{(1)}$ and $a^{(2)} = \tilde{A}q^{(2)}$ at the same time jointly impose orthogonality conditions in the form $q'q^{(1)} = 0$ and $q'q^{(2)} = 0$. In general, a joint draw is taken from the posterior of the Normal-Wishart for (B,Σ) to obtain the candidate q vectors. Each draw for q that satisfies the above restrictions is kept otherwise it is discarded. The error bands are calculated from draws stored from 10000 draws, which satisfy the sign restrictions. Pure sign restriction approach makes explicit use of restrictions that researchers use implicitly and are therefore agnostic.

The penalty function approach developed by Uhlig (2005) will be used to test the robustness of the results from both single shocks at the end of this chapter. This function rewards responses that satisfy the sign restrictions and penalizes heavily those violating the restrictions. Unlike the pure sign restriction approach, the penalty function uses additional restrictions, which lead to possible distortion of the true direction of the responses from the imposed sign restrictions. In addition, the other robustness test estimates the exchange rate

and inflationary shocks together assuming the orthogonality property and replacing gross foreign reserves excluding gold with foreign exchange reserves. The main body of this chapter uses the pure sign restrictions approach.

3.3.2.1 Sign restriction

The sign restriction identification of the exchange and inflation rate shocks follows the similar specification in Granville and Mallick (2010). However, this specification extends the analysis to include all three exchange rate measures rather than looking at one measure. The exchange rate and inflation rate shocks in Table 3-1 are restricted to last at least K=6 months. The manner in which monetary policy authorities' reaction policy instrument represented by the real interest rate responds to these shocks has implications for the output stabilisation outcomes. Strict inflation targeting is concerned only with the inflation rate and does not attach any weight to the stabilisation of the output gap and other macroeconomic variables.[32] Hence, Table 3-1 defines the inflation shock following this definition by imposing a positive sign on the inflation rate. In contrast, the flexible inflation targeting attaches varying weights on the stabilisation of the output gap, interest rate, real exchange and inflation rate.[33] Subsequently, Table 3-1 defines the exchange rate depreciation shock following the flexible inflation targeting description by imposing a positive sign on the exchange rate. This assumes that the monetary authorities give relatively a higher weight to exchange rate stabilisation while observing both inflation and output path.

The identifications discussed in the preceding paragraph reflect the South African institutional framework, separated mainly by the institutional importance of exchange rate. The oversold forward book was closed in early years after adopting inflation targeting framework and an overbought forward book introduced after 2009. Despite flexible inflation targeting using more information than given by equations in the theoretical section I use sign restriction approach, which allows the identification based on weaker definitions of pure and flexible inflation targeting. The identification pursued in this chapter considers what policymakers care about and are based on institutional shifts in the importance of variables. It is worth mentioning, that no central bank in reality follows the loss function specified in both theoretical and empirical literature, and the emphasis on important variables evolves with

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[32] The instrument is set such that conditional inflation forecast equals the inflation target. Any shocks causing deviations between the conditional inflation forecast and the inflation target are met by an instrument adjustment that eliminates the deviation.

[33] The larger the weight attached on output gap stabilization, the slower the adjustment of conditional inflation forecast towards the long run inflation target. The policy instrument under the flexible inflation-targeting is adjusted such that the conditional inflation forecast approaches the long run inflation rate gradually, minimizing the fluctuations on the output gap, exchange rate and interest rates.

time perhaps due to preference of politicians and macroeconomic shocks. Unlike, Svensson (1997) who derived optimal policy rules, this chapter applies the Bayesian approach using pure and flexible inflation targeting definition in a looser sense based on the variables in the derived models only.

The real exchange rate affects aggregate demand channel of the monetary transmission of monetary policy.[34] It affects the relative prices between domestic and foreign goods, foreign demand for domestic goods, affects inflation through domestic price of imported goods and intermediate inputs,[35] and affects the nominal wages via the effect on inflation on the wage setting. The two main shocks are consistent with aspects of strict and flexible inflation targeting definitions respectively. The inflation and the exchange rate depreciation shocks are defined by imposing three sign restrictions for each shock shown in Table 3-1. The analysis uses three exchange rates because policy discussions in South Africa focus more on nominal rand per dollar exchange rate rather the REER. It is very important for this chapter to use all exchange rate measures rather than a single measure to be informative and be inclusive of all concerns from economic stakeholders including the competitiveness issues. In addition, more trade transactions in South Africa are invoiced in United States dollars.

Table 3-1 Sign restrictions for inflation and exchange rate shock

Models	Type of shock	r_t	π_t	Δe_t	Δy_t	ΔIR_t	π_t^0
1. Pure IT							
	Inflation	?	+	?	?	+	+
2.Mixed IT							
	Rand	?	?	+	?	+	+
	REER	?	?	-	?	+	+
	NEER	?	?	-	?	+	+

Notes. The ? indicates the variable was left unrestricted whereas (-)/+ implies (negative)/ positive effects . The positive sign on the Rand price of one dollar implies depreciation of the rand. However, the negative sign on both the real effective exchange rate and nominal effective exchange rate imply depreciation. IT refers to inflation targeting

First, the sign restrictions imposed suggest that the oil price does not decrease as an exogenous positive shock. Second, the change in foreign exchange reserves does not decrease in response to inflation or exchange rate depreciations shocks. The study uses three exchange rates. Third, the rand per dollar exchange rate change will not decline in response to its own

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[34] The role of exchange rate in an open economy framework is important in the monetary transmission mechanism.
[35] These are components of the consumer price inflation.

positive shock whereas both nominal and real effective exchange rates should not rise after depreciation shock. The identifications in Table 3-1 assume these exchange rate depreciations occur due to own innovations given changes in the foreign reserves and oil price inflation.

The response of output to inflation rate is left unrestricted. This follows the literature evidence that has not converged regarding the effects of inflation rate on output growth. The literature emphasizing threshold effects advocates the non-linear relationship between inflation and output growth (see e.g. Gillman and Kejak, 2005). According to Fischer (1993), there is a threshold above and below which inflation effects on the output growth differ. The nonlinear relationship between inflation and output growth has been found to be positive for low levels of inflation and negative or non-significant for high levels (see Sarel, 1996; Ghosh and Phillips, 1998; and Gillman and Kejak, 2005). The second argument suggests that inflation, affects output growth through inflation uncertainty channels as postulated by Friedman (1977). However, literature reports mixed evidence. Given this explanation, we leave the output response to inflation rate open for the data to decide.

The relationship between inflation and the interest rate is unrestricted due to the inability to distinguish between transitory and permanent price increases. The specification reflects the monetary authority's discretionary response to inflationary developments. When authorities deem the inflation developments as transitory increase in price levels, they may react a little, if not at all compared to environment of persistent price inflation. In the latter scenario, policymakers may react aggressively or choose to smooth interest rate over some period anticipating that inflation rate will fall into the target band. The opportunistic approach to monetary policy developed by Orphanides and Wilcox (2002), introduces the concept of zone targeting which has a range of values for the inflation rate around the desired rate. Zone targeting argues that policymakers should raise real interest rate when inflation is above zone of discretion and cut real interest rates when inflation is below the zone (Martin and Milas, 2006). Hence, this justifies leaving the interest rate response to inflation rate open for the data to decide rather than prejudging it. [36]

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[36] During the recent financial crises many central banks (e.g. Bank of England in 2011) did not raise interest rate when inflation was rising and in extreme cases some banks (e.g. Brazil 2011, Hungary 2012) even lowered interest rates. The South African Reserve bank was not exempt, when it left interest rate unchanged when inflation rate was outside the target band since late 2011.

The overall inflation does not decline in response to its own shock. South African foreign exchange reserves excluding gold accumulation increased since the adoption of the inflation-targeting framework in particular after closing the forward book. A monetary or inflation shock can emerge from growth in foreign reserves or due to the oil price inflationary shock. Domestic currency depreciation makes domestic exports cheaper compared to the imported goods and can lead to rising inflation rates. Higher demand for domestic goods driven largely by increased export demand can increase industrial production. The methodology applied in this analysis enables the result to reveal the effect rather than me prejudging this outcome. Moreover, the exchange rate changes can be either an appreciation or depreciation and these changes are equally likely to happen under the pure sign restriction. However, this method keeps those impulse vectors, which satisfy the imposed sign restriction while discarding those violating them.

3.4   Data

This analysis uses monthly data from January 2000 to January 2010 under the inflation targeting period for six variables.[37] The six variables are: the growth in foreign exchange reserves excluding gold, output growth approximated by manufacturing production growth, inflation rate, growth in exchange rates (i.e nominal rand, nominal effective exchange rate (NEER), real effective exchange rate (REER)), growth in oil price index and real interest rate. The data is obtained from the International Monetary Fund IFS database. The three measures of exchange rate used for this analysis are the nominal rand per US dollar (R/$), NEER and REER in separate estimations. The real interest rate equals the difference between nominal interest rate and expected inflation rate. The expected inflation rate is calculated using the methodology in Davidson and Mackinnon (1985). Certain studies use expected inflation rate as a forecasted inflation rate from a random walk model. Moreover, literature uses different forecasts for example, Ostry et al. (2012) used four quarters ahead inflation forecasts as expected inflation to calculate real interest.   Both the inflation rate and expected inflation rate display similar trends in Appendix A 3. The growth rates refer to year on year percentage changes.[38] A positive increase in the REER and NEER represents appreciation respectively and depreciation for the rand-dollar exchange rate.

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[37] The percentage calculated using the year on year percentage changes approach alters the starting period. The estimation period starts from January 2001 rather 2000. However we need the observation from 2000.

[38] For example, the inflation rate (π_t) is calculated using formula $\pi_t = 100 \times (\log(cpi_t / cpi_{t-12})$

Table 3-2 shows the descriptive statistics of all variables, in particular the mean, standard deviation, minimum and maximum values. Oil price inflation has the highest standard deviation value indicating that it is the most volatile variable with both the minimum and maximum growth rate exceeding 65 per cent. All the three exchange rate measures show that the exchange rates deviate from their means by 15-21 per cent, which is higher than deviations of inflation, expected inflation and interest rates. The reserves excluding gold as well as foreign exchange show deviations from the mean growth rates of about 20 per cent. These percentage deviations from both reserves and foreign exchange mean growth rates exceed percentage deviation of CPI inflation rate, nominal interest rate, real interest rates and expected inflation rate. The mean growth rates of the reserves excluding gold and foreign exchange experienced average growth rates of at least 18 per cent, which are the highest growth rates compared to all other variables possible, indicating the active accumulation of both reserves and foreign exchange by the central bank. The growth in manufacturing volume index is extremely low and being less than 1 per cent over the period and its deviation from the mean is nearly 7 per cent, possibly reflecting huge negative effect of the recession in 2009.

Table 3-2 Descriptive statistics

Variable	Mean	Minimum	Maximum	Std error
Nominal interest rate	9.01	6.43	12.80	1.90
CPI inflation rate	5.99	0.16	12.20	3.13
Oil price index inflation rate	8.94	-80.80	65.70	35.00
Rand per US dollar	1.55	-42.00	47.10	20.60
NEER	3.98	-37.70	28.80	16.50
REER	0.23	-34.70	31.10	15.70
Manufacturing index	0.89	-22.50	8.90	6.43
Foreign reserves excluding gold	18.40	-7.13	72.40	20.20
Foreign exchange	18.40	-7.27	75.00	21.00
Real interest rate	2.75	-0.95	6.43	1.73
Expected inflation rate	6.24	0.89	12.60	2.95

Notes. The nominal interest rate, expected inflation rate and real interest rate are expressed in percentages in levels whereas the remaining variables are growth rates presented in per cent. Std refers to standard

Table 3-2 shows the annual percentage changes of all the variables except that the real and nominal interest rates are in levels. For most periods under review, the manufacturing index grew by nearly 5 per cent between 2003 and 2008 and contracted by 16 per cent in 2009 due to recession. The consumer price inflation, nominal interest rates and expected inflation rates variables move closely together, with the regimes of lower rates of changes and higher rates of changes coinciding on same periods. Higher inflation rates, expected inflation rates and

nominal interest rates occurred in 2002-2003 and 2007-2008 with lower rates in 2004-2007 and after 2009. The nominal interest rates remained above the 6 per cent lower bound whereas the real interest rates remained positive for most periods except in 2008 and 2009 showing transitory negative values.

Figure 3-1 Plot of variables
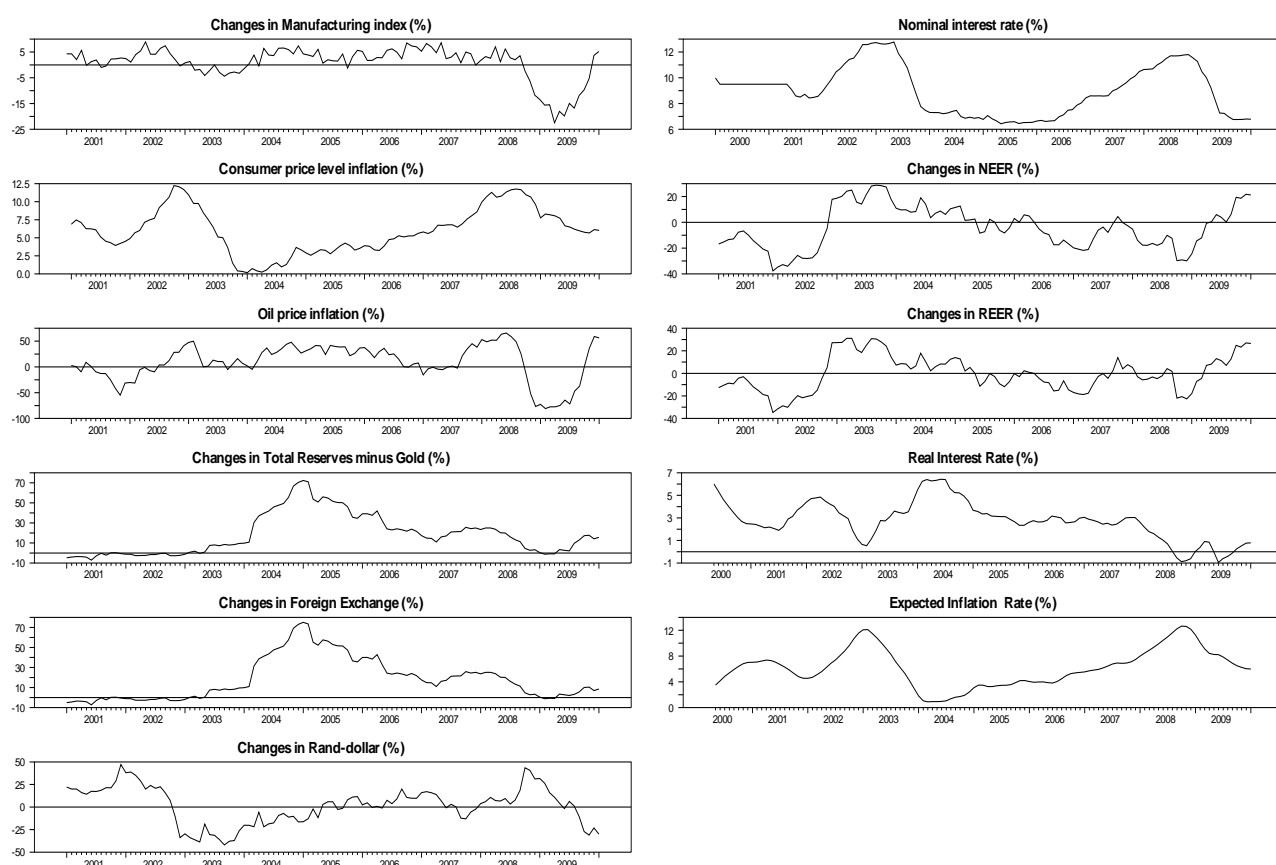
Oil price inflation displays huge upward and downward movements between 2007 and 2010. In annual terms, the oil price increased by more than 50 per cent in 2008 and declined by nearly 75 per cent from the fourth quarter of 2008 to the second quarter of 2009. In the last quarter of 2009, it increased by nearly 50 per cent due to low base effects in the previous year. The growth in the foreign reserves excluding gold and foreign exchange reserves are negative before 2003 reflecting the period in which the South African Reserve Bank closed the forward book. The higher growth rates between 2004 to early 2005 reflected low base effects in previous years and the Central Bank continued gradually to acquire reserves. All three exchange rates depreciations tend to be persistent in the periods 2000 to 2002, mid-2006 to early-2007, late-2007 to early-2009. The exchange rates appreciation periods include the periods of late 2002 to early 2005 and from the second quarter of 2009.

Table 3-3 shows annual contributions to gross domestic output from mining and manufacturing output between 2000 and 2010. Throughout the year, the contributions to overall gross domestic product from mining sector have been relatively lower than those from manufacturing since 2000. Hence, this chapter approximates output with manufacturing production in the main section of the analysis and uses mining production in some sections. However, the mining sector is used to examine whether exchange rate depreciation shocks can stimulate it.

Table 3-3 Annual contribution of the mining and manufacturing sectors to GDP growth in per cent

Year	GDP	Mining	Manufacturing
2000	4.2	7.6	19
2001	2.7	8.3	19.1
2002	3.7	8.7	19.2
2003	2.9	7.4	19.4
2004	4.6	7.2	19.2
2005	5.3	7.6	18.5
2006	5.6	8.4	17.5
2007	5.5	8.8	17.0
2008	3.6	9.7	16.8
2009	-1.5	9.0	15.3
2010	2.9	9.4	13.8
2011	3.1	9.8	13.4

## 3.5   Results

This section discusses the various VAR sign restriction results estimated using 6 lags with effects restricted to last at least 6 months.[39] The focus is on comparing the responses of real interest rates to exchange rate depreciation shocks to those of inflation shocks. In addition, the analysis compares how these shocks influence real output growth. The first part of the analysis presents results based on the individual estimated shocks following the Uhlig (2005)`s approach. The second, part discusses three robustness tests namely the penalty function, changing K=6 months to K=9 months and uses foreign exchange amount rather than total reserves excluding gold and concludes with two shocks estimated together following the Mountford and Uhlig (2009) approach.[40] The growth in the nominal exchange rate refers three exchange rate changes and output refers to manufacturing output, which contributes about 18 per cent to the country's GDP.

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[39] Similar periods have been imposed by Uhlig (2005); Mallick and Rafiq (2008)
[40] Horizon periods in which shocks are expected to last.

Figure 3-2 Exchange rate shocks

Rand depreciation shock

Impulse Responses with Pure-Sign Approach
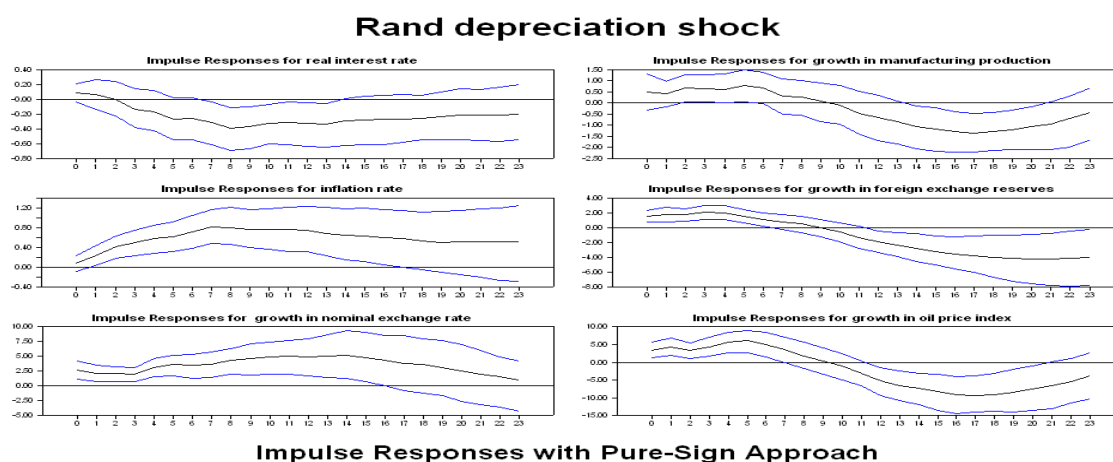
NB growth in nominal exchange rate refers to rand per US dollar changes

Nominal effective exchange rate depreciation shock

Impulse Responses with Pure-Sign Approach

Real effective exchange rate depreciation shock

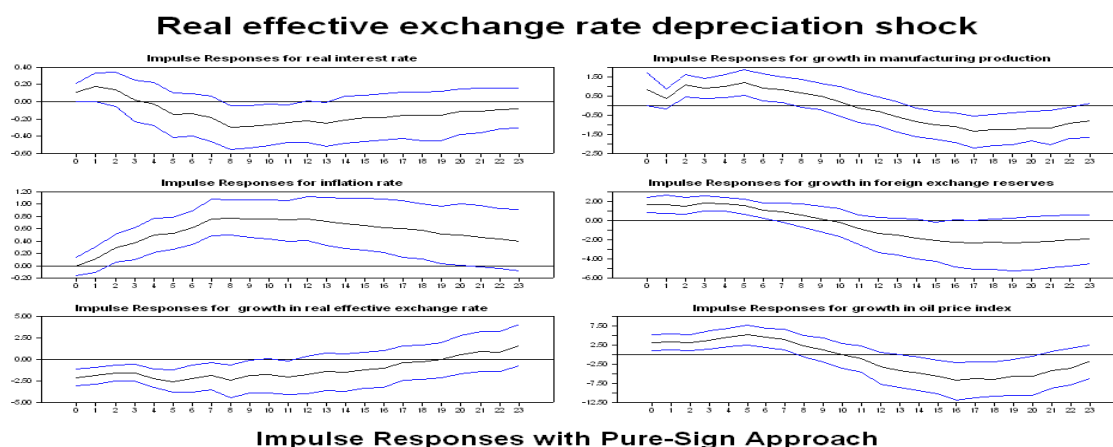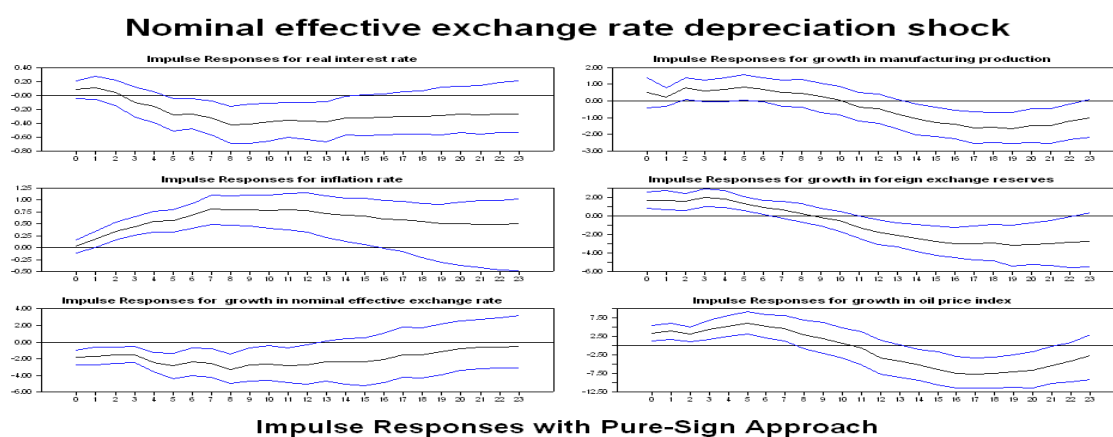Impulse Responses with Pure-Sign Approach

Figure 3-2 shows the responses to the nominal rand per US dollar, nominal effective exchange rate and real effective exchange rate depreciation shocks respectively. Consistent with the theoretical predictions, inflation responds positively to currency depreciation across all measures of exchange rates. These three different exchange rate depreciations

64

significantly increase the inflation rate by a maximum of 0,8 percentage points in the seventh month. After 19 months, the increase in the inflation rate converges to 0,4 percentage points, which is not significantly different from zero. Growth in foreign reserves remains positive for 10 months exceeding the imposed six months. Granville and Mallick (2010) suggest that high foreign exchange reserves and high real interest rates should appreciate domestic currency. However, there is no significant evidence of the rand appreciation.

All three different exchange rate depreciations have a positive impact on output growth and only the REER depreciation has significant real effects for 8 months.[41] Two relationships emerge from the impulse responses. First, the impulse responses for output (denoted by manufacturing) and oil price inflation show similar movements. Friedman (1977) suggested that high inflation rate has negative effects on real output hence that reduced output growth would weaken the oil price inflation. Both output and oil price inflation declines coincide with the return of exchange rate to pre-shock levels following the depreciations. Alternatively, the oil price inflation would decline in the long run despite South Africa being a small open economy which cannot influence world oil prices. According to Mishkin (2007), the country, which becomes more productive compared to other countries in the long run expects its currency to appreciate. Oil price inflation should decline following such domestic currency appreciation.

Second, the impulse responses for output and foreign reserves show close co-movements. Perhaps the synchronized rise and declines in reserves and output reflects the relationships in equation [3.2]. According to the first component in equation [3.2] a change in the manufactured export pulls reserves in the same direction, *ceteris paribus*. An exchange rate depreciation, which stimulates output growth due to increased export results in more accumulated foreign reserves. In addition, exchange rate changes influence the physical accumulation of foreign reserves and monthly revaluations.[42] The lack of significant evidence of currency appreciation points to the dominance of manufacturing exports, over exchange rate effects in foreign reserves accumulation implied by both components in equation [3.2].

The inflation dynamics due to an inflationary shock (in Figure 3-3) are less persistent compared to those arising from exchange rate shocks. Inflation rises for 18 months in

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[41] Perhaps the volatile currency, which fails to self-correct resulting in persistent appreciations in certain periods as in may weaken output growth.
[42] Persistent exchange rate appreciations or depreciation alters the amount of reserves in any point in time during revaluation process.

response to the exchange rate depreciation shock, which is longer than the nine months due to the pure inflationary shock. This suggests that the real interest rate (or nominal interest) response towards the purely inflationary shock is more aggressive compared to exchange rate shocks. Granville and Mallick (2010) argue that the New Keynesian theoretical models do not predict a sufficient degree of inflation persistence after a monetary (purely inflationary) shock. The inflation rate should rise and recede to pre-shock levels quickly rather than dying slowly as predicted by the empirical literature.

Figure 3-3 Inflation shocks
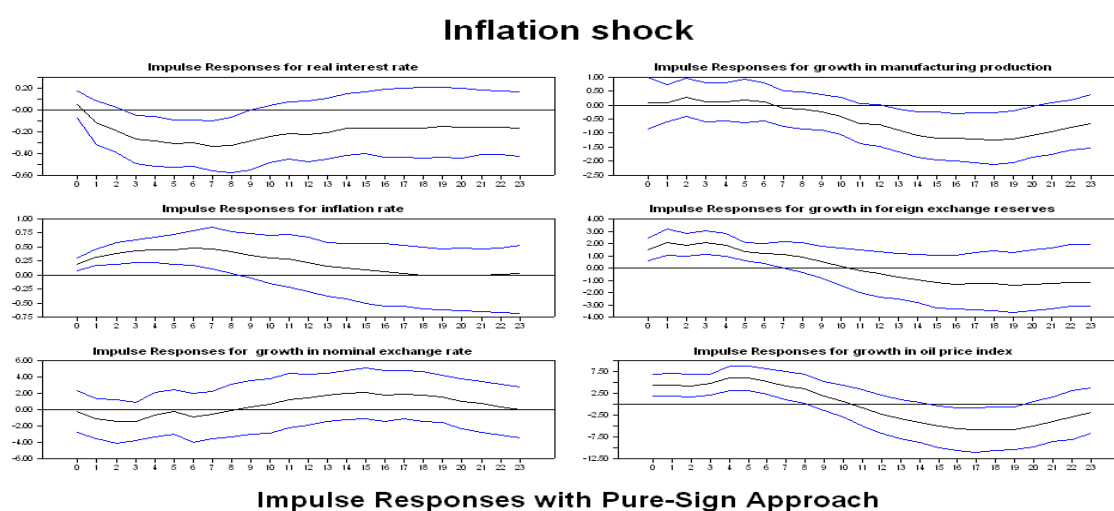
Monetary policy conducted in forward looking manner, requires interest rates smoothing over time in anticipation that inflation would eventually fall within the target band. The significant real interest rates decline in Figure 3-3 suggests that the change in nominal interest rate is marginally lower than the change in inflation rate. The Fisher effect holds over the long horizons as the real interest rate returns to pre-shock level, perhaps indicating the nominal interest rate increased by the similar change in the inflation rate.[43] This evidence indicates that monetary policy is effective in lowering the inflation rate over the long horizon.

Growth in manufacturing output remains significantly positive for long periods in response to REER depreciation only, suggesting competitiveness amongst trade partners is important. All exchange rate depreciation shocks exert significant inflationary pressures, which is controlled in the long run by the central bank through raising the interest rate. The reaction of monetary policy to the exchange rate shocks supports the flexible inflation targeting practices discussed

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[43] This is based on estimations (not shown here) using nominal rather than real interest rate.

in the literature section. The response of the real interest rate to the inflationary shocks suggests a strict inflation targeting approach does not enhance output growth.

Since expected inflation is calculated from the forecasted inflation one period ahead. This section also tested the robustness of the results in preceding section using two, three, and four periods ahead forecast. In addition, the results were robust to using forecasted inflation rate two and three periods ahead for expected inflation rate. In addition, the above results were confirmed using the deviation of inflation rate from the mid band target of 4,5 per cent of the 3-6 per cent target.

This chapter analyzes the behavior of central bank's policy reaction function to mining output, given that, South Africa is also a commodity producing country. This follows literature conclusions that inflation targeters specializing in commodity exports tend to adopt flexible inflation targeting regimes. In this framework, the interest rates react to real exchange rate fluctuations. Hence, I focus on mining productions reaction to exchange rate depreciation shocks and the path of the real interest rates that captures monetary authorities' behaviour.

The real interest rate is the difference between the nominal interest rate and the expected inflation rate. Figure 3-4 shows the responses of mining output to exchange rate depreciation shocks. The real interest rate declines significantly in certain quarters and return to preshock levels in almost all cases. This implies that monetary authorities respond slowly to inflation originating from the exchange rate depreciations. Despite a depressed real interest response to exchange rate depreciations, the growth in the mining output tends to drop (although significant) in certain periods. This suggest that monetary policy has a lesser stimulative effect in the mining sector whose growth is relatively exogenous,[44] and the sector has many structural problems. The structural problems are articulated in the Chamber of mines report in 2009 linking the decline in mining sector to declining grades of gold or platinum, high ash content in coal, greater depth of gold and platinum mines, increasing strips of ratios of coal and iron. The non-geological factors include commodity demand, input material costs changes, exchange rates changes, factor cost increases, infrastructure and bottlenecks, and

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[44] Currency depreciation may give an incentive to reduce output as the same output may yield the same value in domestic currency

insufficient investment in capital equipment, mine development, new technologies, and poor life mine planning led to marginal operations being pushed outside of business.

Figure 3-4 Exchange rate shocks and mining output
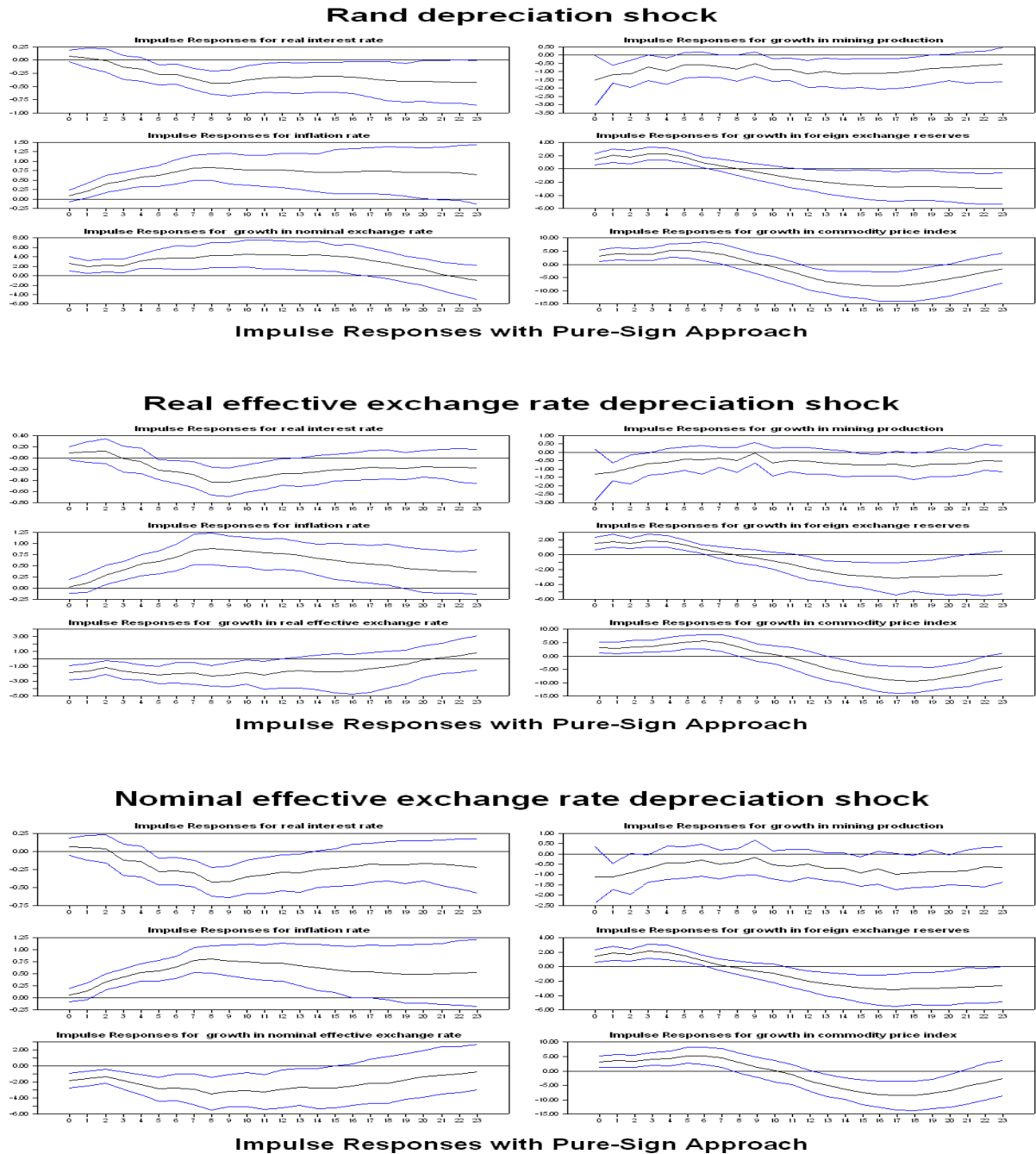
3.5.1 Variance decomposition analysis

Table 3-4 shows the variance decompositions of different exchange rate shocks and the various inflation shocks on manufacturing output growth estimated using three different

exchange rates. The objective is to find out if there is any different impact on inflation shock, which is dependent on a particular included exchange rate. The variance explained by inflation shocks is lower after three quarters than the corresponding variability explained by exchange rate shocks over all horizons. Amongst these three exchange rates, real effective exchange rate (REER) induces more variability in manufactured output in 14 months relative to the rand-dollar exchange rates and NEER. Moreover, the REER long run values are lower than other exchange rate long run values.

Table 3-4 Variance decompositions in per cent

Steps	NEER	RAND	REER	INFNEER	INFRAND	INFREER
1	8.70	8.90	10.7	8.80	8.70	8.60
2	11.0	10.9	12.7	10.9	11.3	10.1
3	12.5	12.4	13.6	11.9	11.8	12.1
4	12.6	12.5	14.0	12.0	12.1	12.6
5	13.2	13.2	14.3	12.5	12.4	13.0
6	13.4	13.3	14.8	12.4	12.6	13.2
7	13.7	13.4	14.9	12.5	12.9	13.4
8	13.6	13.5	15.0	12.6	13.4	13.5
9	13.9	13.8	15.2	12.6	13.5	13.6
10	14.2	14.1	15.3	12.7	13.6	13.7
11	14.4	14.3	15.3	13.0	13.7	14.0
12	14.5	14.7	15.5	13.2	13.8	14.2
13	14.9	15.1	15.6	13.3	14.3	14.3
14	15.0	15.2	15.6	13.6	14.5	14.5
15	15.0	15.7	15.4	13.8	14.7	14.7
16	15.2	15.7	15.4	13.9	14.8	14.8
17	15.4	15.9	15.4	14.0	14.9	15.0
18	15.6	15.9	15.5	14.2	14.9	15.1
19	15.8	16.0	15.6	14.5	14.9	15.2
20	16.1	16.0	15.7	14.6	15.0	15.1

Notes. Inflneer, inflrand and inflreer refers to inflation shocks estimated using nominal effective exchange rate (NEER), rand dollar exchange rate and real effective exchange rate (REER). Steps ahead refer to horizons in months.

3.5.2   Robustness analysis

This section specifically examines the robustness of the earlier findings of manufacturing growth response using penalty function, changing horizons for which shocks are expected to last and using foreign exchange reserves employing the orthogonality assumptions. However, all impulse responses are available in the appendices.

Figure 3-5 All exchange rate depreciation shocks and inflation shocks from penalty function
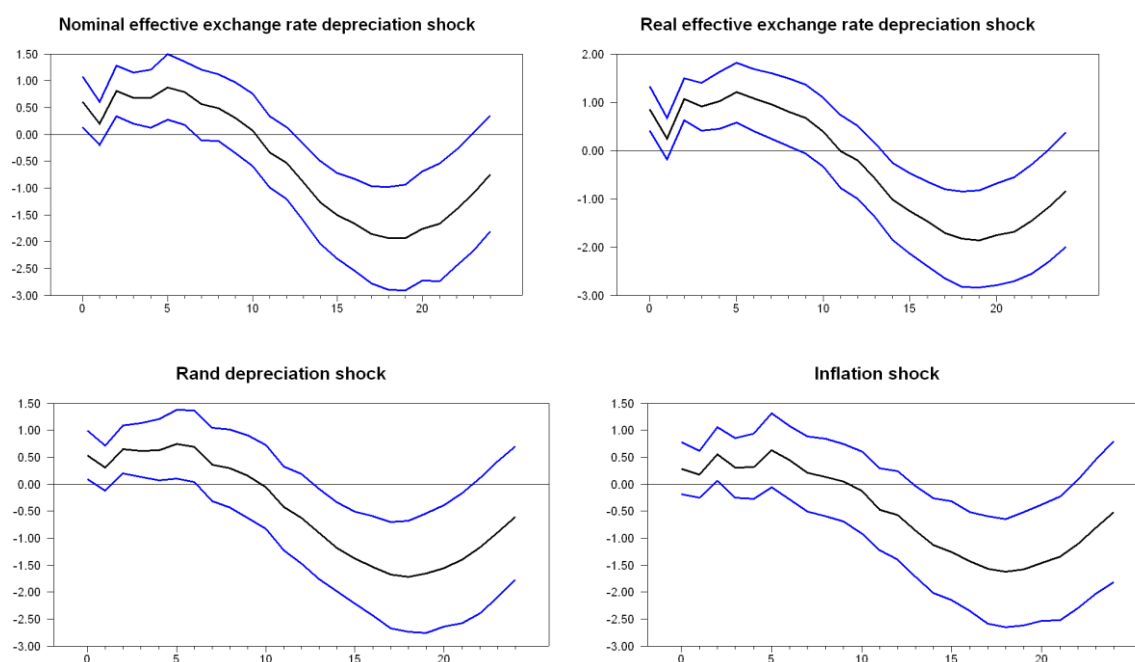

The first robustness approach uses a penalty function approach. The impulse responses from the penalty functions in Figure 3-5 looks qualitatively similar to those from pure sign restriction approach. The initial magnitudes are larger in the penalty function because it searches for a large initial reaction of the exchange rate and inflation shock separately. The error bands are considerably much sharper in the penalty function since the additional restrictions introduce some distortion in the pure sign restriction. The real effective exchange rate depreciation in Figure 3-5 achieves higher growth rates thereby outperforming the nominal rand depreciation, nominal effective exchange rate depreciation and inflation shocks given the similar constraints.[45] These findings are robust to the penalty function technique. All impulses responses from the penalty function are in Appendix C 3.

The Second, robustness approach tests the sensitivity of the earlier findings by increasing the quarters for which shocks effects are expected to last. Thus quarters imposed increase from K=6 months to K=9 months and results are shown in Figure 3-6 . This follows Uhlig's (2005) argument that impulse responses could be sensitive to the periods imposed on the restrictions. Similar to the preceding findings the sensitivity tests in Figure 3-6 conclude that real effective exchange depreciation outperforms all other shocks including the inflation shocks in

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[45] Output grew by nearly 1 per cent, which is larger than growth rates achieved under both nominal rand and nominal effective exchange rates shocks. Similarly the inflation shocks, does not lead to significant output growth rates given same constraints.

stimulating output growth.[46] Hence, these results are robust to the change in the periods of the imposed shocks.

**Figure 3-6 Exchange rate and inflation shocks on manufacturing for K=9 months**
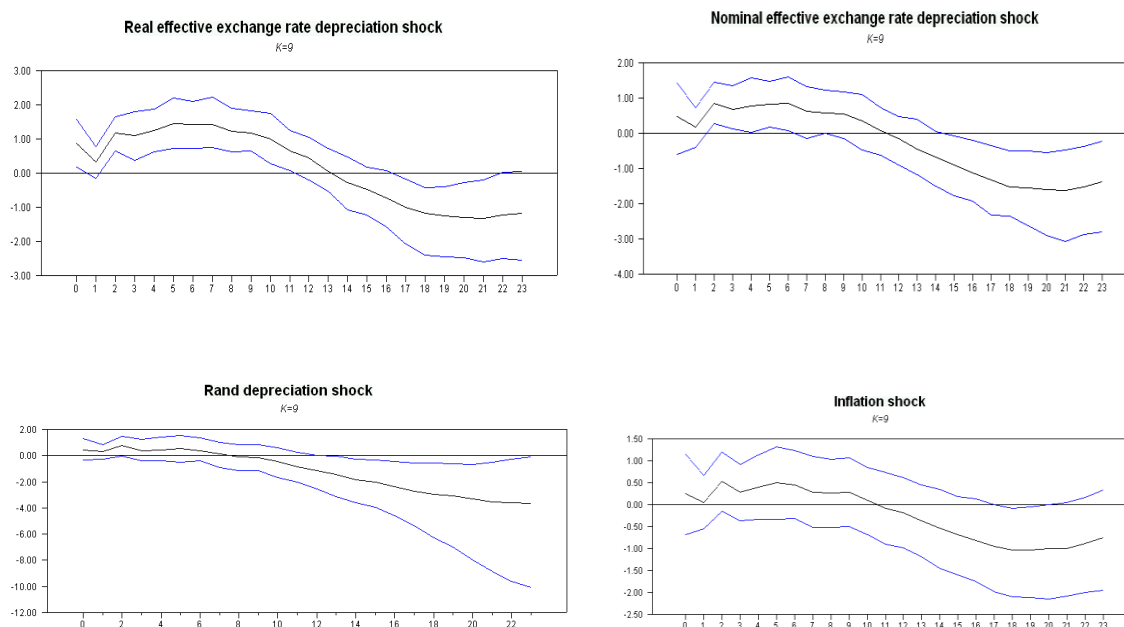
The third robustness analysis assesses further the impacts of the exchange rate and inflation shocks under the orthogonality assumption, which avoids the sequential estimation and ordering problems. Sequential estimation procedure has sampling property problems in which the sequences of shocks affect the results (Rafiq and Mallick 2008).[47] The structural shocks are orthogonally drawn and impulse vectors subsequently derived, which makes the ordering of these shocks less important for the results. These results in Figure 3-7 are robust to changes in the ordering of the two shocks and do not differ from those estimated using individual shocks. The real effective exchange rate leads to significant growth in output (manufacturing) for at least 7 months compared to the inflation, rand-dollar and nominal effective exchange rates depreciation shocks. Moreover, Appendix B 3 shows all impulse responses. The conclusions are robust to the ordering or sequential estimation matters, hence eliminating any sampling uncertainty related to the ordering of the shocks.

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[46] . Additional figures for different periods (not shown here) confirm that the inflation shocks are not growth enhancing under all different exchange rate measures.

[47] Two vectors drawn simultaneously eliminate any sampling uncertainty created by such sequentially sampling draws. Furthermore, the order in which the shocks are established can have implications for the results.

Figure 3-7 Exchange rate depreciation and inflation shocks
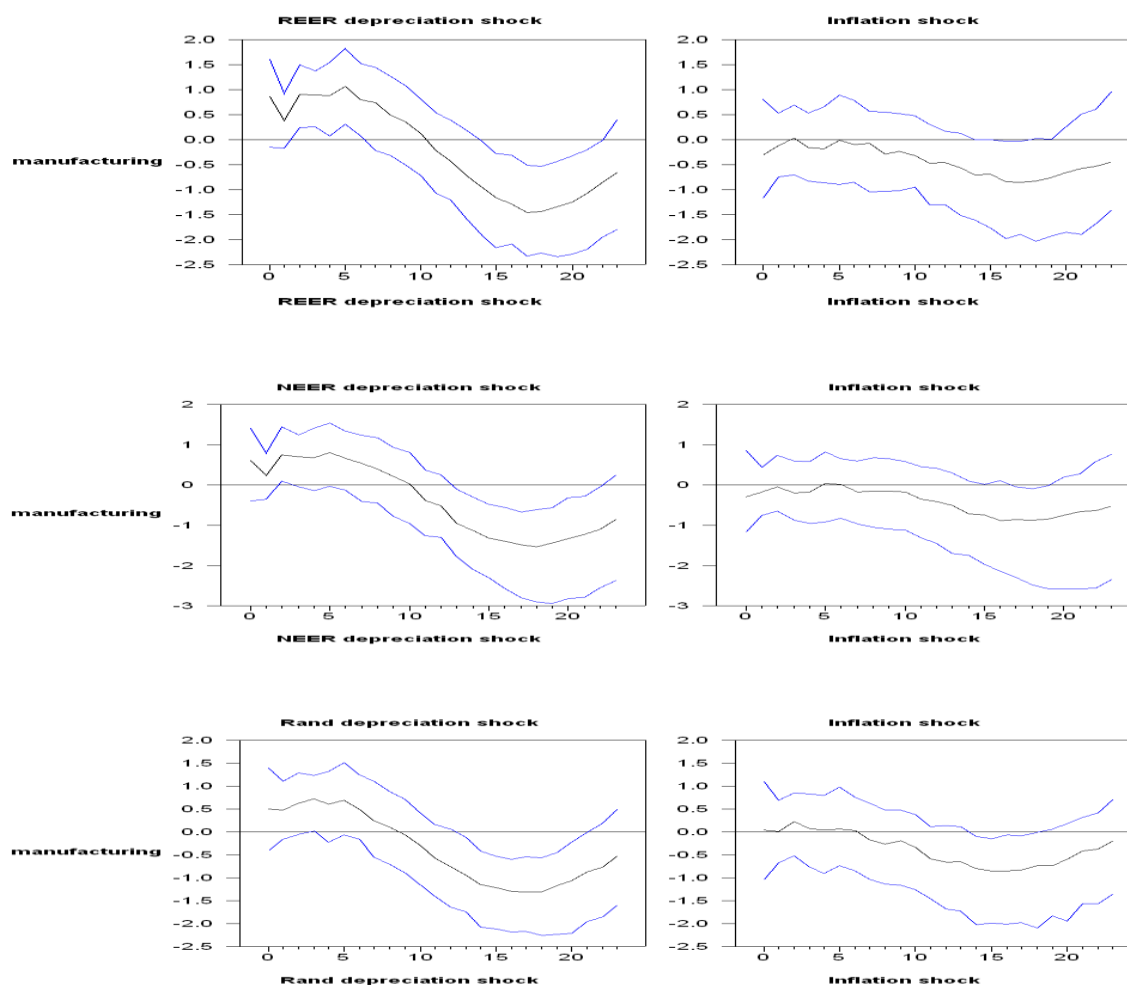
The fourth robustness test in Figure 3-8 uses the foreign exchange definition rather than the gross foreign reserves minus gold, and assumes the orthogonality conditions between the two shocks. Appendix D 3 shows the full results. Similarly, the real effective exchange rate (REER) depreciation leads to significant output growth compared to the other shocks.[48] Overall, the results are robust to the alternative definition of reserves and the orthogonality assumption.

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[48] Moreover, we reach the same conclusion (results not shown here) using the foreign exchange for individually assessed shocks.

Figure 3-8 Exchange rate depreciation and inflation shocks using foreign exchange definition
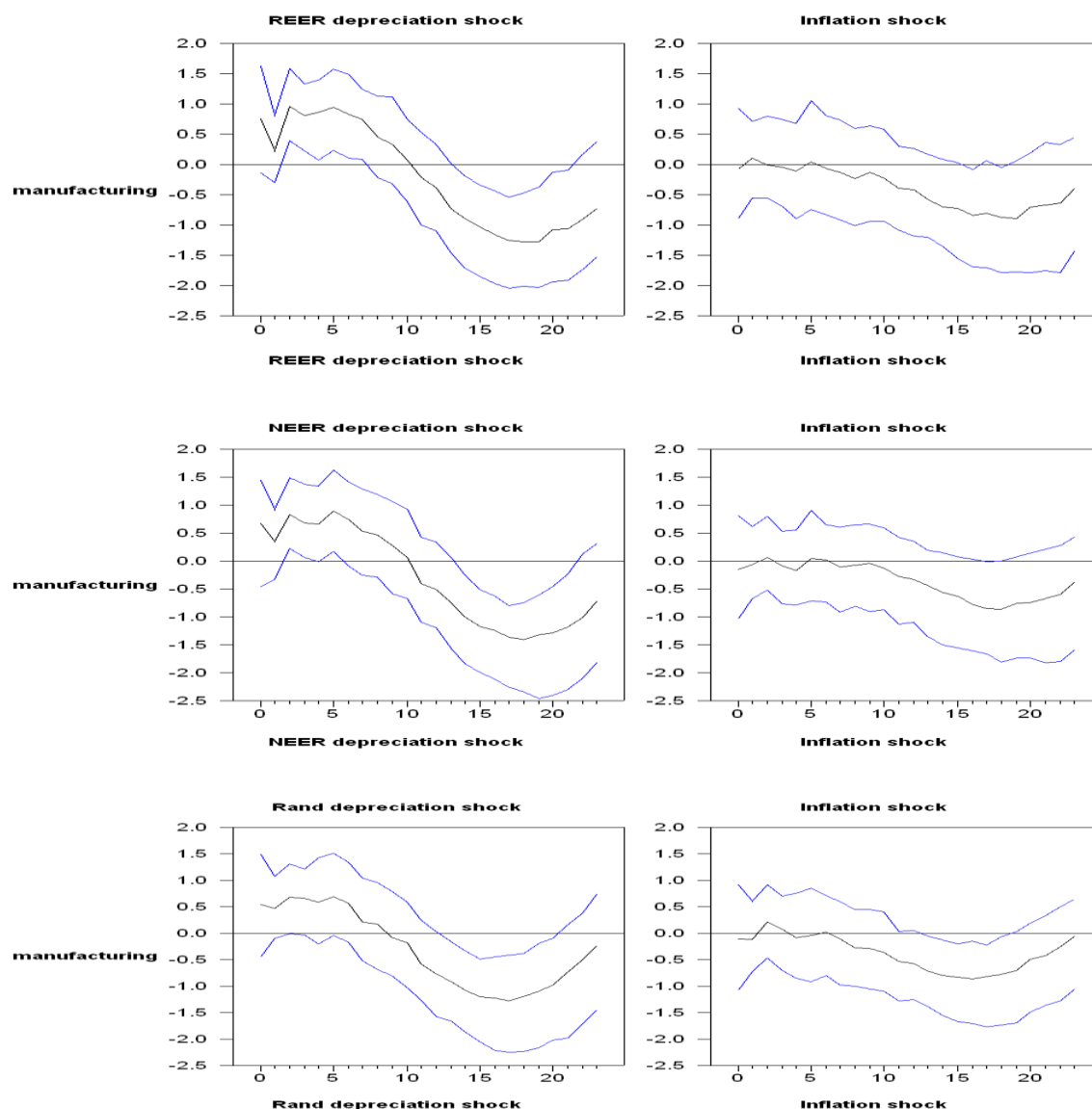

3.6 Conclusion

Chapter 3 investigated the response of the real interest rate to the inflationary and exchange rate shocks in an environment of foreign reserves accumulation and oil price inflation, in the South African inflation targeting period. There is significant evidence, which shows that the real interest rate reacts negatively to the inflation rate shocks. However, this reaction suggests that the Fisher effect holds in the long run. This indicates both the nominal interest rate and inflation rate probably increased by nearly the same

magnitudes confirming the effectiveness of monetary policy in the long run to both shocks. Evidence from inflation shocks suggest the strict inflation targeting approach is not compatible with significant real output growth. In contrast, under the flexible inflation targeting framework, REER depreciation has significant growth enhancing ability when compared to other shocks. The monetary authorities significantly dampen the inflationary effects from exchange rate depreciations through policy tightening. In policy terms, this means policymakers focusing more on the flexible inflation targeting framework, putting some weight on the exchange rate, which deals with competitiveness relative to trading partners in an environment of reserves accumulation and uncertain high oil prices. Under such circumstances, the monetary policy manages to control the inflation pressures associated with such a shock.

The finding that manufacturing growth deteriorates when exchange rate competitiveness weakens has policy implications. In this instance, the South African Reserve Bank can learn lessons from other emerging market central bank experiences. The Brazilian central bank has intervened indirectly in the foreign exchange market by changing the composition of domestic debt. This involved increasing the placement of dollar denominated debt in times of stress, providing exchange rate insurance to the private sector, fostering liquidity in the foreign exchange market and facilitating the adjustment in domestic absorption to sudden capital inflows. The Chilean central bank reserves the right to participate in the market under exceptional circumstances through foreign exchange rate operation or through provision of foreign exchange hedging instruments. Despite, such weaker response to exchange rate depreciations, the growth in mining output tends to drop although significantly in certain periods. This suggest that monetary policy has a lesser simulative effect in mining production facing many structural problems.

Appendix A 3 Comparison between actual and expected inflation rates

Figure Appendix A 3-1 Actual and expected inflation rates
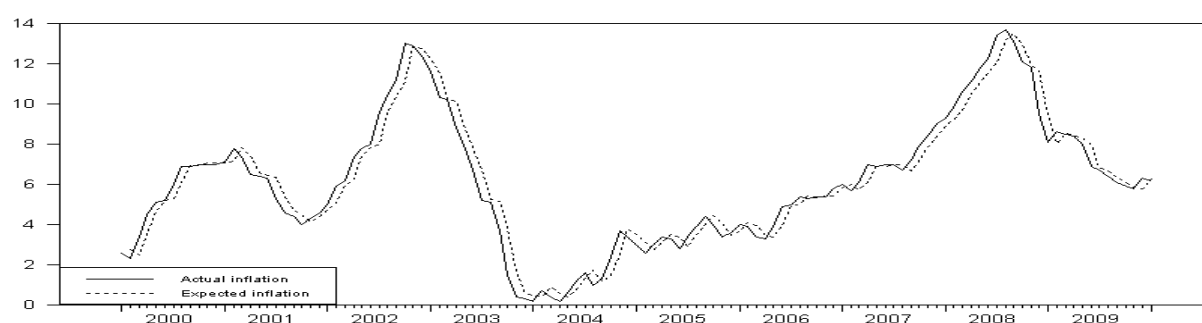
Appendix B 3 Results from orthogonality assumption

Figure Appendix B 3-1 NEER depreciation and inflation shocks
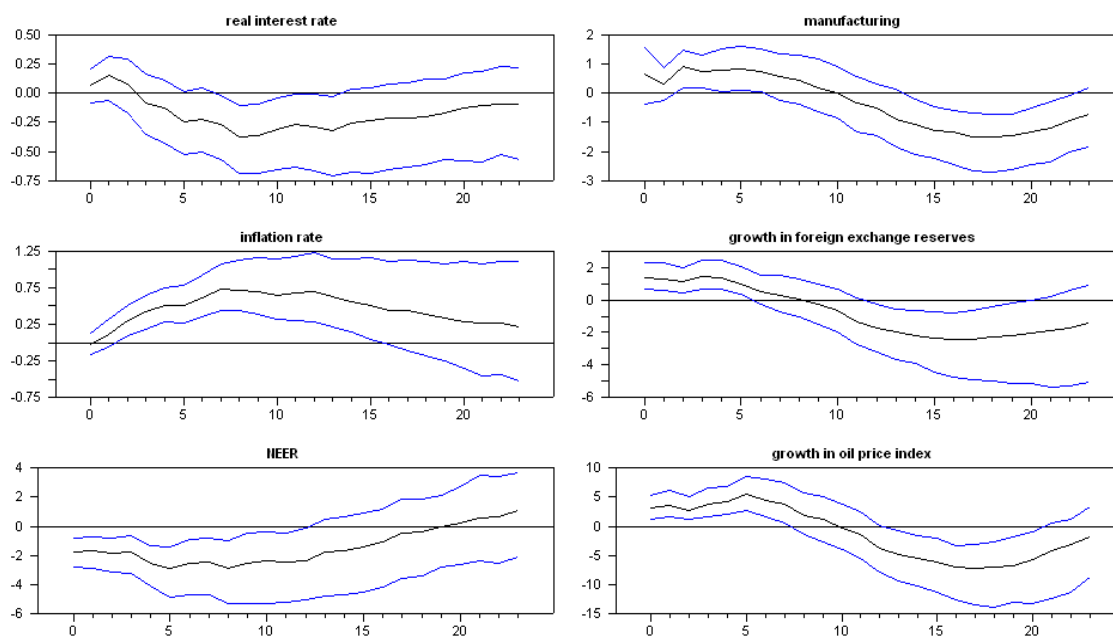
Responses to NEER depreciation shock
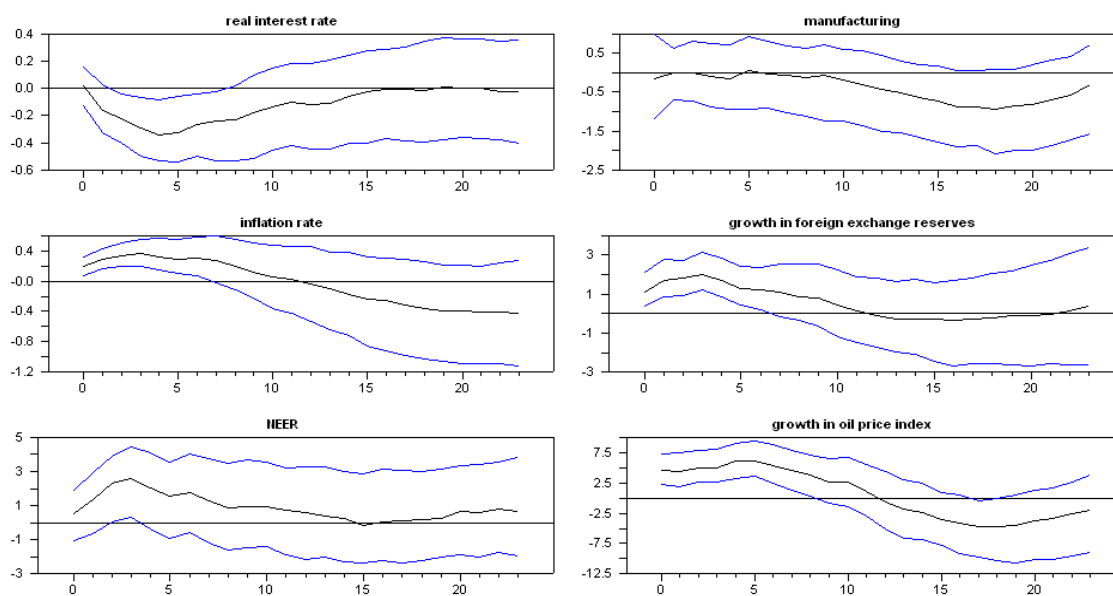
Responses to Inflation shock

Figure Appendix B 3-2 REER depreciation and inflation shocks

Responses to REER depreciation shock

Responses to Inflation shock

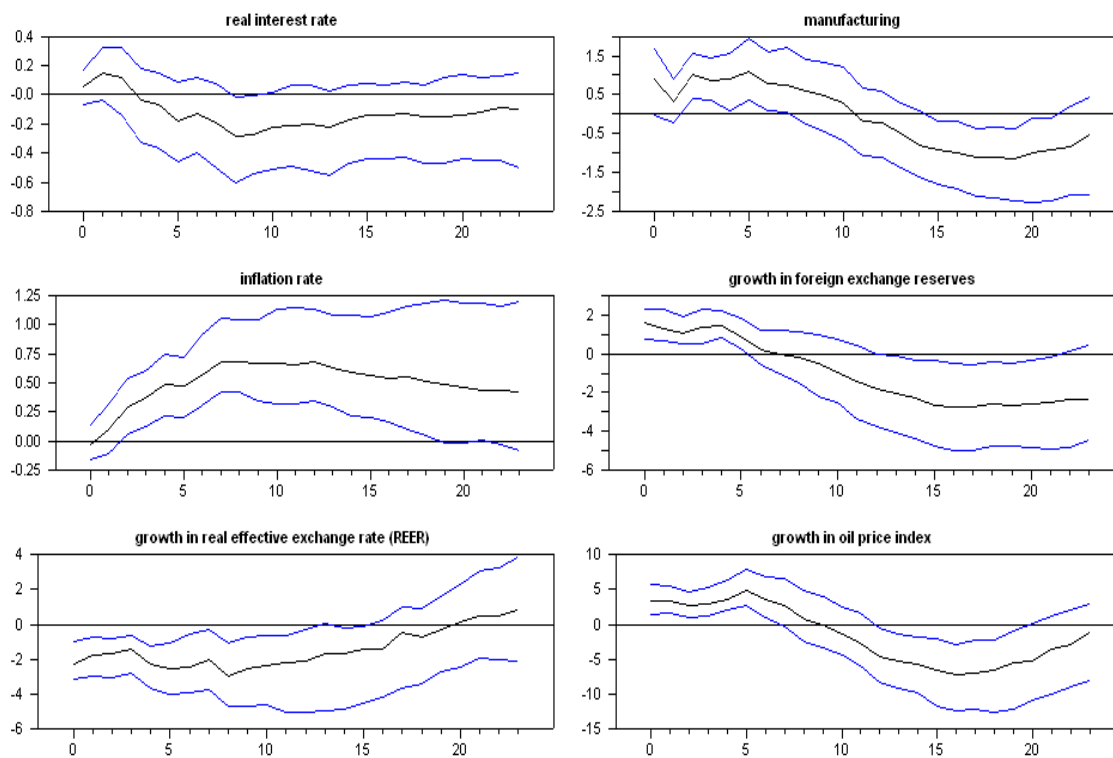**Figure Appendix B 3-3 Rand depreciation and inflation shocks**

Responses to Rand depreciation shock

Responses to Inflation shock

Appendix C 3 Sensitivity results using penalty function

Figure Appendix C 3-1 Exchange rate shocks from Penalty function

Rand depreciation shock

Impulse Responses with Penalty Function Approach

Nominal effective exchange rate depreciation shock
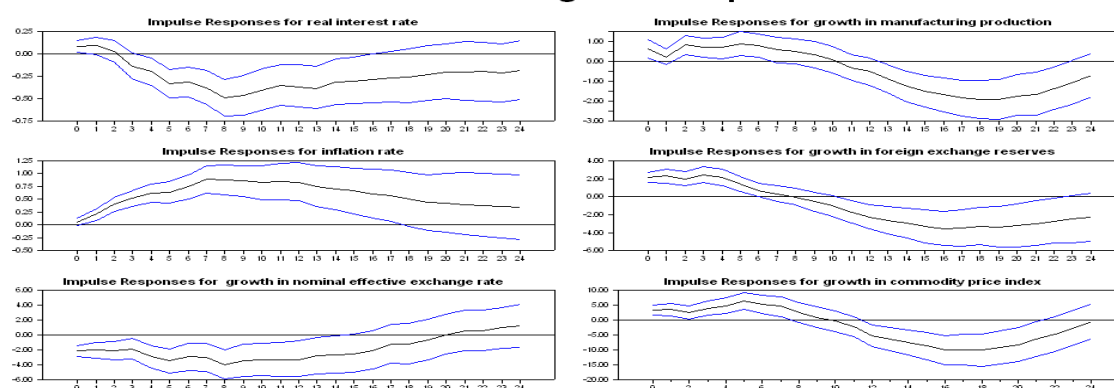
Impulse Responses with Penalty Function Approach

Real effective exchange rate depreciation shock
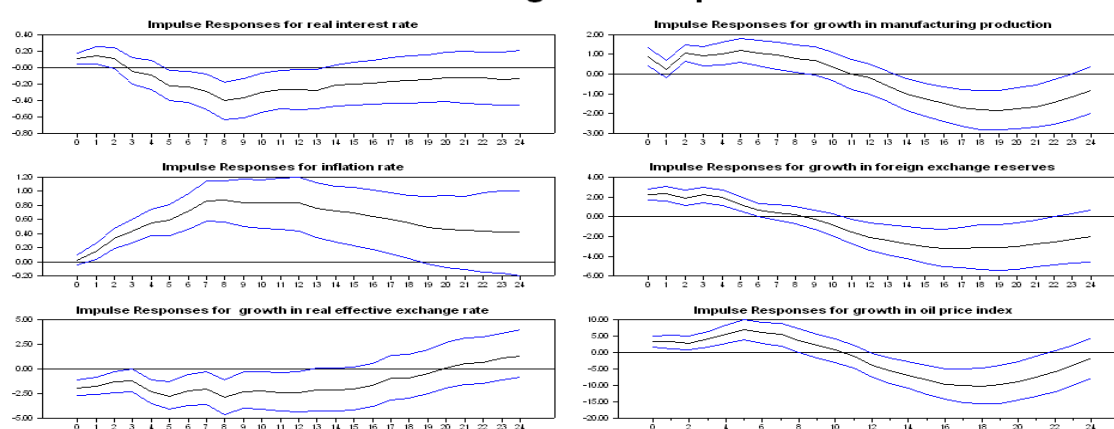
Impulse Responses with Penalty Function Approach

Figure Appendix C 3-2 Inflation shocks from Penalty function

Inflation shock

Impulse Responses with Penalty Function Approach

Inflation shock

Impulse Responses with Penalty Function Approach

Inflation Shock

Impulse Responses with Penalty Function Approach
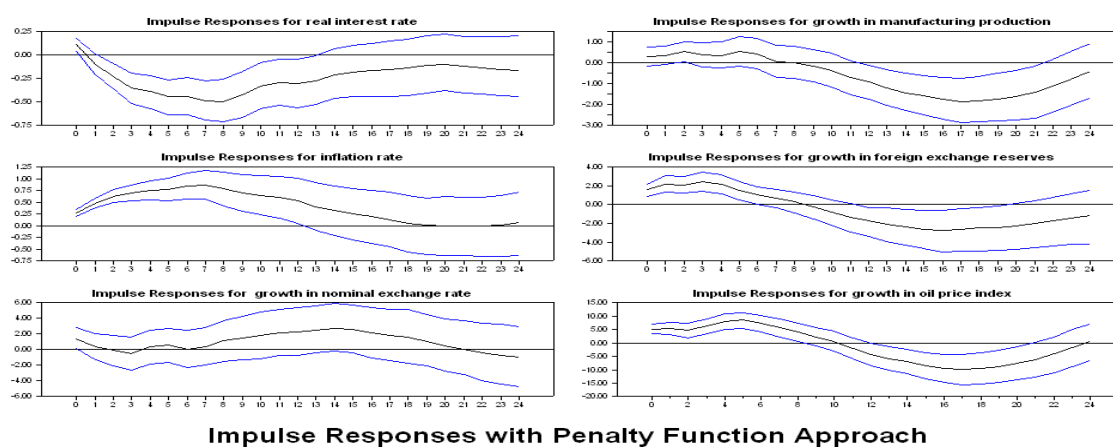
Appendix D 3 Orthogonality assumptions using foreign exchange definition

Figure Appendix D 3-1 REER depreciation and inflation shock
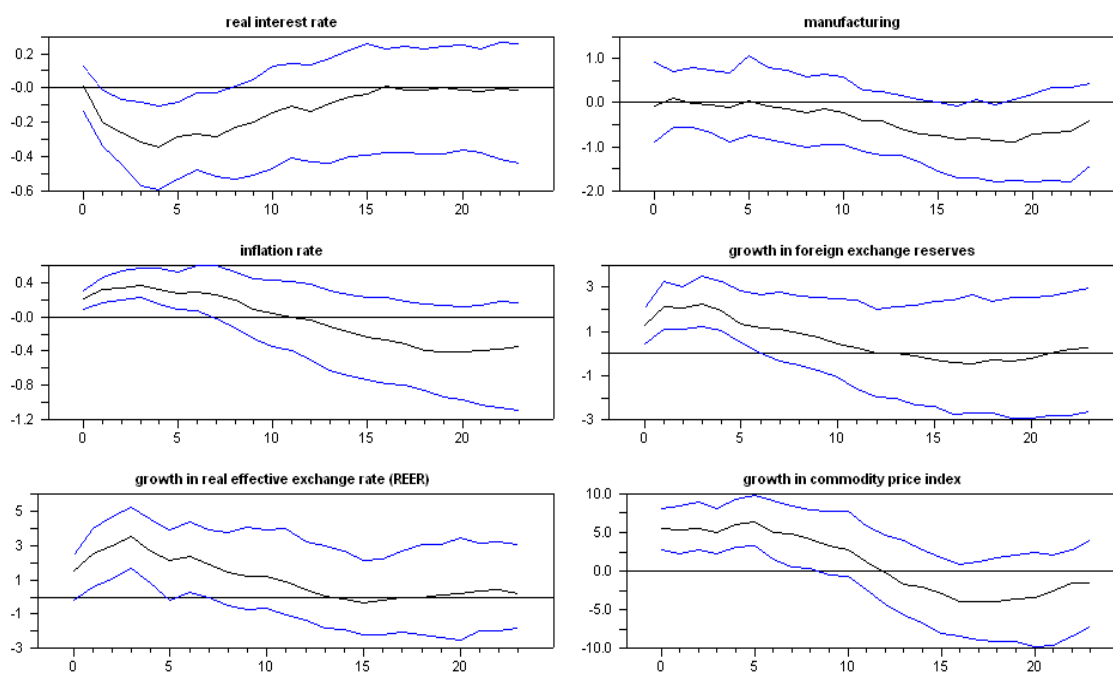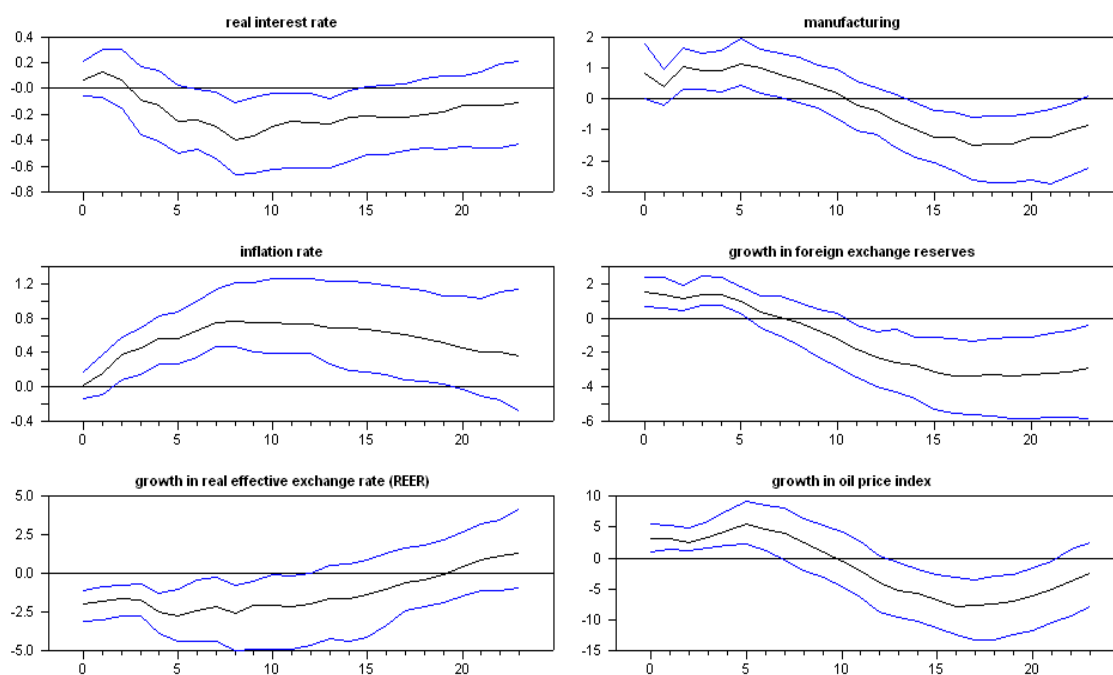

Responses to REER depreciation shock
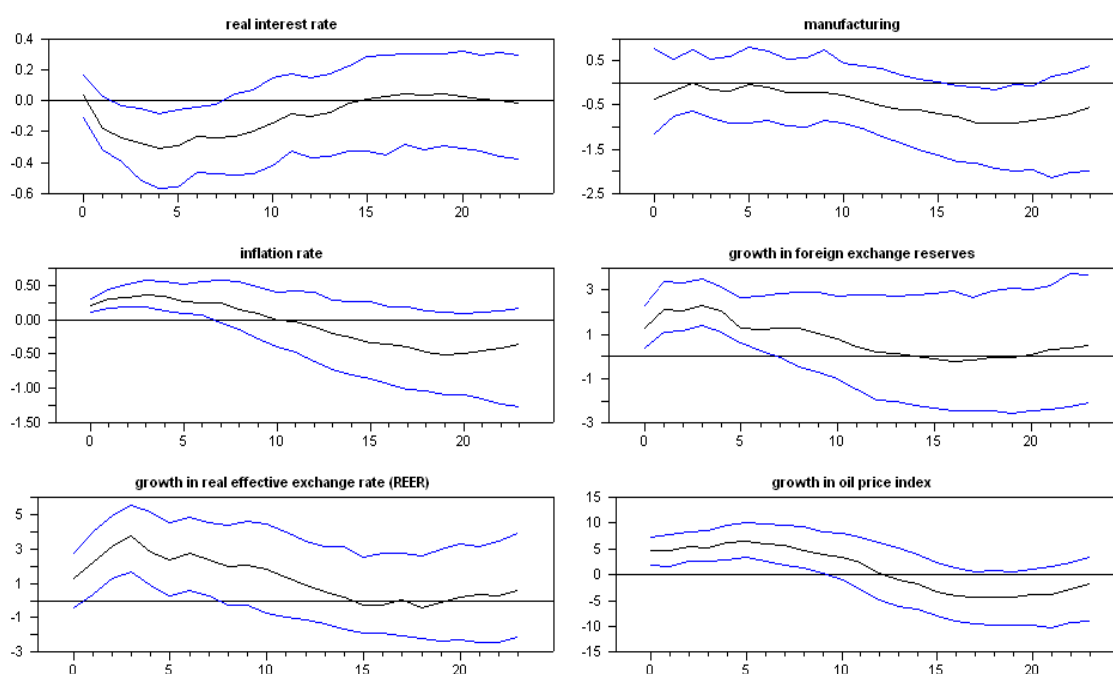
Responses to Inflation shock

Figure Appendix D 3-2   NEER depreciation and inflation shocks
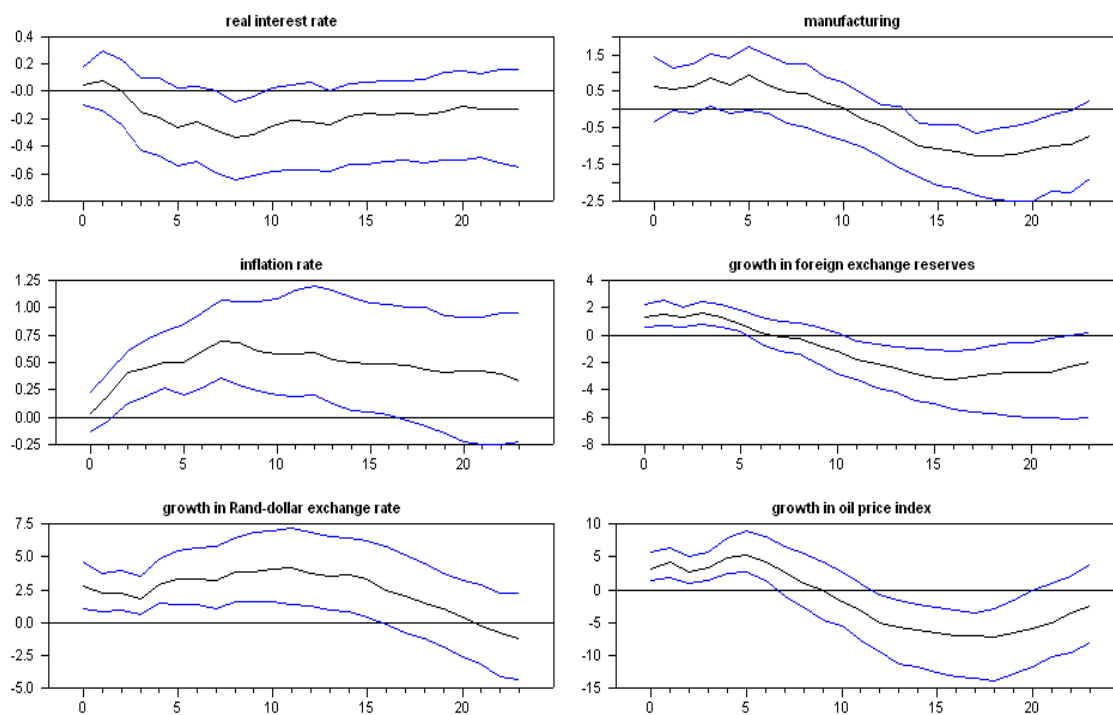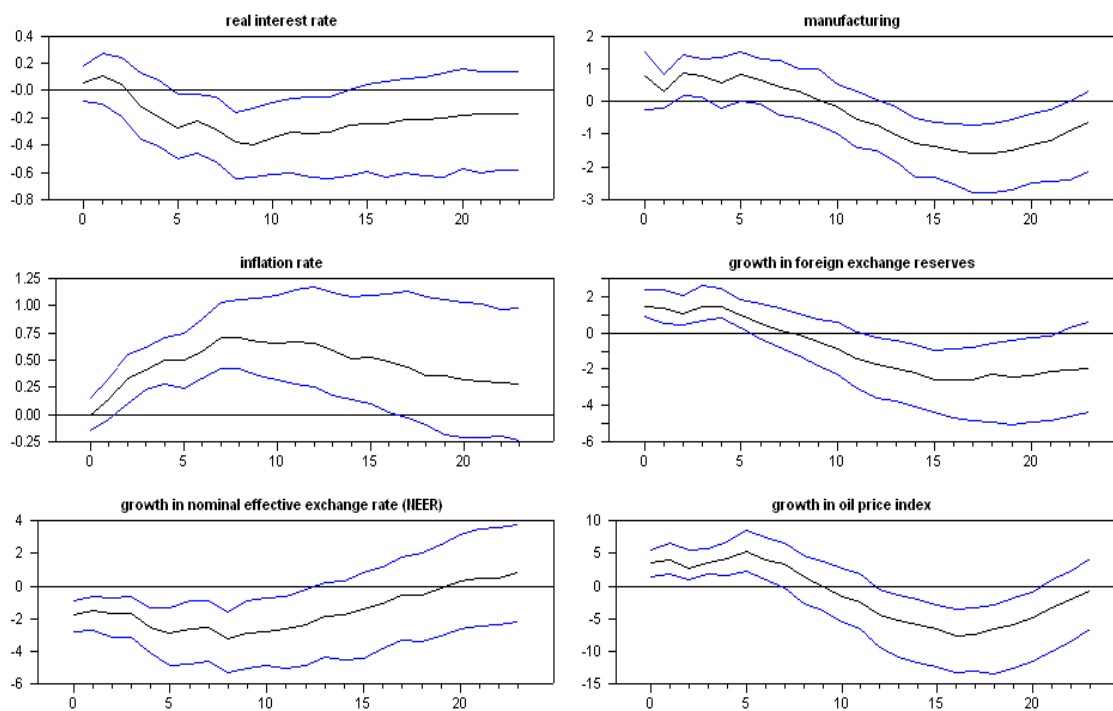

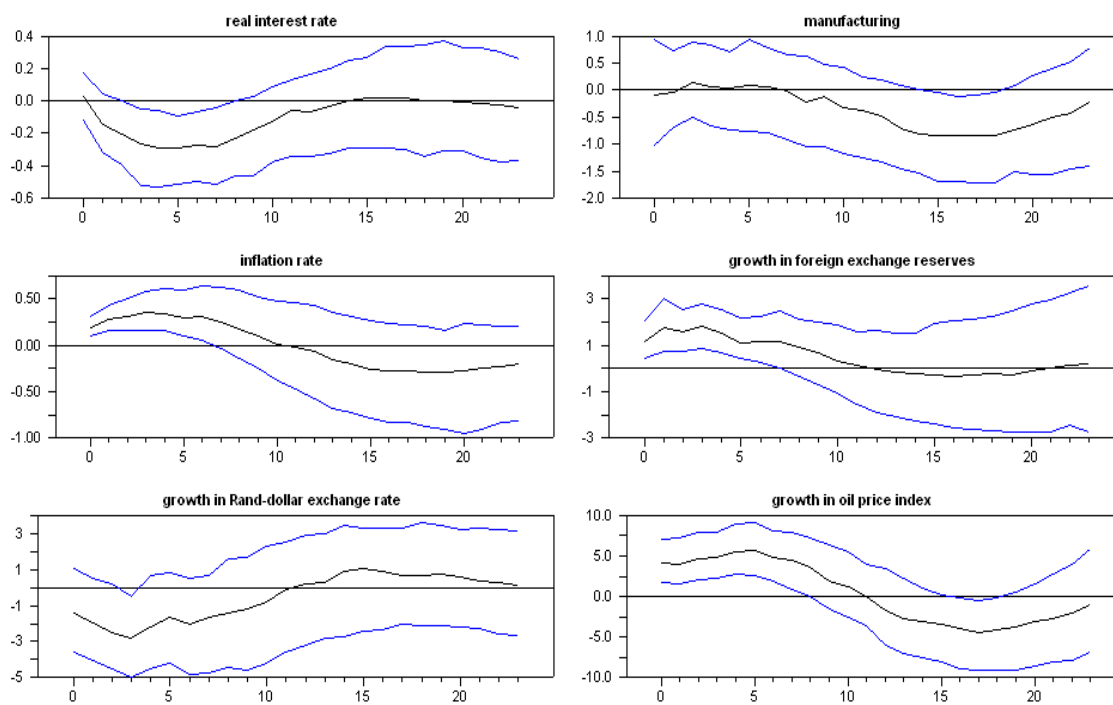Responses to NEER depreciation shock
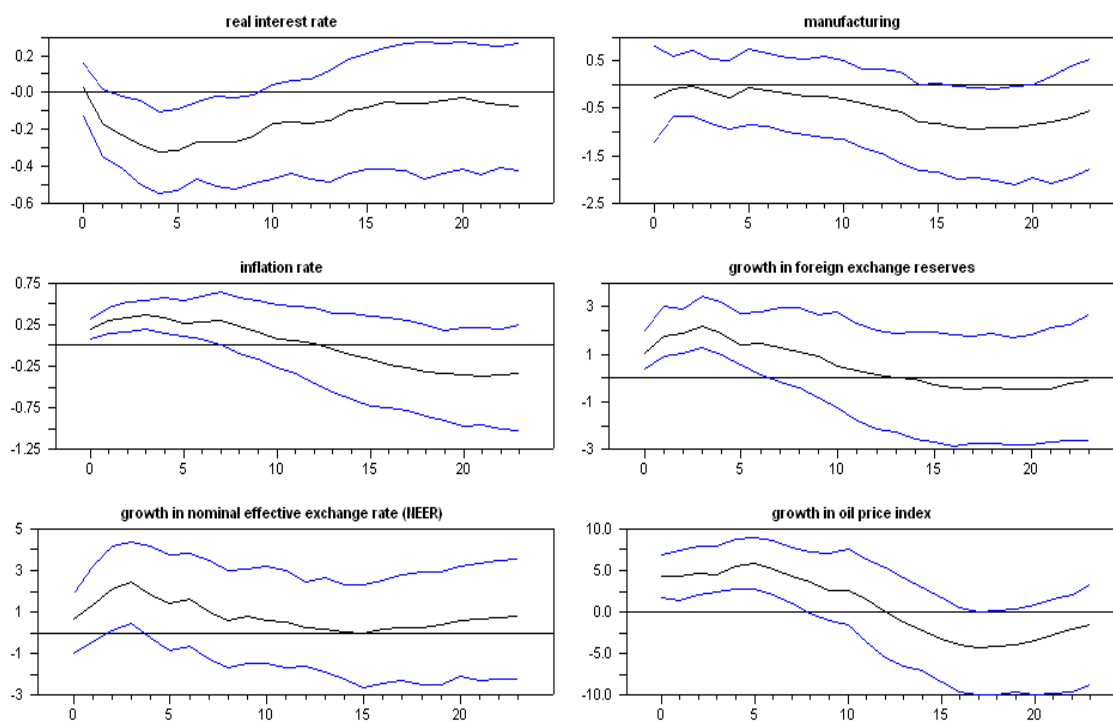
Responses to Inflation shock

Figure Appendix D 3-3 Rand depreciation and inflation shocks
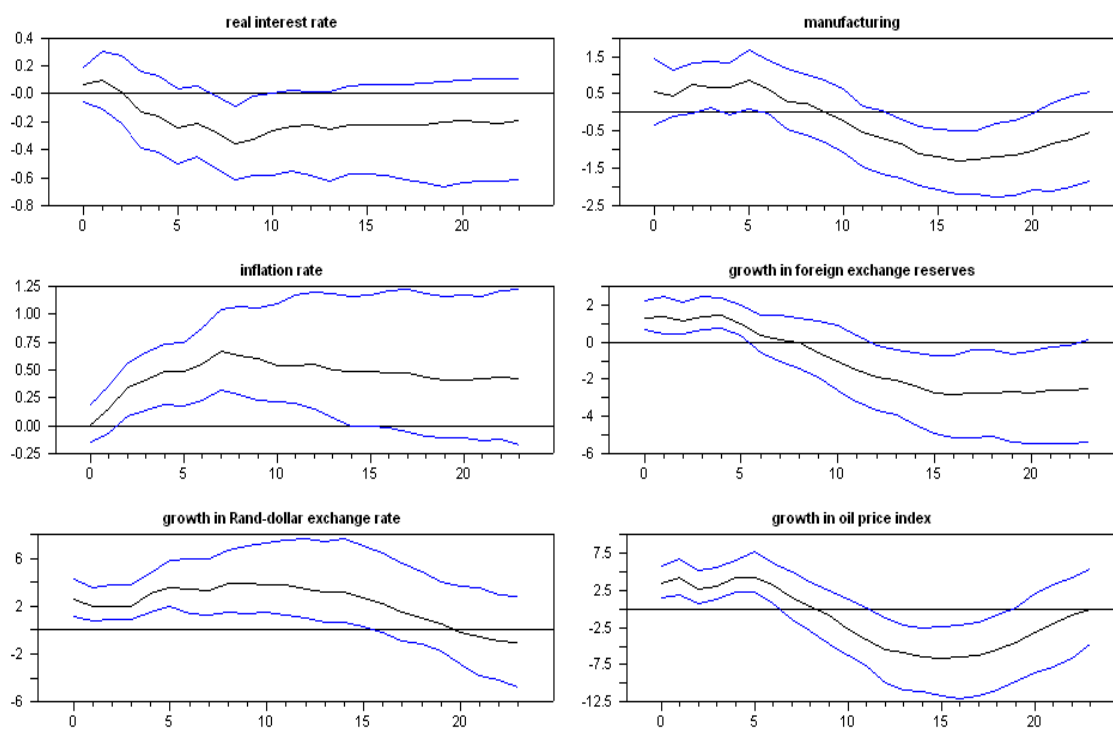
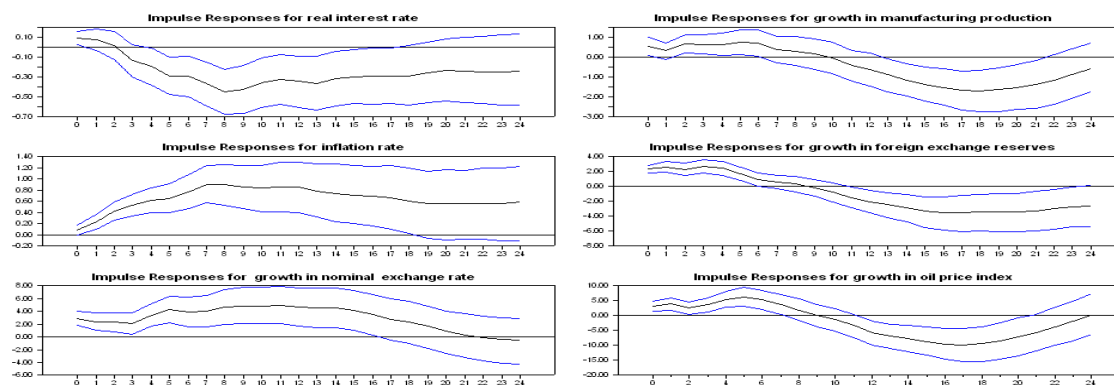Responses to Rand depreciation shock
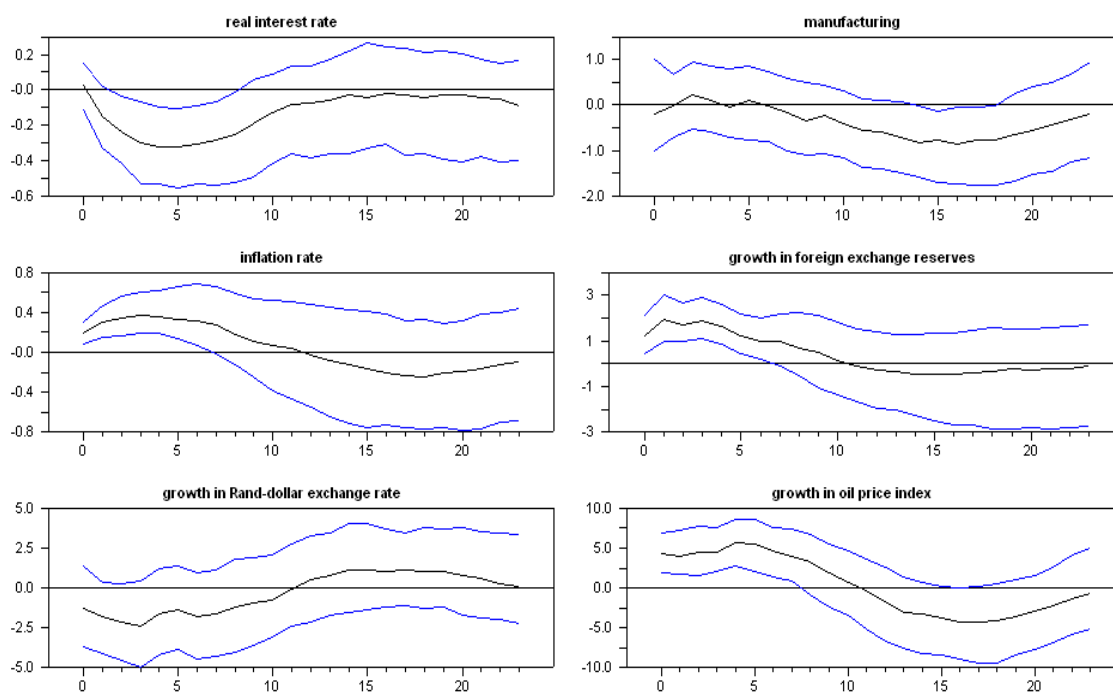
Responses to Inflation shock

CHAPTER 4 : MONETARY POLICY AND EXCHANGE RATES SHOCKS ON TRADE BALANCE

4.1 Introduction

Chapter 4 focuses on two fundamental questions in South Africa: (1) Does the contractionary monetary policy shock affect the trade balance in a different way compared to exchange rate appreciation shocks? (2) Does monetary policy affect the trade balance through the expenditure switching or income channel? The latter question has implications for monetary authorities concerned about facilitating economic growth through the net exports channel while the former encompasses all relevant economic policy-makers. Any evidence that is consistent with the expenditure switching effect implies that monetary authorities can change the direction of demand between domestic output and imported goods through exchange rate adjustment.

The effects of monetary policy and the exchange rate on the trade balance remain an important topic among academics and policy-makers because of the policy implications. Ivrendi and Guloglu (2010) explained two theoretical hypotheses linking monetary policy to both exchange rates and the trade balance in open economies. The first hypothesis suggests that monetary policy affects the exchange rate through the overshooting hypothesis, suggesting that a contractionary monetary policy shock initially leads to the appreciation of the exchange rate followed by a gradual depreciation. The second hypothesis suggests that monetary policy affects the trade balance via either the expenditure switching or the income absorption channel. The expenditure switching effect implies that the contractionary monetary policy leads to currency appreciation through capital inflows thereby worsening the trade balance. Hence, an exchange rate appreciation makes the values of imported goods and services cheaper relative to exports. In contrast, the income absorption effect shrinks real GDP and real imports, leading to a trade balance improvement. When the expenditure switching effects dominate the income absorption effects, the trade balance deteriorates and vice versa. A depreciation (appreciation) of the domestic currency against other currencies improves (deteriorates) the trade balance, but might worsen (improve) it in the short run, generating a *J*-curve.

The motivations for this study are based on the institutional policy framework and on the lack of empirical studies that separate the income and expenditure switching effects, through

which monetary policy can affect the trade balance. Hence, a distinction between the channels is important for proper policy prescriptions. First, this analysis contributes to literature on methodological aspect by comparing the effects of contractionary monetary policy and exchange rate appreciation shocks on South Africa`s trade balance using the sign restriction approach. These shocks use sign restriction based on the existing empirical literature and structural models. Second, to the best of my knowledge, no study has done this analysis to answer these South African questions and this approach differs from Fratzscher et al. (2010) because the latter authors` study answers a different question. In addition, this study is interested in contributions of trade balance to gross domestic product.

Finally, the institutional policy issues raised in the New Growth Path (NGP) points to growth phase in 2000s with imbalances in the economy shown by persistent trade deficits. Figure 4-1 shows the gap between the real imports and exports merchandise as percentage of gross domestic output widened since 2003Q4. The NGP further suggests trade deficits are funded with short-term capital flows attracted by relatively higher South African interest rates by international standards. Furthermore, the NGP argues that a strong currency even though it enables reductions in interest rates, leads to cheaper imports, lowers manufacturing and tradable-goods sectors` competitiveness, and generates consumption in the country's upper income group. The NGP proposed strategies which require stronger focus on exports to regions including the rapidly growing economies and that monetary policy should do more to support competitive exchange rates and reduce real interest rates. As a result the chapter investigates what drives the widening trade gap shown in Figure 4.1.

Figure 4-1 Real imports and exports as percentage of gross domestic product
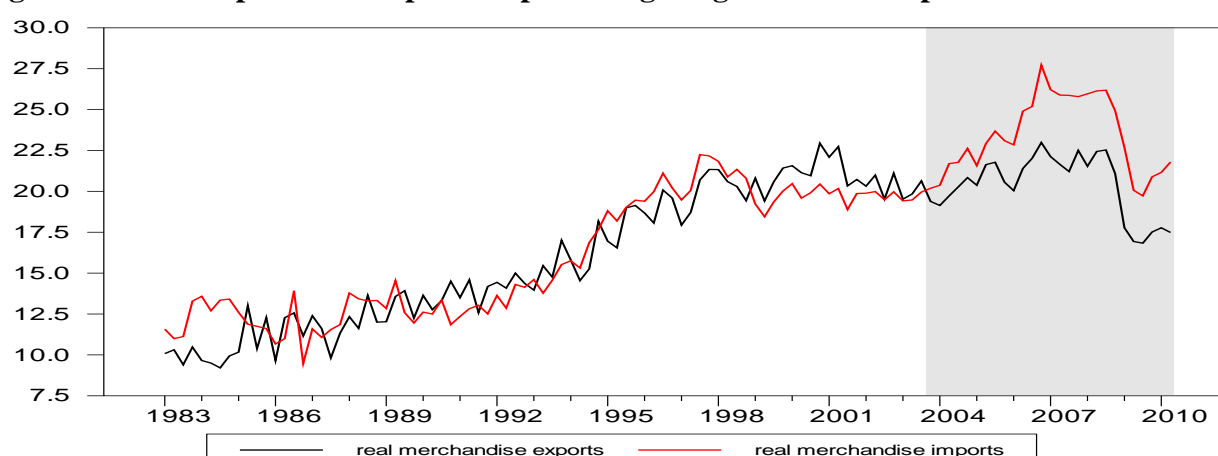
It is due to the above stated reasons, that an understanding of how monetary policy affects trade balance is very important for monetary authorities to appropriately give support to competitive exchange rates. In addition, it is very important to distinguish the appropriate channel in which monetary policy affects trade balance either through the expenditure switching channel through adjusting exchange rates or through the income effect. In identifying factors driving the trade balance gap, this chapter includes the relative interest rates, consumption, and exchange rates variables identified in the New Growth Path document.

The organization of the analysis is as follows: Section 4.2 reviews the literature; Section 4.3 derives a theoretical model which includes all these variables and explains the sign restrictions in the empirical analysis. Section 4.4 presents the data, while Section 4.5 discusses the empirical results. Section 4.6 gives the conclusion and two appendices.

4.2   Literature review

Empirical evidence on the effects of monetary policy on exchange rate has been controversial and most findings confirm that contractionary monetary policy shock effects on an exchange rate are not contemporaneous. Eichenbaum and Evans (1995) found that following a monetary policy shock, the domestic currency appreciates for a substantial period, which is inconsistent with the predictions of overshooting hypothesis. Grilli and Roubini (1995) analyzed the response of the exchange rate to a contractionary monetary policy shock and found initially a gradual appreciation of the exchange rate and then the appreciation is followed by gradual depreciation. This exchange rate response is referred to as delayed overshooting puzzle and is a violation of the uncovered interest parity condition. Scholl and Uhlig (2008) indicated there may be a forward discount puzzle even without delayed overshooting. Jang and Ogaki (2004) found using the SVECM that a contractionary monetary policy leads to an appreciation in domestic currency after the shock and the peak response occurs within four months and carried on for five years. They claimed that they found evidence for the overshooting behavior of exchange rate. [49]

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[49] The theoretical literature on monetary policy and trade (or current account) imbalances has recently focused on open macroeconomic models that allow short-run price (or wage) rigidities, market imperfections and international capital mobility. These models let researches to analyze the impact and dynamic effects of monetary policy shocks, in the presence of sticky prices, market imperfection and capital movements, on various macroeconomic variables.

The other hypothesis that relates monetary policy to trade balance is called the J-Curve hypothesis. This hypothesis suggests that a real depreciation of domestic currency lowers the relative price of domestically produced goods, which in turn increases the exports and reduces the imports of the country. The J curve theory argues the trade balance adjustment is not immediate since quantities of imports and exports do not adjust at the same time but the value of imports rise leading to a trade balance deficit. This means that the trade balance deteriorates due to the depreciation of domestic currency in the short run. The expansionary monetary policy on trade balance causes a trade deficit and then leads to a trade surplus giving an impression of J curve.

Literature evidence has been supportive of the j-curve theory. Koray and McMillin (1999) found a J curve trade balance response to monetary policy shocks. Nadenichek (2006) investigated the dynamic responses of the trade balance to movements in the real exchange rates between the US and other G-7 countries and found evidence of a J-curve in five countries. Lee and chin (1998, 2006) analysed the relationship amongst monetary policy, the current account, and real exchange rate variables for seven industrialised countries. They found a J-curve evidence and that monetary policy shocks explained high volatility of the US current account. Lane (2001) used a set of VAR models using different alternative schemes in exploring the role of monetary policy shocks in the US current account, and found evidence consistent with a J-curve and that monetary policy explained high volatility of the US current account.

The traditional Mundell–Flemming–Dornbusch (MFD) predicts that a monetary expansion leads to depreciation in the nominal exchange rate and a deterioration of the terms of trade. This adjustment resulting in improved trade balance is known as the expenditure-switching effect, whereas, the income-absorption effect occurs when this same policy stimulate domestic demand, through an increase in imports worsening the trade balance. While the two effects move the trade balance in opposite directions, the movements of the trade balance are determined by the dominant effect (Kim, 2001). Kim (2001)`s results are consistent with the expenditure switching effect, but there is little evidence of the J-curve effect. Ivrendi and Guloglu (2010) found that a contractionary monetary policy shock leads to an improvement in the trade balance, contradicting the findings of trade puzzles reported in many empirical studies. Prasad and Gable (1998) concluded that monetary expansion in most industrial economies is linked, in the short run, to the improvement in the trade balance and has significant effects on trade-balance fluctuations.

Despite the effects of monetary policy and the exchange rate on the trade balance remaining important topic among academics and policy-makers because of the policy implications, the empirical results tend to provide conflicting results. The econometric investigations of monetary policy shocks on the trade balance have been done using multivariate models such as VAR, SVAR, SVECM and VECM.[50] Various models estimated used certain assumptions such as cointegration relationship among variables and through imposing other structural restrictions. Ivrendi and Guloglu (2010) argue that most of the conflicting empirical results in empirical literature are due to the consequences of restrictions imposed on the models stated above.

Ivrendi and Guloglu (2010) investigated the relationships among monetary policy shocks, the exchange rate and the trade balance in five inflation-targeting countries using SVECM, with both long-run and short-run restrictions. The long-run restriction imposed in the model suggests that money has no effect on the real macroeconomic variable in the long run. This assumption is consistent with both the Keynesian and monetarist approaches. These parametric VAR models are criticised for failing to produce models where shocks have the desired properties resulting in price and exchange rate puzzles. These puzzles have been reported in literature applying recursive VAR approach. In addition, recursive results are sensitive to changes in the ordering of variables (Sarno and Thornton, 2004). An alternative approach to overcoming the criticism was proposed by Uhlig (2005), a less structured approach in which the shock is identified by sign restrictions satisfying the prior economic understanding of how a particular shock should behave. Fratzscher et al. (2010) used sign restrictions to analyse the US current account.[51]

4.3   Methodology

4.3.1   Theoretical model

This chapter assumes a small open economy with goods and financial markets represented by standard IS-LM framework. The goods market equilibrium equation [4.1] expresses national income (Y_t^{dom}) as function of consumption (C_t), investment (I_t), Government spending (G_t),

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[50] Structural Vector Autoregression models (SVAR), Structural Vector Error Correction Models (SVECM), Vector Error Correction Models (VECM),

[51] Uhlig (2005) imposed the sign restrictions for several periods. Unlike Canova and de Nicolo (2002), the Uhlig (2005) identification was based on impulse responses and not on cross correlations.

exports (EXP_t) and imports (IMP_t). Exports depend upon foreign income (Y_t^{for}) and real exchange rate (E_t^R) while imports depend on domestic income and real exchange rate. The focus in this derivation is on determinants of the trade variables, the main variables for the analysis.

[4.1] $Y_t^{dom} = C_t + I_t + G_t + EXP_t(Y_t^{for}, E_t^R) - IMP_t(Y_t^{dom}, E_t^R)$

The real exchange rate in equation [4.2] is expressed as relative price of foreign prices in domestic currency to domestic prices.

[4.2] $\quad E_t^R = E_t P_t^{for} / P_t^{dom}$

Equation [4.3] defines net exports (NX_t) as the difference between exports and imports.

[4.3] $\quad NX_t(Y_t^{dom}, Y_t^{for}, E_t^R) = X_t(Y_t^{for}, E_t^R) - IMP_t(Y_t^{dom}, E_t^R)$

Hence, I substitute equation [4.3] into [4.1] to get the equation [4.4]

[4.4] $\quad Y_t^{dom} = C_t + I_t + G_t + NX_t(Y_t^{dom}, Y_t^{for}, E_t^R)$

The derivation incorporates the money markets equilibrium stating that money supply equals money demand as shown by equation [4.5]. The real money demand depends on the level of transactions in the economy measured by real output and the opportunity costs of holding money compared to holding bonds that earn the nominal interest rate (i_t^{dom}).

[4.5] $\quad M_t \big/ P_t = L_t(Y_t^{dom}, i_t^{dom})$

Arbitrage is important in financial markets. Equation [4.6] shows that exchange rate depends on domestic and foreign interest rate, and future exchange rate assuming investors can choose between domestic and foreign bonds (i_t^{for}). Investors would exchange foreign currency for domestic currency when repatriating currency.

[4.6] $E_t = \dfrac{1+i_t^{for}}{1+i_t^{dom}} E_{t+1}^e$

The goods and financial markets are linked by equation (4.6) using the real exchange. The real exchange rate is given by equation [4.7].

$$[4.7] \quad E_t^R = \left(\frac{1+i_t^{for}}{1+i_t^{dom}} \right) \left(\frac{P_t^{for}}{P_t^{dom}} \right) E_{t+1}^e$$

Substituting the real exchange rate equation [4.7] into equation [4.4] shows that net export depends on domestic and foreign interest rates; prices, output, and expected exchange rate.

$$[4.8] \quad Y_t^{dom} = C_t + I_t + G_t + NX_t (Y_t^{dom}, Y_t^{for}, \left(\frac{1+i_t^{for}}{1+i_t^{dom}} \right) \left(\frac{P_t^{for}}{P_t^{dom}} \right) E_{t+1}^e)$$

Dividing equation [4.8] by national income (Y_t^{dom}) gives the contribution of each component. All components add up to one hundred percent. The last component of equation [4.9] shows net exports as percentage of national income, imports, and exports respectively

$$[4.9] \quad 1 = \frac{C_t}{Y_t^{dom}} + \frac{I_t}{Y_t^{dom}} + \frac{G_t}{Y_t^{dom}} + \frac{NX_t (Y_t^{dom}, Y_t^{for}, \left(\frac{1+i_t^{for}}{1+i_t^{dom}} \right) \left(\frac{P_t^{for}}{P_t^{dom}} \right) E_{t+1}^e)}{Y_t^{dom}}$$

I now state the assumptions I make in this empirical analysis. First, the empirical section uses consumption rather than the national income for two reasons. Consumption is the largest contributor to GDP averaging nearly 60 per cent and this study is interested in contributions of trade balance to GDP. In addition, using consumption variables captures changes in consumption function between domestic and foreign goods. However, the disadvantage is that using consumption creates another loop in the transmission mechanism. Second, the chapter uses relative inflation rates rather than price levels, which are consistent with the importance of inflation rate rather than consumer price levels. Third, I use current exchange rate rather than expected exchange rates.

4.3.2 Econometric model

The methodology applied in this analysis is similar to the approach in Chapter 3 but uses two shocks in the main section and four shocks in robustness analysis. Fry and Pagan (2007) suggested that sign restrictions provides a useful technique for quantitative analysis, when variables are simultaneously determined (e.g. exchange rate and interest rate) making it harder to justify any parametric restrictions to resolve the identification problem. However, Scholl and Uhlig (2008) rejected to embrace Fry and Pagan (2007)'s argument related to non-uniqueness of the median impulse response in sign restrictions as an issue arising generally with all identification procedures. Even, Fry and Pagan (2007), admit that identification issues affect all forms of VARs, not only those using sign restrictions. Structural vector

autoregression models (SVARs), structural vector error correction models (SVECMS) and vector error correction models (VECM). Busch (2010) argues that it is possible to identify five structural shocks when given five endogenous variables in a model. However, it is common practice in sign restriction literature to have fewer shocks than the identified number of endogenous variables (see Uhlig 2005; Mountford and Uhlig,2009; Fratzscher et al., 2010) This chapter identifies two structural shocks: the contractionary monetary policy shocks and exchange rate appreciation shocks in South Africa in the framework of VAR.

This analysis modifies the methodological specification in Fratzscher et al. (2010) to estimate a VAR in an open-economy framework to account for the international transmission mechanism. The variables are expressed in a vector Y_t in equation [4.15]

$$[4.15] \quad Y_t = [c_t - c_t{}^*, p_t - p_t{}^*, i_t - i_t{}^*, exch_t, tb_t]'$$

where South African variables are consumption (c_t) and the exchange rate $(exch_t)$, inflation rates (p_t), the money-market interest rate (i_t) and the trade balance (tb_t) expressed as a percentage of the South African gross domestic product. Ivrendi and Guloglu (2010) used the trade balance measured in terms of logarithms of the ratio of nominal exports to nominal imports following the precedent in Koray and McMillin (1999). However, the log form of the ratio of export to import is the export coverage of imports and not trade balance.[52] Instead, this section uses the difference between exports and imports, expressed as percentage of GDP, which is consistent with specification in equation [4.9]. US variables are private consumption $(c_t{}^*)$, inflation $(p_t{}^*)$ and federal funds rate $(i_t{}^*)$. The private consumption gap is given by $(c_t - c_t{}^*)$, the inflation gap by $(p_t - p_t{}^*)$ and the interest rate gap is denoted by $(i_t - i_t{}^*)$. However, the real effective exchange rate $(REER)$ is the main exchange rate variable in the analysis. This methodology uses relative variables because both the trade balance and exchange rates are essentially relative flows or prices as done in Fratzscher and Straub (2009). Expressing consumptions, inflation rates, and interest rates as relative variables is consistent with this empirical specification.

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[52] Their reason to use the logarithm of the ratio of export to import approach was to reduce the scale and not to destroy the statistical properties of the cointegration equations. They were aware that some authors defined the trade balance as exports minus imports such as Kim (2001).

The study controls for the US effects due to a number of reasons and test the effects of aggregation using OECD data. OECD data includes some countries that are not South Africa`s main trading partners hence the determinants of trade balance may be neutralized and distorted by aggregation. It is not the appropriateness of OECD variables which matters but the origins of latest financial crisis, its effects onto the rest of the world and how US Federal Reserve responded. First, the global economy has remained uncertain following the onset of the 2007 US financial crisis and the subsequent global recession in 2008. The US subprime mortgage crisis effects were transmitted onto the rest of the world leading to the global recession in 2008.[53] Second, the unexpected huge US quantitative easing programme lowers interest rates and widens the relative rates, prompting capital flows into emerging markets, and appreciating these currencies hence distorting trade balances. All these unexpected effects induced global trade imbalances, thereby affecting growth projections since 2010. Capital flows affected the South African equity market thereby affecting the cost of raising capital and rand-dollar exchange rates. Third, policy discussions in South Africa mostly focus on the rand–dollar exchange rates, which is often the currency for invoicing trade transactions. This happens despite the euro area being South Africa's biggest trade partner.

Fourth, for a long time the US remains South Africa's major trading partner and member of strategic trade initiatives such as African Growth and Opportunity Act (AGOA). There has been an increasing integration in trade between US and South Africa possibly strengthened by the AGOA that was signed into law at the end of 2000. This is attested by the International Monetary fund's IFS direction of trade statistics, which shows the value of exports from South Africa to US has increased from $400 million in 1998Q4 to $3 billion in 2007Q4. Fifth, the weight of US trade is about ten per cent in the calculation of South African trade weighted real exchange rate. This motivates the inclusion of US variables in this study.

Finally, South Africa is commodity exporter of minerals whose demand is mainly exogenous and prices are set in external markets including the US Chicago Mercantile Boards. Hence, the robustness section would include relative stock prices, which also reflects price developments in commodity markets.

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[53] Current-account theory suggests a country with trade balance deficit should expect its currency to depreciate but this will depend on elasticity of demand and supply of goods and Marshal Lerner condition.

The Model 1 (benchmark VAR) in Table 4-1 identifies the contractionary monetary policy and exchange rate appreciation shocks. Moreover, the shock effects should last at least two quarters (see Fratzscher et al., 2010; Uhlig 2005). The signs imposed follow the literature's empirical specifications that uniquely identify these shocks and not shocks that are already included, or those excluded in the model specification and have economic meaning. Granville and Mallick (2010) argue that the sign restriction method is robust to the non-stationarity of series, including structural breaks. According to Rafiq and Mallick (2008), the sign restriction approach does not impose any cointegrating long run relationship between variables and does not preclude their existence. Consequently, Table 4-1 does not impose any long run restrictions on any variables. In addition, the trade balance is unrestricted by the design of the identification procedure for the data to decide. The contractionary monetary policy and exchange rate appreciation shocks represent a one standard deviation increase.[54]

Table 4-1 Model 1 identification

Shocks	c_t-c_t*	p_t-p_t*	i_t-i_t*	$exch_t$	tb_t
Monetary policy	?	-	+	+	?
Appreciation	+	-	-	+	?

The signs in Table 4-1 follow the predictions of conventional theories and previous empirical evidence. These restrictions identifying the monetary policy shocks are standard and widely accepted in the sense that restrictive monetary policy shocks cause interest rates to increase, the exchange rate to appreciate and price level to fall. However, there is a specific transmission sequence of these effects. The contractionary monetary policy shocks suggest that interest rate increases lead to currency appreciation that exerts downward pressure on inflation through lowering the import component.[55] In addition, the effect of contractionary monetary policy shocks on consumption is unrestricted and left for the model to decide. The aggregated consumption measure comprises of durable, non-durable and services components. These components react differently to an interest rate shock, with most literature suggesting durable goods being more interest sensitive than both nondurable and services. Therefore, the specifications leaves consumption unrestricted because I wish not to prejudge such an outcome but leave the result to tell the story. The exchange rate appreciation shock is defined by decreases in both relative inflation and interest rates, whereas relative

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[54] The trade balance is a gap variable between aggregated exports and imports from trading partners. REER or NEER are aggregated exchange rate measures adjusted for prices and currencies of trading partners respectively.
[55] Rafiq and Mallick (2008) imposed a similar restriction that a positive interest rate shock should appreciate the exchange rate. Moreover Krugman and Obstfeld (2003) shows diagrammatically that a high interest rate should appreciate domestic currency.

consumption increases.[56] An exchange rate appreciation would lower the domestic prices of imports hence the inflation rate, prompting a decrease in the interest rate that stimulates domestic consumption.

Table 4-2 shows the specification where the effect of exchange rate is left unrestricted. This specification suggests the exchange rate may respond in either direction reflecting many fundamentals rather than monetary policy effects.

Table 4-2 Model 2 identification

Shocks	c_t-c_t^*	p_t-p_t^*	i_t-i_t^*	$exch_t$	tb_t
Monetary policy	?	-	+	?	?
Appreciation	+	-	-	+	?

There are policy implications for monetary authorities that are consequential from the manner in which contractionary monetary policy shocks affect the trade balances. These effects move the trade balance in opposite directions hence the dominant effect determines the sign on trade balance. The negative trade balance response indicates the dominance of the expenditure switching effect over the income absorption effect. In this instance, a higher interest rate worsens the trade balance through appreciating the exchange rate. A positive trade balance response points to the dominance of income absorption effects over expenditure switching effects. The income absorption effect shrinks real GDP and real imports, leading to a trade balance improvement. Finding any evidence consistent with expenditure switching implies that monetary policy can influence the shift between domestic and imported goods through the exchange rate adjustment. Lastly, theory predicts that exchange rate appreciation worsens the trade balance whereas depreciation improves it. However, the trade balance may deteriorate (improve) in the short run before improving (worsening) in the long run, giving a J-curve effect after a currency depreciation (appreciation).

4.4   Data

The analysis uses quarterly (Q) data obtained from the International Monetary Fund's IFS database in the period of financial liberalisation, beginning in the first quarter of 1983 and

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[56] Pilbeam (2006) showed that consumer price index is calculated using the weighted exports and import components. Hence a domestic currency appreciation should lower import component of consumer price index. Fratzscher et al. (2010) showed the same sequence of events using the similar logic.

ending in the second quarter of 2010.[57] South African variables include inflation rates, interest rate, consumption, the nominal effective exchange rate $(NEER)$, the all-share stock index, the real effective exchange rate $(REER)$, rand–dollar exchange rate $(RAND)$ and the trade balance as a fraction of GDP. The US variables are the federal funds rate representing the interest rate, S&P 500 for stock index, the inflation rate and the consumption index. The consumption indices are calculated by deflating the values by their 2005 average value as the base year. Indices are independent of units of measurement and eliminate problems of using currencies as units of measurement.

Table 4-3 Descriptive statistics

Variable	Mean	Minimum	Maximum	Std error
South Africa NEER	182.25	63.90	620.60	127.15
South Africa REER	108.41	65.80	172.20	20.31
United States federal fund rate (%)	5.09	0.12	11.39	2.67
South Africa money market rate (%)	12.61	6.53	22.50	4.20
S & P 500	63.51	12.02	130.26	38.43
South Africa All share index	55.62	9.05	206.87	48.10
South African consumption index	65.72	24.86	116.01	28.26
United States consumption index	53.55	5.27	157.97	44.78
Trade balance / GDP (%)	0.34	-0.12	1.89	0.43
Rand per US dollar (R/$)	4.86	1.09	12.13	2.59
United States inflation rate (%)	3.00	-1.60	6.20	1.25
South Africa inflation rate (%)	9.70	0.40	19.30	4.63

Note. Std refers to standard.

Table 4-3 gives the summary of descriptive statistics of all variables. The standard deviation of the NEER exceeds those of both REER and rand–dollar (R/$). The South African money-market interest rate has both higher mean values and standard deviation compared to the US federal funds rate. However, the S&P500 has a lower standard deviation compared to the All-Share Index (Alsi). The South African consumption index and the Alsi deviate from their trends by larger values compared to the corresponding US variables. The trade balance, as a fraction of GDP, has shown less variability and the average represents 0,34 per cent of GDP. The inflation rates also vary between the two countries with the minimum negative US value representing a deflationary environment while the South African one does not. The South African inflation rate displays more variation compared to the US inflation rate.

Figure 4-2 shows the time paths of all variables for South Africa and US. I plot some variables together as defined in Table 4-1. The first column in Figure 4-2 compares the South

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[57] Aron et al. (2001) indicated that 1983 saw the ending of agreements among commercial banks, which limited competition and it was a period that saw a large number of new banks being allowed to start new operations.

African variables with the US equivalents. The solid lines represent South African variables and the dotted lines represent US variables. First, the South African consumption index was lower than the US consumption index between 1983 and 2005. Second, the South African inflation rates were higher than the US inflation rates except in two periods between early 2000 and around 2004. Third, over all the horizons, the South African money-market interest rates exceed the US federal funds rate. In most cases, South African interest rates follow the trends of the United States federal funds rate. Fourth, the South African Alsi tracked the S&P 500 stock index for most periods until it rose above it in 2006.

This close correlation in stock indices movements shows that the South African stock index tracks and mirrors the global stock index. The second, column in Figure 4-2 shows the individual South African variables. The increase in the NEER and REER represents an appreciation but depreciation in the rand–dollar (R/$) exchange rates in Figure 4-2. The NEER depreciated significantly for most periods between 1983 and 2010. The REER appreciated slightly after 2002. The trade balance deteriorated for some time after 2005.

Figure 4-2   Plot of variables
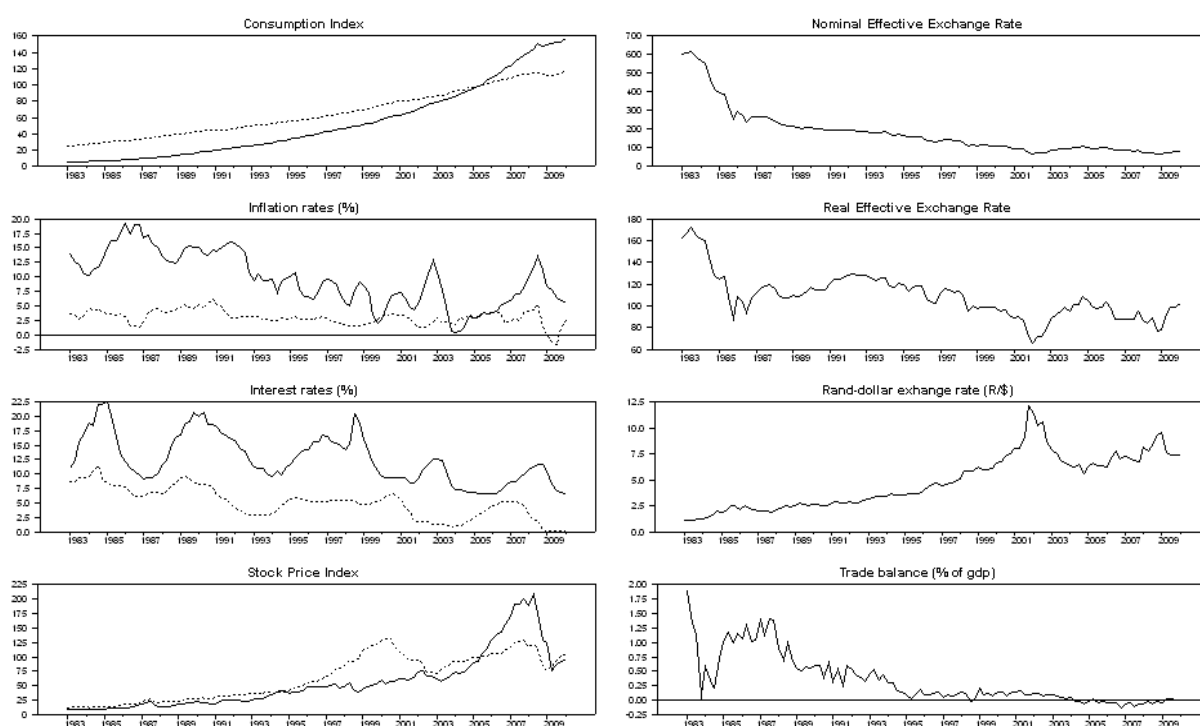
Notes. The solid lines represent South African variable and dotted lines represent US variables. The South Africa equity variable is All-share index. US equity price is the S & P 500 index. The base year for all stock indices is 2005.

4.5   Results

All the impulse responses from two shocks in a Model 1(benchmark VAR) are estimated using two lags selected by Akaike Information Criteria and shocks set to last at least two quarters. The estimation strategy starts from a simple VAR and moves upwards in relation to the model size. Apart from the interest rates and trade balance, which are in percentage, all other variables are expressed in logarithmic form.[58] This analysis compares the impact of exchange rate appreciation shock and contractionary monetary policy shock on the trade balance in South Africa as defined in Table 4-1 and Table 4-2. The later sections deal with the various robustness analyses of the results. The impulse responses represent the median impulse and the bands represent the 16 and 84 percentiles based on our inferences on 10 000 replications.[59]

Before estimating the benchmark VAR sign restriction, the chapter estimates a recursive VAR shown in Figure Appendix A 4-1 using different orderings and found that exchange rate appreciation shock significantly depresses the trade balance but not permanently. However, the decline in trade balance due to contractionary monetary policy is not significant but points to expenditure switching effect. Moreover, the estimation shows that contractionary monetary policy leads to price and exchange rate puzzles. Thus, price level increases whereas the exchange rate depreciates. These are puzzling results, which we correct only through using the sign restriction approach. Specifically I use sign restriction to eliminate (1) the price puzzle by design and correct the wrong exchange response on impact (2) the delayed exchange rate overshooting phenomenon. The overshooting phenomenon occurs when contractionary leads to exchange rate appreciation over longer horizons than predicted by the uncovered interest rate parity conditions.

I now proceed to use sign restriction approach and impose the signs to remove the exchange rate and price puzzle. Hence, I remove not only the wrong exchange rate response but also the delayed overshooting phenomenon reported in literature. As a result, I start by examining the distribution of the initial impacts of exchange rate and trade balance response to contractionary monetary policy using a VAR with two lags selected by AIC. We are more interested in the direction of the initial response, which might be negative, positive, or no

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[58] These are multiplied by 100 to express them as a percentage deviation from their trend

[59] According to Uhlig (2005) the quantiles represent a one standard deviation under the normal distribution. While in empirical studies the 2, 3% and 97, 7% quantiles represent a two standard deviation band in a normal distribution. A high number of replications introduce higher uncertainty surrounding the estimates of the percentiles.

response at all. I do this for two reasons (1) to see if we had eliminated the wrong exchange rate impulse response on impact (2) to examine if there are differential responses to contractionary monetary policy shock under two scenarios; leaving unrestricted the effect of policy rate on exchange rate (Model 2) and when monetary policy can affect exchange rate (Model 1). The responses are shown in Figure 4-3.

Figure 4-3 Initial responses of exchange rate and trade balance to monetary policy shocks
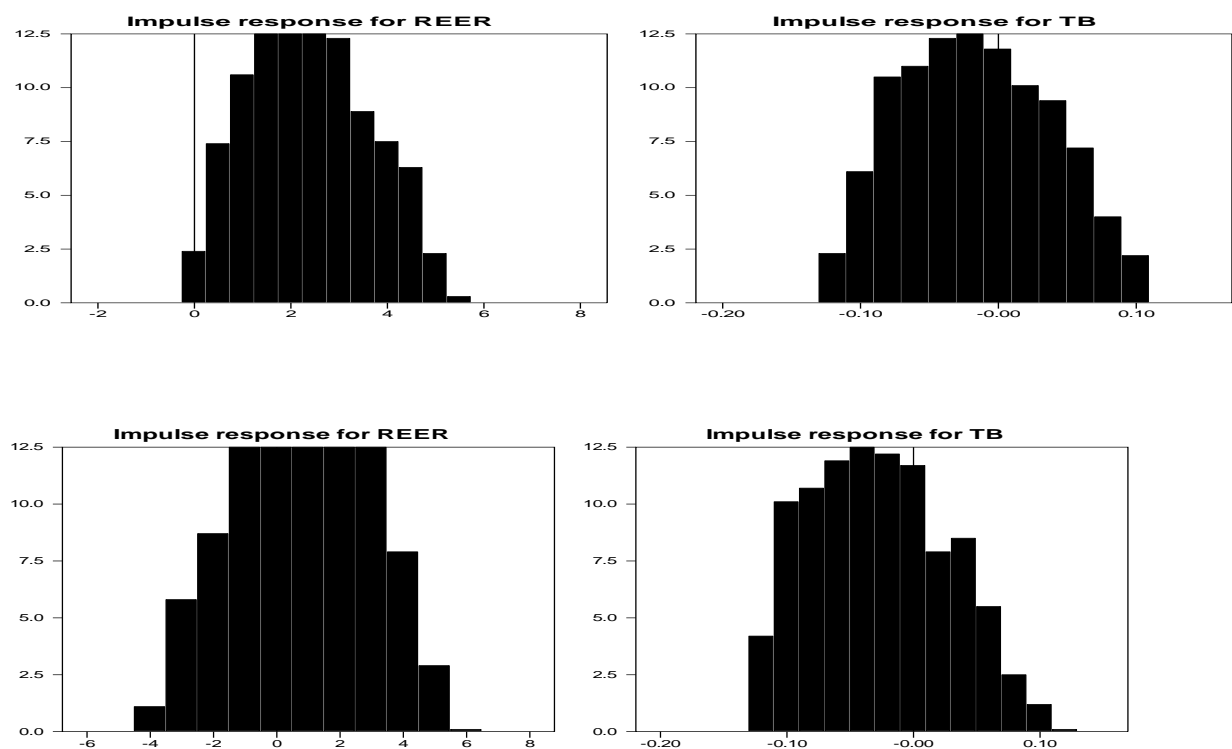
Figure 4-3 shows the distributions of initial responses of both exchange rate and trade balance responses to a contractionary monetary policy shock. The first row of the Figure 4-3 shows the two variable's responses to policy shock when monetary policy directly affects the exchange rate (Model 1). The second row shows the same variables' responses to the same shock when monetary policy effects are not restricted to affect exchange rate (Model 2). While there is an equal chance that exchange rate appreciates on impact, the more bars to the right hand side of zero in each graph imply appreciation. Hence, we conclude that REER is more likely to appreciate on impact. Similarly, the trade balance distribution is more skewed to the left side indicating a much more likelihood to fall in both models. These dynamics on

initial impact show that the effects of contractionary monetary policy on both exchange rate and trade balance tend to be more pronounced when getting rid of the exchange rate puzzle.

4.5.1 Examining the delayed overshooting exchange rate evidence

The overshooting exchange rate puzzle takes place when an increase in interest rate differential on domestic assets is associated with persistent appreciation of domestic currency due to contractionary monetary policy shock as shown in Figure 4-4. This delayed overshooting exchange rate is consistent with evidence that the forward exchange rate is a biased predictor of future spot rate. If uncovered interest parity holds, it implies a positive innovation in domestic interest rate relative to foreign ones should lead to persistent depreciation of the domestic currency over time after impact appreciation. The solid (dotted) line in Figure 4-4 shows the path of REER after contractionary monetary policy shock as predicted by uncovered interest rate parity (overshooting exchange rate puzzle).

Figure 4-4 Delayed exchange rate overshooting puzzle
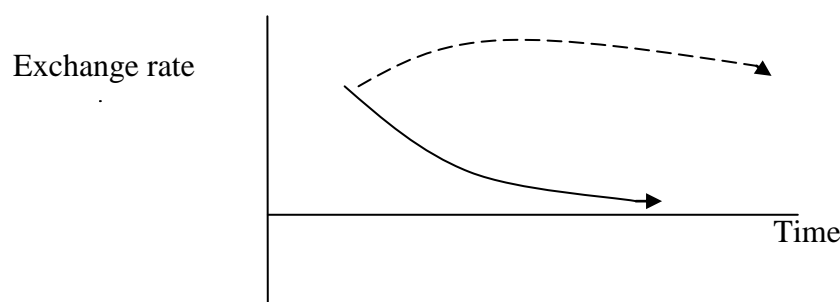
Notes. An increase in Rand/dollar implies a domestic currency depreciation following a positive interest rate differential. In addition, a decrease in REER implies depreciation to similar shock.

The sign-restriction VAR approach uses shocks defined in Table 4-1 with the impulse responses representing the median impulse and the bands represent the 16 and 84 percentiles based on my inferences on 10 000 replications.[60] Figure 4-5 shows the comparison of the REER appreciation and contractionary monetary policy shocks on the trade balance measured by one-standard deviation shocks. A REER appreciation shock as defined in Table 4-1 significantly worsens the trade balance between 2 and 11 quarters, and the maximum decline

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[60] According to Uhlig (2005), the quantiles represent a one-standard deviation under the normal distribution. While in empirical studies the 2,3 per cent and 97,7 per cent quantiles represent a two-standard deviation band in a normal distribution. A high number of replications introduce higher uncertainty surrounding the estimates of the percentiles.

occurs between 3 and 4 quarters. The interaction between the interest rate and the exchange rate conforms to the dynamics implied by the uncovered interest rate parity condition (Solid line Figure 4-4) recorded in empirical work on exchange rates. The uncovered interest rate parity condition predicts currency depreciation following an initial appreciation. The evidence is consistent with the interpretation of an interest rate response indicated by a monetary policy reaction function. Thus, an exchange rate appreciation shock lowers the inflation rates, leading to a reduction in the short-term interest rates as price pressures subside.

Figure 4-5 Exchange rate appreciations and contractionary monetary policy shocks
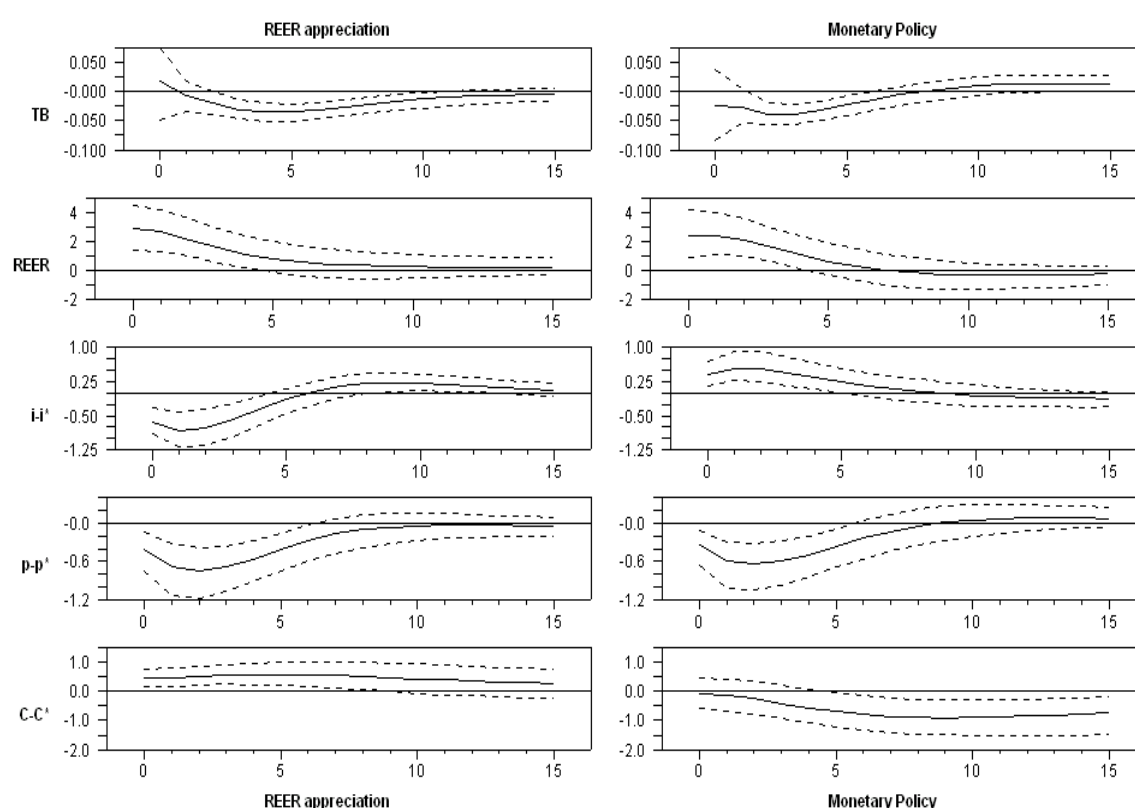
4.5.2 Examining the expenditure switching evidence

This section investigates the expenditure switching evidence through leaving unrestricted the direct impact of monetary policy on exchange rate (Model 2). I let the result to tell the story about the response of exchange rate to contractionary monetary policy shock. The expenditure-switching evidence implies that monetary policy can influence the shift in the composition of domestic output between domestic goods and imported goods over the

identified period. The results are shown in Figure 4-6. Similar to the earlier, the significant decline in trade balance response between 2 and 5 quarters to the contractionary monetary policy shock, suggesting that the expenditure-switching effect dominates the income effect over this period. These conclusions are robust to different quarters, such as 6 and 8 quarters for which the shock effects were expected to last.

Figure 4-6 Examining expenditure switching effects
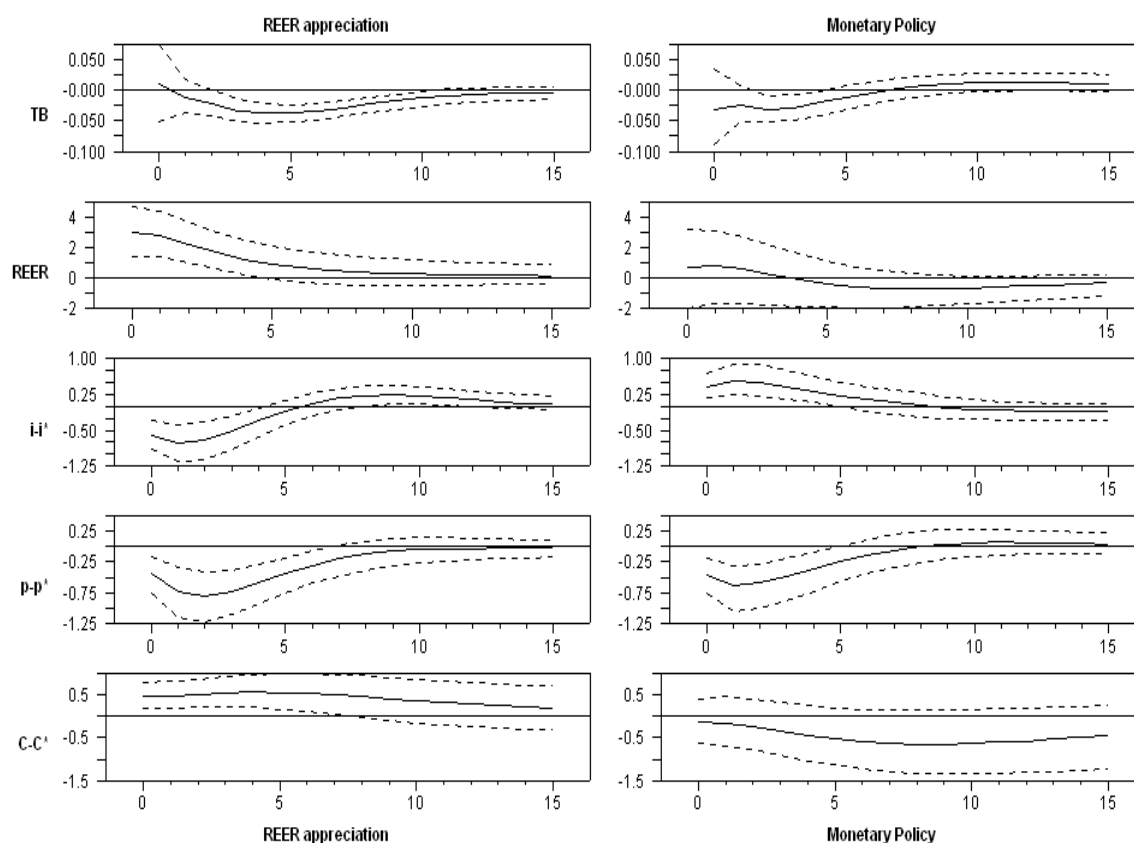
I compare the responses of trade balance to the two versions of monetary policy shocks in Figure 4-7. I graph the two impulses together to find if there are significant differences in the sizes of the trade balance responses between two definitions of contractionary monetary policy. Both parts A and B show no significant differences in trade balance decline. Part C attributes the large trade balance deterioration to the role played by exchange rate. The trade balance deteriorates more when monetary policy is restricted to appreciate the exchange rate. Part D of Figure 4-7 shows the differences in the responses of trade balance (bar graph) to

100

monetary policy shocks using models 1 and 2. The trade balance gap between the two impulse responses suggests that monetary policy effects are potent via the exchange rate. [61]

Figure 4-7 Quantifying the trade balance decline due policy rate via exchange rate
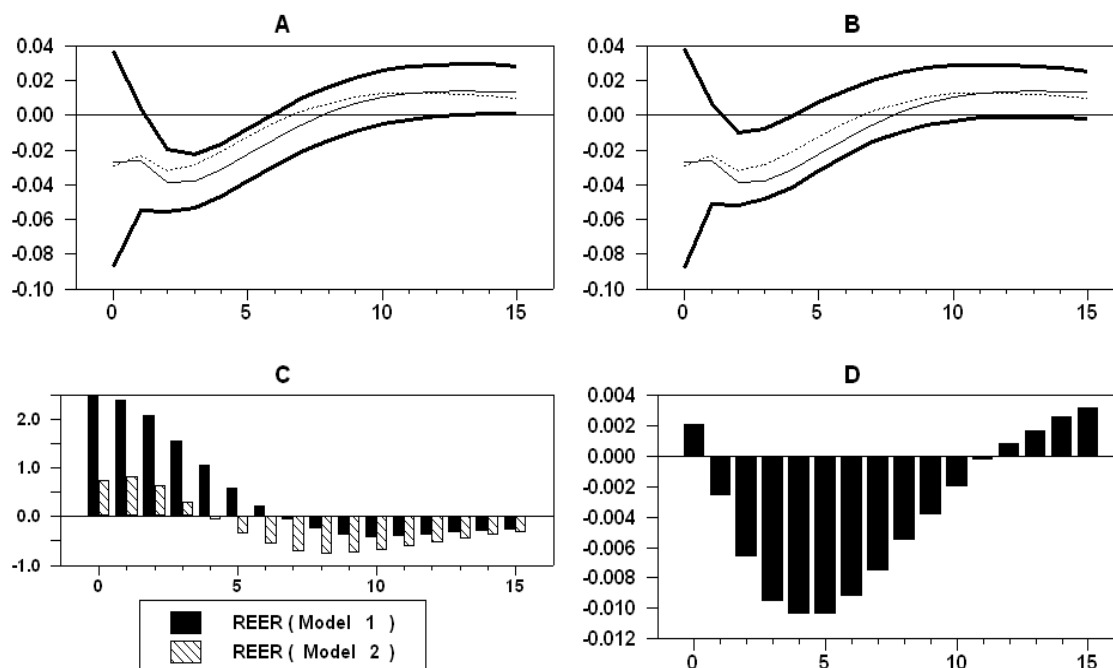
Notes: Thick solid line represents the error bands of trade balance impulse responses while thin and a dotted middle line denotes the impulse responses. The bands in A are from Model 1 while bands in B are from Model 2. The thin middle line represents trade balance response to contractionary monetary defined using Model 1 and the dotted line is the response to a similar shock using Model 2.

I also test the channels through, which the exchange rate and monetary policy shocks affect the trade balance through looking at its components namely, the imports and exports as percentage of gross domestic output. I left the exports and imports variables unrestricted in both specifications (Model 1 and Model 2). The results in Figure 4-8 shows that exchange rate appreciation (first row) and monetary policy shocks (second row) worsen the trade balance through the imports rather than the exports channel. However, the rise on import variable suggests this component reacts significantly to exchange rate appreciation than to contractionary monetary policy shocks in both figures. In addition, the imports rise by more

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[61] Gap is difference in trade balance responses when monetary policy is restricted to appreciate exchange rate and when its effects are not restricted.

when monetary policy influences the exchange rate (Model 1) than when policy effects on exchange rates are left unrestricted (Model 2).

Figure 4-8 Imports and exports responses to monetary and exchange rate shocks
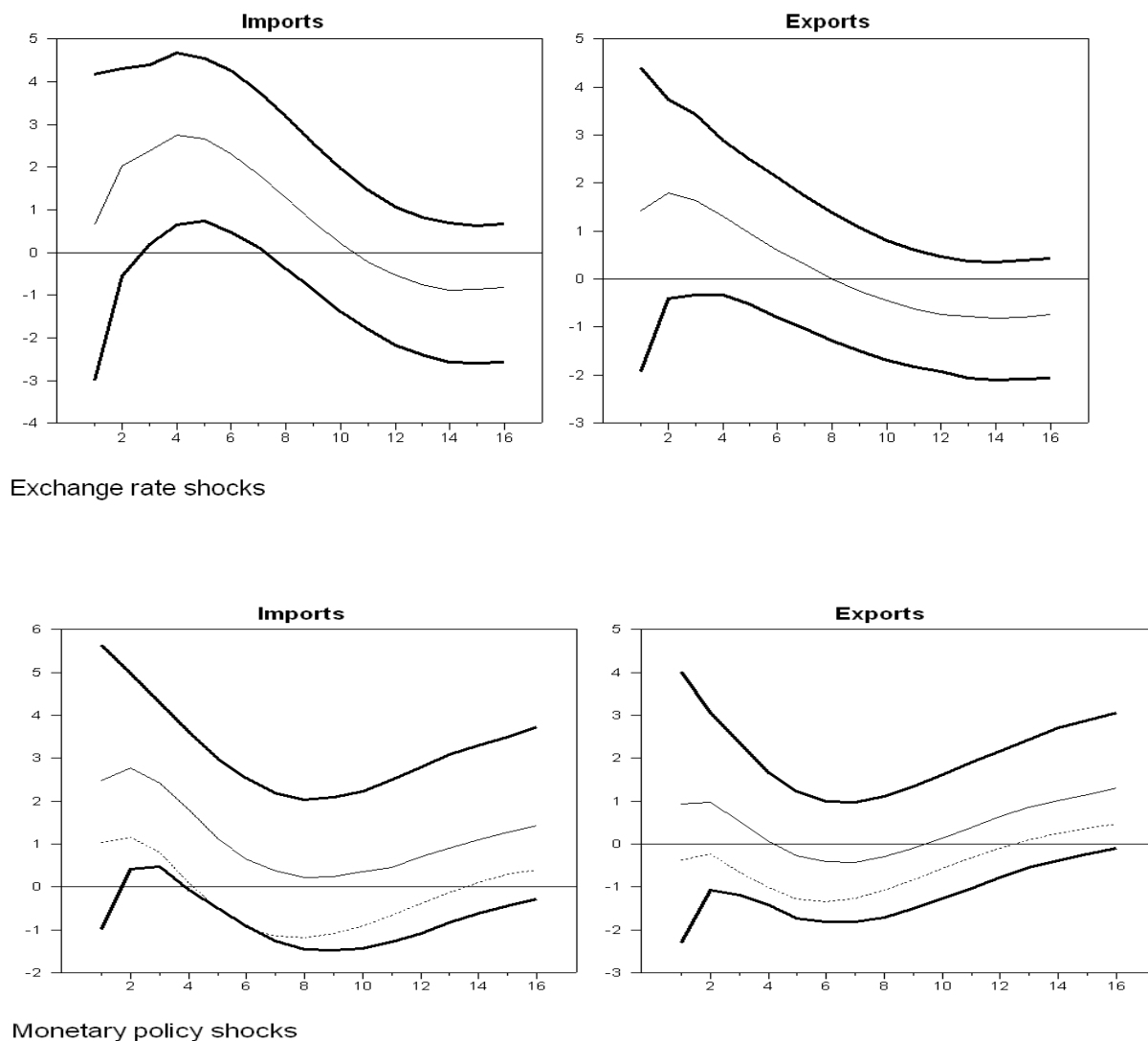

Exchange rate shocks

Monetary policy shocks

Notes: Thick solid line represents the error bands of trade balance impulse responses while thin and dotted middle lines denotes the trade balance impulse responses. The thin middle line represents trade balance response to exchange rate and monetary policy shocks. However, in second, row the thin continuous black line refers to trade balance response with contractionary monetary defined using Model 1 while dotted line is response to similar shock using Model 2.

This analysis goes a step further to assess the robustness of the preceding findings to using two shocks using the OECD data as trading partner. Similar to the findings in the preceding sections, the exchange rate appreciation shock worsens the trade balance as percentage of gross domestic output in Figure 4-9 more than the contractionary monetary policy shocks. Differences are visible in the magnitudes upon impact and peak periods and the trade balance response with US data (thin solid line) lies below the same variable response using OECD

data (dotted line). This points to the importance of US developments on South African trade balance. A similar trend is visible when assessing the trade balance responses to the contractionary monetary policy which has left exchange rate unrestricted (Model 2).

Figure 4-9 Comparing trade balance responses using US and OECD data on expenditure switching effect
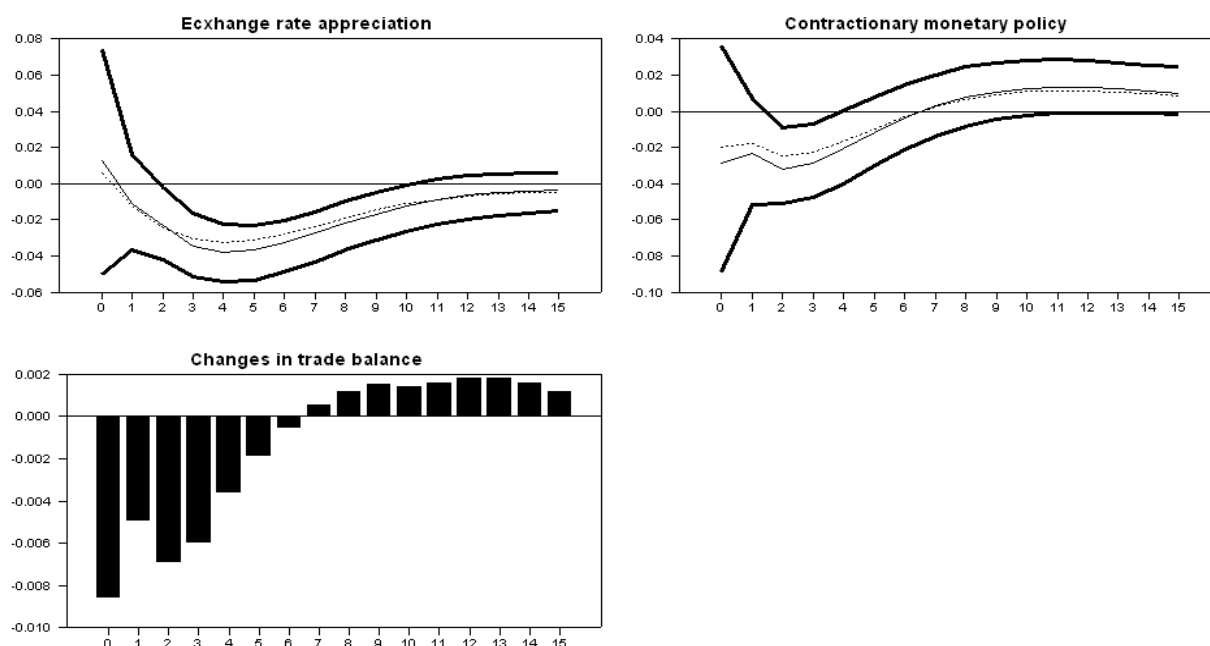
Notes. The solid continuous median line refers to the model with US variables and dotted middle line refers to model with OECD data. Changes in trade balance refer to differences between median impulse using US and OECD data. Bands are from the model with US variables with contractionary policy defined in Model 1.

Furthermore, I find purging the direct effects of monetary policy on exchange rate using the OECD data makes monetary policy less powerful. The trade balance as a percentage of gross domestic output declines (insignificantly) suggesting that monetary policy shock still operates through the expenditure switching channel. I conclude that letting the monetary policy to influence exchange rate anyhow using the OECD data alters the significance and not the expenditure switching effect suggesting that aggregation introduced some biases in the results.

The next section conducts robustness tests based on additional sign restriction shocks founded on both empirical evidence and theoretical models. Of great significance is the inclusion of equity markets variable because South Africa is a commodity exporter. Most developments in the mining sector are quickly reflected in stock markets indices.

4.5.3 Robustness analysis

The robustness tests rely on two additional shocks captured by the inclusion of the relative equity variable motivated by unexpected developments in 2010. In addition, South Africa is a commodity producing country that exports minerals. Developments in these commodities are reflected in the main stock market index. The relative equity $(eq_t - eq_t^*)$ variable represents the difference between the South African Alsi (eq_t) and the US S&P 500 index (eq_t^*). There are three reasons to justify the inclusion of equity variable. First, the relative equity variable is included due to unprecedented capital inflows into the bonds and stock markets of emerging-market economies in 2010. In addition, the stock market variables affect the trade balance indirectly through affecting the exchange rate. Second, the relative equity captures the distortionary effects on the trade balances and currencies of higher-yields emerging-market economies after the US quantitative easing programme that lowered interest rates towards zero. Large amounts of capital inflows tend to appreciate exchange rates, which in turn impacts the trade balance.

Asset price movements are highly positively correlated globally, such that an increase in equity values in South Africa may reflect an even stronger rise in equity values in United States. Moreover, during the 2010, foreigners invested their capital into stock and bond markets in South Africa and the carry trade activity appreciated the trade weighted exchange rates and domestic currency. Third, Tobin's q theory suggests that when the market price of the firm is high compared to replacement cost of capital, new plants and equipment become cheaper relative to market value of the firm (Mishkin, 2007). Investment spending will increase since firms can buy many new investment goods with small issue of stock. An increase in investment should worsen the trade balance.[62]

Three additional shocks defined in Table 4-4 are equity appreciation and private absorption. However, the exchange rate appreciation, equity appreciation, monetary policy and private absorption shocks are estimated together. Private absorption is very important because consumption contributes about 59–63 per cent to the South African GDP. This is by far the highest contribution relative to other components of the GDP. Furthermore, consumption contributed about 2 percentage points to the real GDP growth rate between 2001 and 2010 when the real growth rate averaged 3,5 per cent.

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[62] This arises from defining the trade balance (TB) equals national savings (NS) minus investment (I) i.e TB =NS-I. Hence investment on capital purchased from abroad would deteriorate the trade balance.

Table 4-4 Augmented VAR identification

Shocks:	$c_t - c_t^*$	$p_t - p_t^*$	$i_t - i_t^*$	$exch_t$	$eq_t - eq_t^*$	tb_t
Equity	+	?	+	?	+	?
Private absorption	+	+	+	?	?	?

Table 4-4 defines the equity shock by imposing restrictions such that an increase in relative equity prices leads to increases in both relative interest rates and consumption (see Fratzscher et al. 2010). The signs imposed on relative equity variable have empirical VAR support. Bjørnland and Leitemo (2009) found short-term interest rates increased following a positive stock price shock using a VAR with a combination of short and long run restrictions. In addition, Rigobon and Sack (2004) concluded that interest rate significantly increased in response to higher equity prices using an identification method based on heteroscedasticty of the data. A 10 per cent stock market wealth appreciation increases consumption by 1 per cent in South Africa (IMF, 2004).[63] Consumption rises in response to a positive equity shock through the canonical wealth effect (Fratzscher et al., 2010; Di Giorgio and Nistico, 2007).

Barnett and Straub (2008) suggest the private absorption shocks may be caused by a change in time preferences rate, hence Table 4-4 adopts their restrictions. Private absorption shock is defined by imposing positive restrictions on relative consumption, inflation rates, and interest rates. Alternatively, this private absorption shock represents a shift in the consumption function towards domestically produced goods, which exerts upward pressures on prices and interest rates. According to Krugman (2003) the exchange rate should appreciate, hence the sign on this variable is left unrestricted.

Some shocks identified using sign restrictions may in fact partly reflect other shocks, for example, increase in equity price may be due to productivity shocks. Our identification procedure ensures that the productivity shocks differ from equity shocks similar to Fratzscher et al. (2010). The productivity shocks lead to increases in equity prices but lower interest rates and domestic prices while the latter rise in response to equity prices shocks. On the contrary, a productivity shock may increase output and reduce unemployment, hence increase wages, leading to higher prices, which lead to monetary tightening. Even under this transmission channel, the equity shock differs from productivity shock as the relative price

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[63] Aron et al. (2007) found significant wealth effects for South Africa. They found the marginal propensity to consume (MPC) out of net liquid wealth estimate of 0,2; an MPC out of directly held illiquid financial wealth of around 0,08 and MPC out of housing of 0,10.

levels are left unrestricted.[64] The identification makes sure the shocks do not define shocks already specified in the model. Both the private absorption and monetary policy shocks lead to an increase in interest rates. However, private absorption leads to increases in consumption and inflation rates but the latter variable decreases under monetary policy shock (Table 4-1).

Figure 4-10 Main shocks, private absorption and equity appreciation shocks
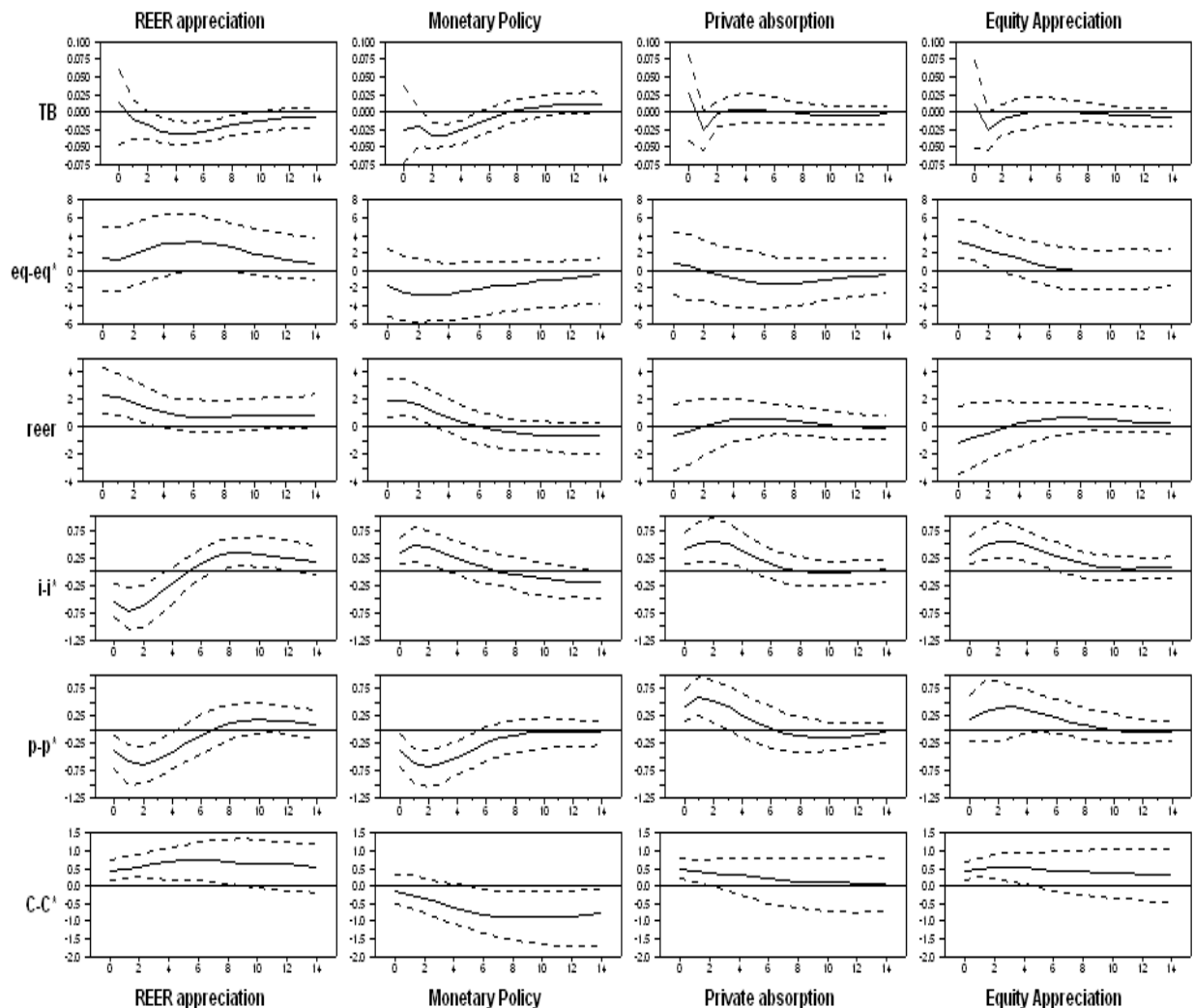
The dynamics of the trade balance in Figure 4-10 are virtually identical to results from the benchmark VAR models. The trade balance deteriorates significantly between 2 and 11 quarters after an exchange rate appreciation shock which is relatively a longer period compared to effects of the monetary policy shocks. The findings conclude that exchange rate appreciation shocks dominate the monetary policy shocks by significantly worsening the

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[64] They showed the signs of the responses of relative consumption, relative interest rates were similar in response to both house, and equity prices shocks. However, equity shocks differ from housing shocks, as these are identified as the shocks with the largest contemporaneous impact on equity prices whereas the response of house prices to equity is uncertain.

trade balance for longer periods but not permanently. Both private absorption and equity appreciation shocks have no significant influence on the trade balance movements in South Africa. In addition, the equity appreciation shocks lead to an insignificant increase in inflation rates and exchange rate appreciation. Perhaps the latter suggests the influence of capital inflows on the exchange rate.

Figure 4-11 Trade balance responses to various shocks

Notes: Thick solid line represents the error bands of impulse responses while thin and dotted middle line denotes the trade balance impulse response. The thin continuous middle line represents trade balance response to various shocks with contractionary monetary defined using Model 1 and dotted line shows similar response to various shocks with monetary policy defined using Model 2. The bands come from model using main shocks, in which monetary policy was constrained to impact exchange rate (Model 1).
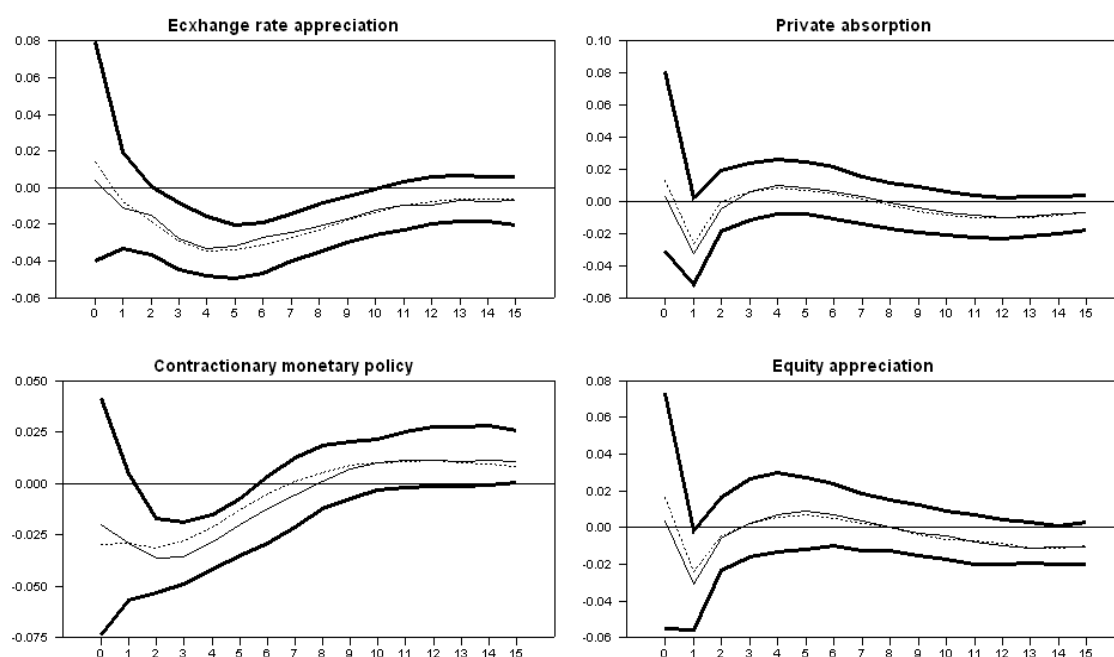
The dynamics of the trade balance in Figure 4-11 are virtually identical to preceding results. The trade balance deteriorates significantly between 2 and 11 quarters after an exchange rate appreciation shock, which is relatively a longer period compared to effects of the monetary policy shocks. This suggests that an exchange rate appreciation shock dominates the monetary policy shocks by significantly worsening the trade balance. In contrast, neither the private absorption nor equity appreciation shocks have significant influence on the trade balance movements. Figure 4-12 compares all trade balance responses from four shocks. The contractionary monetary policy shocks have a big effect on trade balance in first four quarters than exchange rate appreciation shocks and the later remains persistently depressed. The equity appreciation and private absorption shocks show similar trends.

Figure 4-12 Comparisons of trade balance impulse responses from various shocks
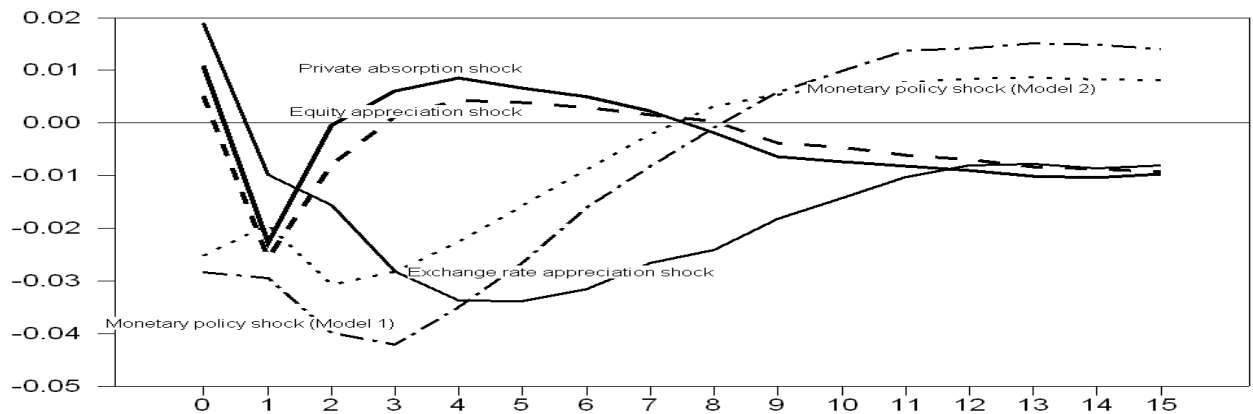
Figure 4-13 shows the effects of using the NEER to examine the sensitivity of the preceding conclusions. Evidence concludes significantly and similarly that an exchange rate appreciation shock lowers the trade balance more than the contractionary monetary policy shocks. Furthermore, we find that contractionary monetary policy works through the expenditure switching channel, which adjusts the exchange rate rather than altering the incomes.

Figure 4-13 Main shocks, private absorption and equity appreciation shocks
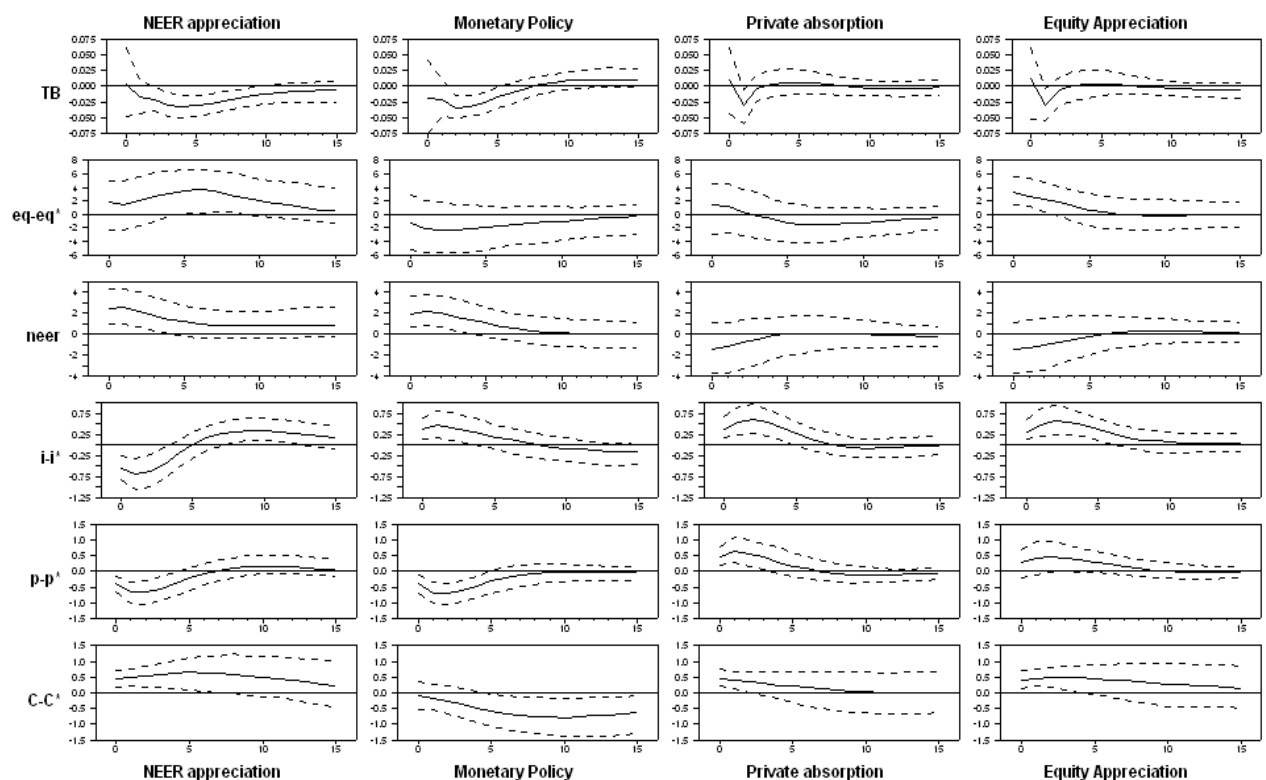
Most invoicing of trade transactions in South Africa uses the US dollar despite a large weight given to the euro area in the calculation of the trade-weighted exchange rate. Hence, the third robustness test uses the bilateral rand–dollar exchange rate. A rand appreciation refers to a decrease in the exchange rate. The rand–dollar exchange rate appreciation shocks lowers significantly the trade balance for longer periods compared to the monetary policy effects in Figure 4-14. Furthermore, the rand appreciation against the dollar leads to an insignificant J-curve on impact while contractionary monetary policy shows the dominance of expenditure switching effects over the income absorption effects. Overall, these results are robust to the inclusion of equity appreciation, private absorption and supply shocks. In addition, the conclusion is robust to the definition of the exchange rate.

Figure 4-14 Rand appreciation, various shocks on trade balance
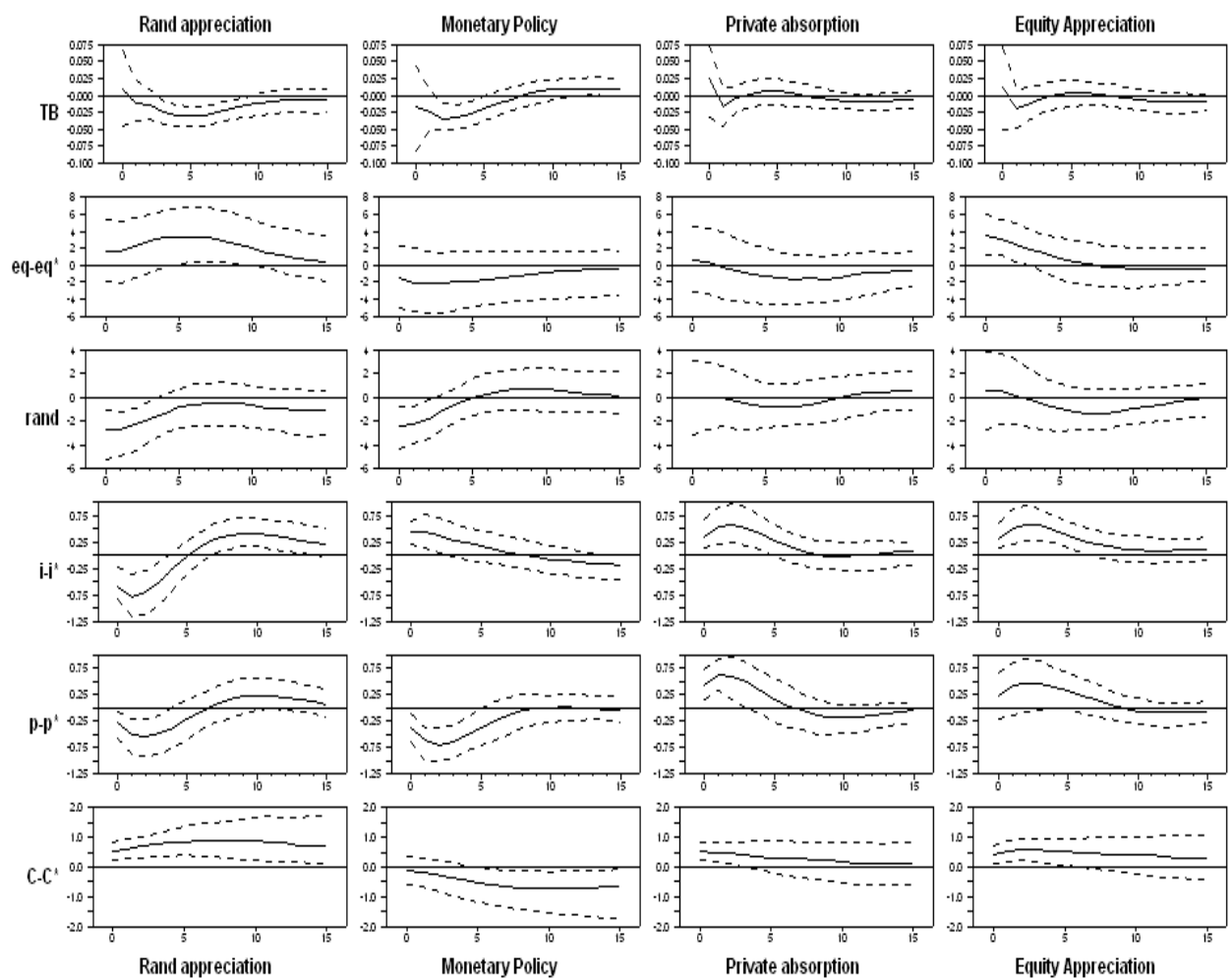
4.5.4 Variance decomposition

This section examines the variability between monetary policy, exchange rates and other shocks in explaining trade balance fluctuations. Table 4-5 shows the forecast error variance decompositions for various shocks. All shocks tend to explain a smaller fraction from the first quarter and converge to high values over the longer horizons. The supply, NEER and REER shocks explain more volatility in trade balance movements than monetary policy shocks whereas the rand appreciation induces slightly less variability over all horizons. The equity and private absorption shocks explain less variability in the trade balance over all horizons. Perhaps the high variability of both trade-weighted exchange rates possibly justifies why REER and NEER appreciation depress the trade balance more than the contractionary monetary policy shocks.

Table 4-5 Variance decomposition of various shocks in per cent

Steps	Equity	Monetary	NEER	REER	Rand	Supply	Private Absorption
1	10.1	9.80	10.1	10.3	10.0	10.2	10.0
4	13.0	13.6	14.7	13.8	13.2	14.0	13.6
8	14.5	15.3	16.3	15.5	15.1	15.6	15.0
10	14.7	15.5	16.4	15.7	15.4	15.8	15.2
12	14.9	15.7	16.4	15.8	15.6	15.9	15.4

4.4.5 What are institutional implications of these findings?

The findings in this chapter have implications for South African policy making institutions. The findings are as follows: First, contractionary monetary policy affects the trade balance through the expenditure-switching channel suggesting it alters the exchange rates. Second, the exchange rate appreciation shock worsens trade balance for longer periods but not permanently. Third, the variance decompositions shows that REER and NEER appreciation induces more trade balance fluctuations. This perhaps explains why the REER and NEER appreciation depress the trade balance for relatively longer periods but not permanently than the contractionary monetary policy shocks. These findings have implications for policies such as those stated in the New Growth Plan, which may fail to boost the economic growth and employment through net exports channel.

How can a monetary policy authority deal with the negative effects of exchange rate shocks and fluctuations? Monetary authorities can learn lessons from other emerging markets

economies. However, the chapter acknowledges that structural issues faced by South Africa are not similar to those of the Latin American countries, and situations prompting central banks behavior are different. Furthermore, this does not compel the South African Reserve Bank to follow the approaches discussed here but the purpose is to show how other central banks acted. First, the Chilean central bank reserves the right to participate in the markets under exceptional circumstances through foreign exchange rate operations or through provision of foreign exchange hedging instruments. This takes place when, the excessive currency appreciation or depreciation threatens financial market volatility, or when overreaction sends wrong signals about prices. The Chilean central bank after August 2001 intervened, after explaining that foreign exchange rate was depreciating very rapidly due to difficult conditions abroad.[65] Second, the Brazilian central bank has intervened indirectly in the foreign exchange market by changing the composition of domestic debt. This involved increasing the placement of dollar denominated debt in times of stress providing exchange rate insurance to the private sector and fostering liquidity in the foreign exchange market.

What does the finding of long run neutrality of exchange rate on net exports contribution to GDP mean? This means the exchange rate will have limited effect in longer run because the trade balance contributions to GDP will return to preshock levels. The finding that all different exchange rates impact trade balance for longer time but not permanently reveals competitiveness is very important in short and medium term. This means that economic policy institutions should work together to deal with identified effects and find ways to deal with both strong currency and competitiveness issues. There is a possibility of threshold effects on exchange rate effects on trade balance as percentage of GDP. The chapter is unable to prescribe a particular band of exchange rate, optimal policy rate, and threshold level so that the shocks would have different impact on the contribution of trade balance to GDP.

4.6   Conclusion

Chapter 4 compares the effects of contractionary monetary policy and exchange rate appreciation shocks on the trade balance in South Africa using a Bayesian sign restriction approach. Evidence found that trade-weighted exchange rate appreciation shocks worsen the trade balance for longer periods than contractionary monetary policy shocks in South Africa.

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[65] The actual intervention consisted of the sale of foreign exchange worthy more US$800 million and an issue of exchange rate-indexed debt payable in pesos worth another US$3 billion, which include re-issuing of notes falling due.

Additional sensitivity tests of the findings concluded the main evidences are robust to different specifications. These robustness tests included using the additional shocks, replacing real with nominal effective exchange rates and assuming the rand–dollar exchange rates as the main currency of invoicing trade transactions. All these findings indicate that monetary policy operates through the expenditure switching channel rather than the income channel in the short run to lower the net trade balance. In addition, similar conclusions emerged when using the exchange rate depreciation shocks and expansionary monetary policy shocks. The forecast error variance decomposition shows that trade-weighted exchange rate shocks are important drivers of trade balance movements in South Africa than monetary policy shocks.

These findings have policy implications. A significant deterioration in the net exports due to exchange rate appreciation shocks indicates that the contribution of net exports to GDP will remain depressed for longer periods but not permanently. Hence, this finding does not violate the neutrality of exchange rate effects in long run growth. Furthermore, the findings of the expenditure switching channel suggest that, in the short run, monetary policy can be used to change the direction of demand between domestic output and imported goods through exchange rate adjustment, *ceteris paribus*. Overall, this evidence suggests that policies dealing with exchange rates including competitiveness among trade partners rather than monetary policy would be ideal to generate prolonged but not permanent economic growth through the net exports channel.

Appendix A 4   Robustness : Depreciation and monetary expansion shocks

Figure Appendix A 4-1 Results using recursive VAR
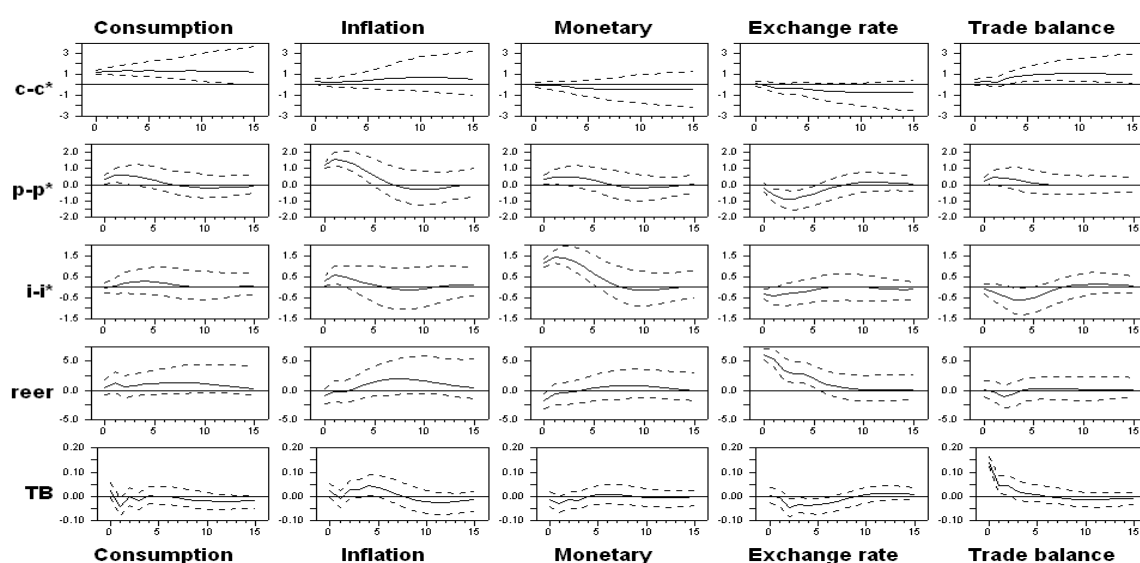
Figure Appendix A 4-2 REER depreciation and expansionary monetary policy shocks
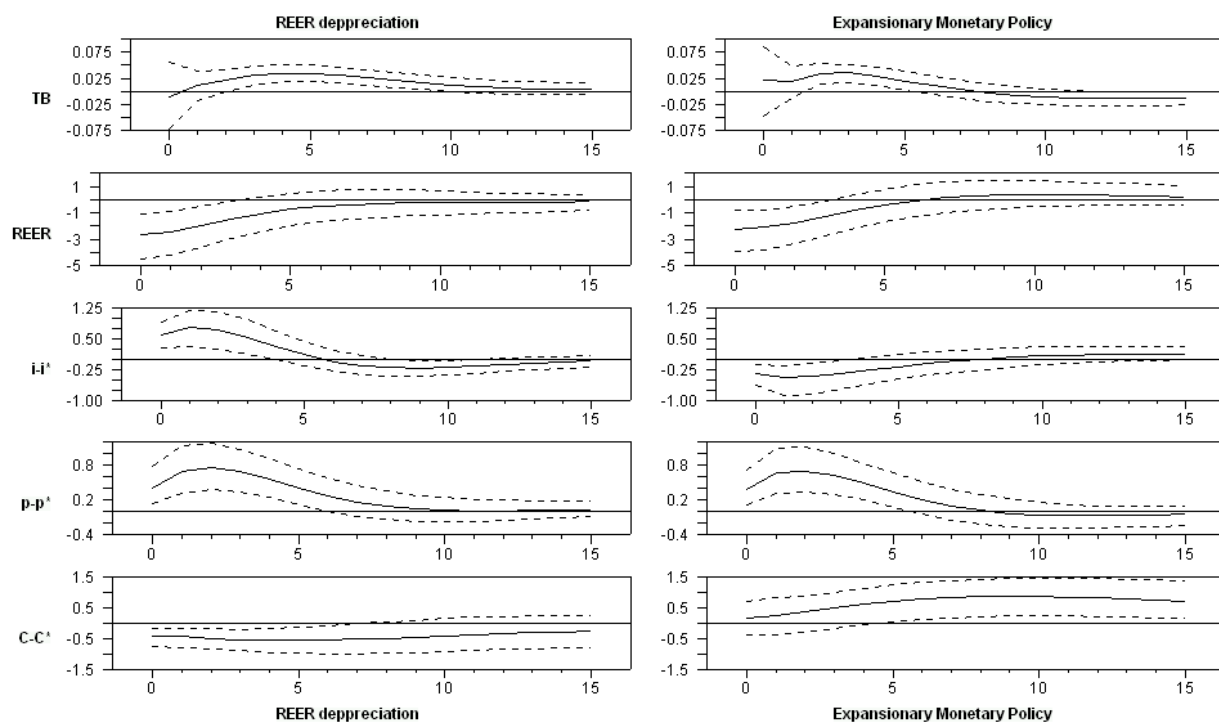
Figure Appendix A 4-3 Rand depreciation and expansionary monetary policy shocks
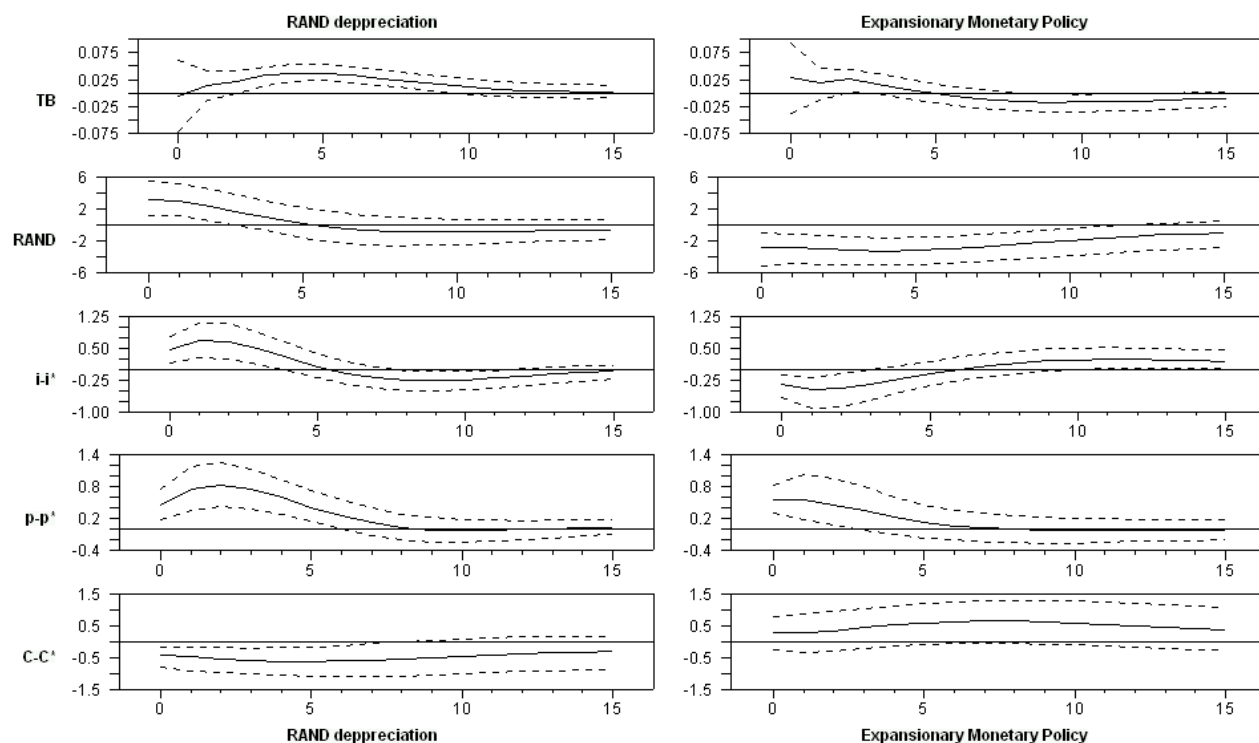
Notes. An increase in Rand-dollar represents depreciation

Figure Appendix A 4-4 NEER depreciation and expansionary monetary policy shocks
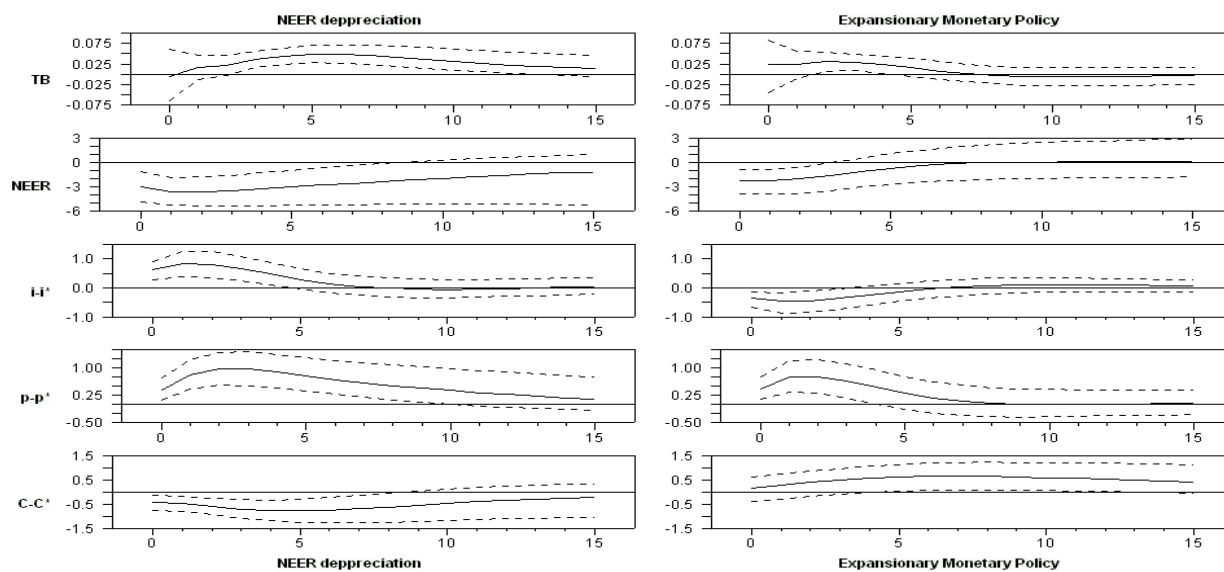
Appendix B 4 Robustness through excluding foreign variables

Figure Appendix B 4-1 REER appreciation and contractionary monetary policy shocks
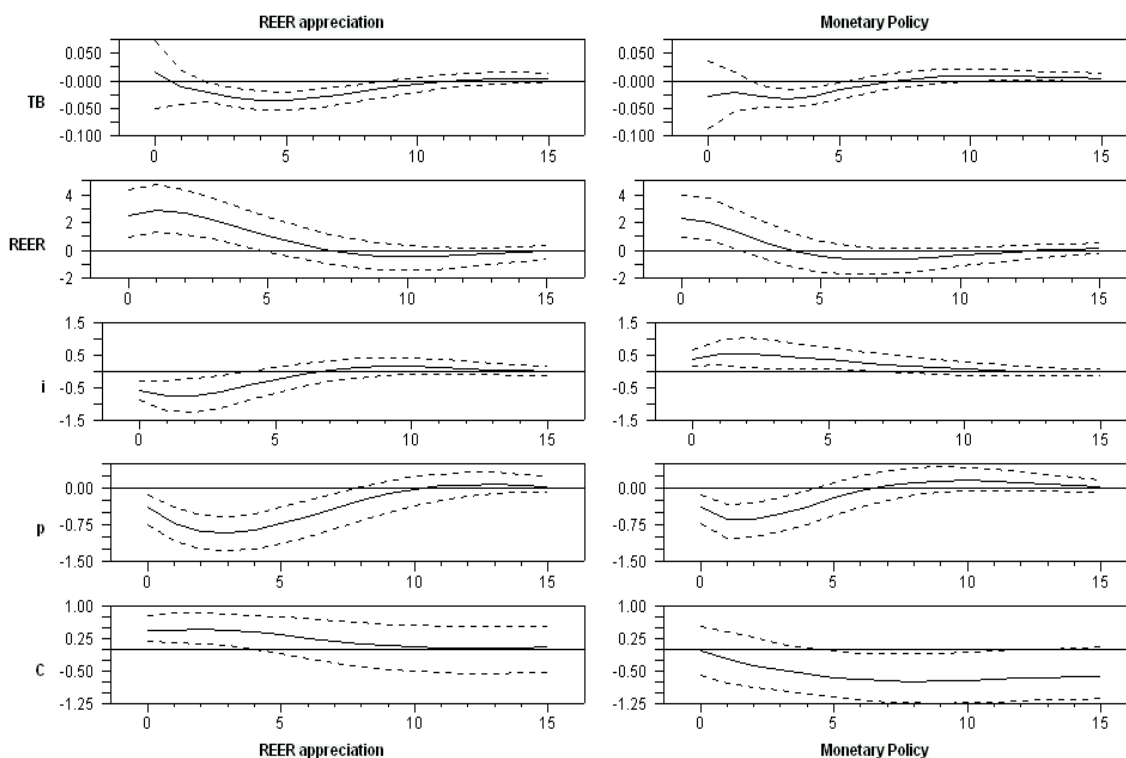
Figure Appendix B 4-2 NEER appreciation and contractionary monetary policy shocks
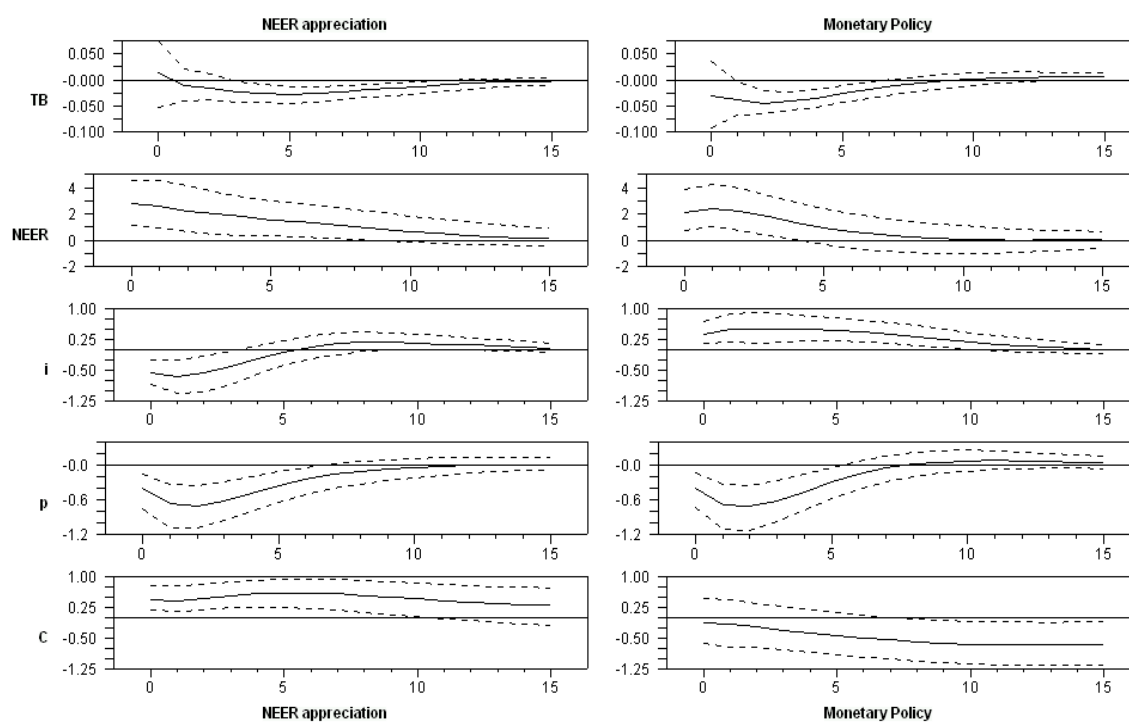
Figure Appendix B 4-3 Rand appreciation and contractionary monetary policy shocks
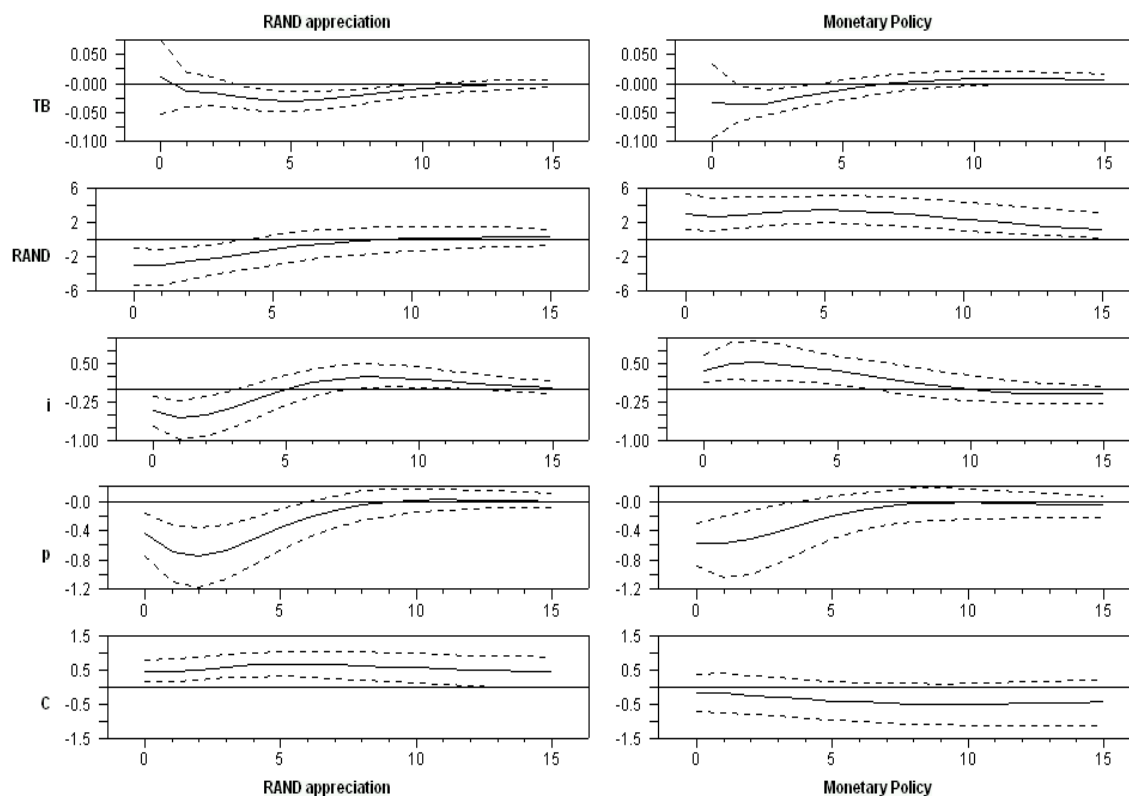
Notes. A decrease in Rand-dollar represents depreciation

Figure Appendix B 4-4 Main shocks on imports and exports in Model 1
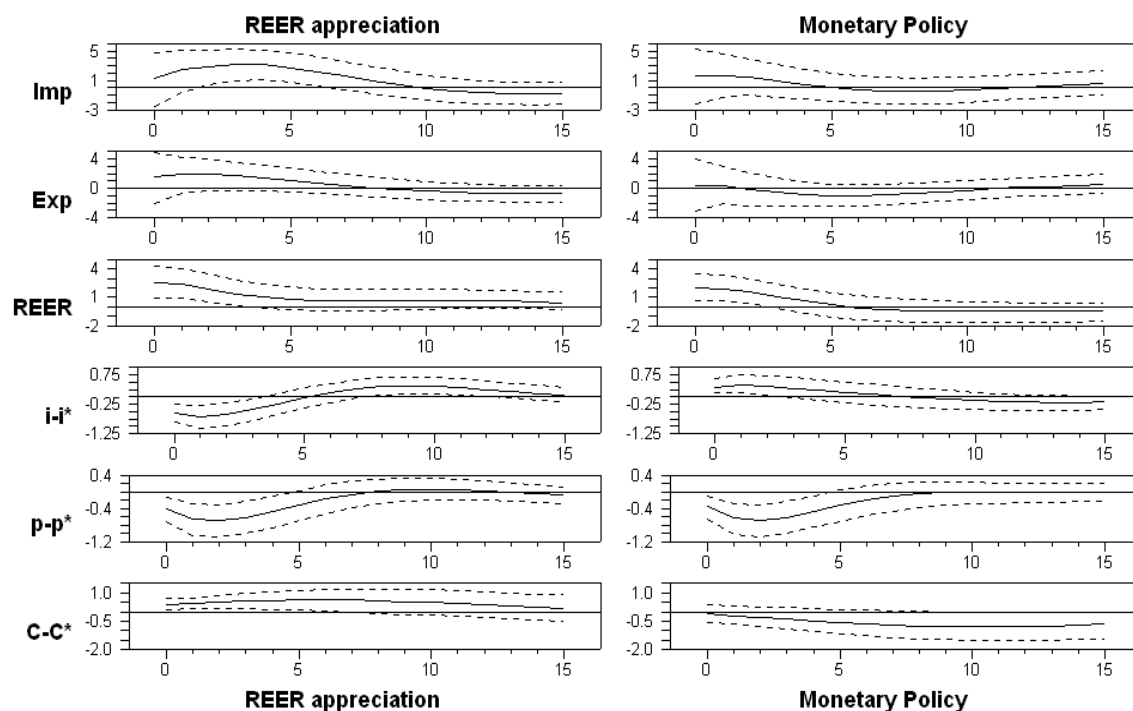
Figure Appendix B 4-5 Main shocks on imports and exports in Model 2
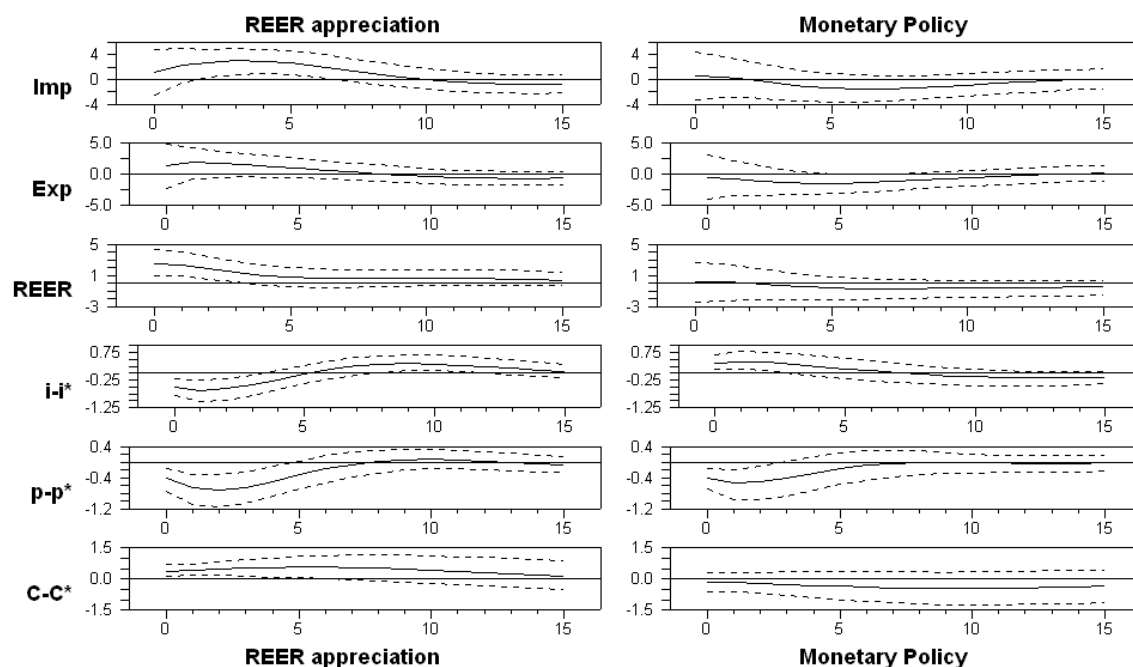
Figure Appendix B 4-6 All shocks effects on imports and exports
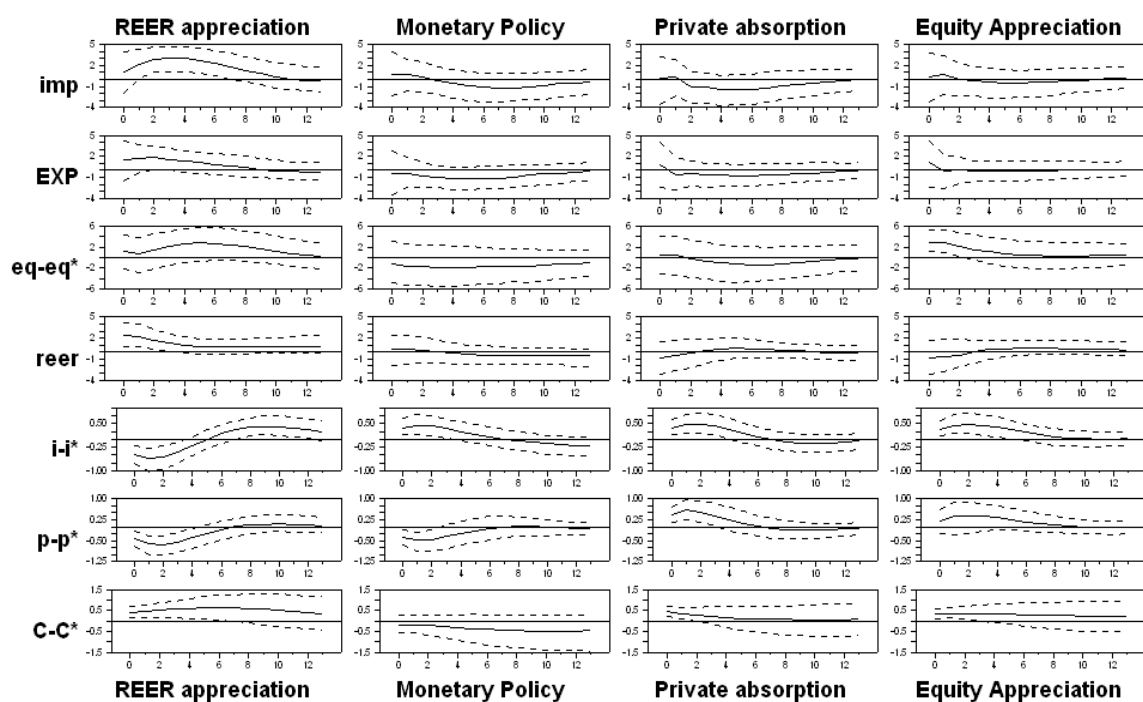
Figure Appendix B 4-7 All shocks effects on imports and exports
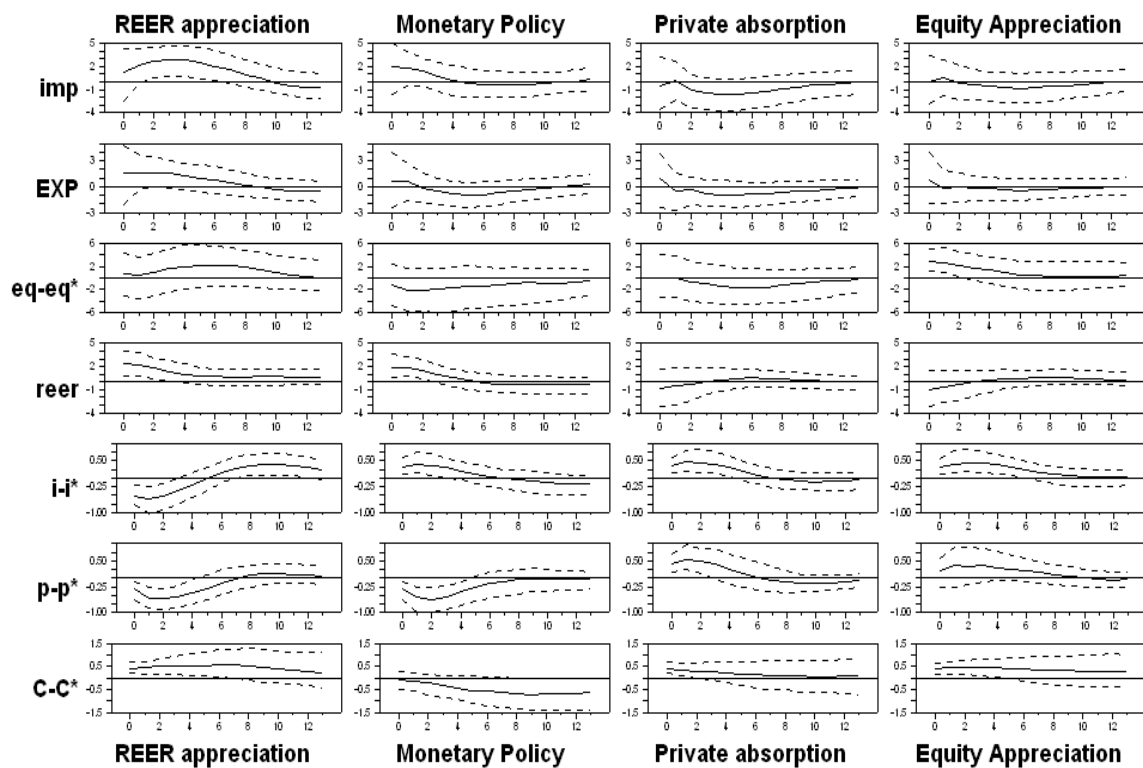
CHAPTER 5 : MONETARY POLICY AND OUTPUT

5.1 Introduction

This chapter investigates to what extent does contractionary monetary policy impact output on South Africa and Korea, using a sign restriction VAR approach. The financial crisis, which started in US subprime mortgage market in 2007, has resuscitated the debate about the negative impact monetary policy can have on the economy as a whole. Nevertheless, the unconventional policies during extraordinary periods appear to be more effective than traditional policies. Reflecting on the recent financial crisis, is merely cutting interests rate enough?

Even before the onset of financial crisis in 2007, the extent of the effects of contractionary monetary policy shocks on output remained a big question. First, this points to the fact that theory has not converged regarding the effects of monetary policy on output reflecting different theoretical models' diverse prediction of economic activity reaction. The classical model asserts that nominal policies, such as money-supply changes, affect nominal variables like prices rather than real variables such as output that are determined by supply-side factors. In addition, changes in money supply lead to proportional changes in the price levels leaving output unaffected, leading to monetary neutrality. The new classical model's policy ineffectiveness proposition suggests that systematic or anticipated policies that change aggregate demand have no effect on the business cycle even in the short run, whereas only unanticipated policies matter. Furthermore, an undesirable policy outcome can be experienced in New Classical model. For instance, an expansionary monetary policy can lead to a decline in aggregate output if the public expects an even more expansionary policy than the one actually implemented. The actual surprise in the policy would be negative, and depressing output (Mishkin, 2007).

Nonetheless, the New Keynesian model predicts that output would respond to both anticipated and unanticipated monetary policy shocks. In contrast, the Real Business Cycle argues that monetary policy cannot affect output. Even if it could, it would be suboptimal to try to eliminate the business cycle. Thus, real and not monetary factors are responsible for fluctuations in output even in the short run and monetary policy should focus on controlling the price level. It asserts a stronger position than the new classical model, that monetary and other nominal demand-side shocks have no significant effect on output. The monetarist view

argues that money supply in the short run influences real variables but the long run influence is on the price level and other nominal magnitudes. The preceding view states that real and not monetary factors determine real variables such as output in the long run. The Real Business Cycle (RBC) theorists argue that the dynamic responses of optimising agents to changes in economic conditions have long-lasting effects and these explain fluctuations in economic activity.

Second, the measurement and identification of various shocks that give rise to macroeconomic fluctuations remain a central concern to macroeconomics studies and remains an unresolved dispute in macroeconomics (Mountford, 2005). In this investigation, we define the policy shocks using a sign restriction approach based on weaker prior beliefs on how monetary policy affects the economy. Mountford (2005) further argues that research on monetary policy shocks tends to assume that the reaction of certain variables to monetary policy shocks is either contemporaneously zero or zero in the long run. The problem of imposing restrictions on the long-run effects of monetary policy effects is that economic theory is not definitive regarding this issue. Furthermore, the economic theory does not give a conclusive guidance on the timing of the economy's response to monetary policy shocks casting doubt on contemporaneous zero restrictions. Christiano et al. (1999) put forward that identification schemes exist which lead to different inferences of monetary policy shocks than the consensus view. These identifying selection schemes reject the identifying assumptions that do not satisfy the qualitative features of a set of impulse responses and not the entire set of models, for example, the sign restriction approach proposed by Uhlig (2005).

Third, South African studies report mixed evidence on the response of output to contractionary monetary policy shocks. Evidence included positive response (see Bonga-Bonga and Kabundi, 2010), negative and persistent effects on real economic activity (Gupta et al. 2010) and immediate decline on impact (Kabundi and Ngwenya, 2011). These results are based on structural vector error correction and factor augmented autoregression models using differenced and stationary data. This chapter improves the discussion by using data in levels, using sign restriction vector autoregression approach based on weaker prior beliefs about the monetary policy. Despite, the literature investigating the contractionary monetary policy effects on output using sign restriction being very small and presenting mixed evidence in developed economies. Rafiq and Mallick (2008) found that monetary policy innovations were most potent in Germany, and unequivocally, a restrictive monetary policy

shock did not lead to a short-run output contraction in Italy. Uhlig (2005) concluded that contractionary monetary policy shocks had no clear effects on US real gross domestic product.

Having highlighted the theoretical and identification issues, the remainder of introduction focuses on the reasons why this study matters. First, this study is motivated by implications of estimated financial conditions. As shown in Figure 5-1 financial conditions are an important intermediary that relays the policy rate changes into real economy. Monetary policy works, in the first instance by affecting financial conditions, including the levels of interest rates and asset prices (Bernanke, 2007). Changes in financial conditions in turn influence a variety of decisions made by households and firms, including choices about how much to consume, to produce, and to invest.

Figure 5-1 Linkage between financial conditions, monetary policy and real economy
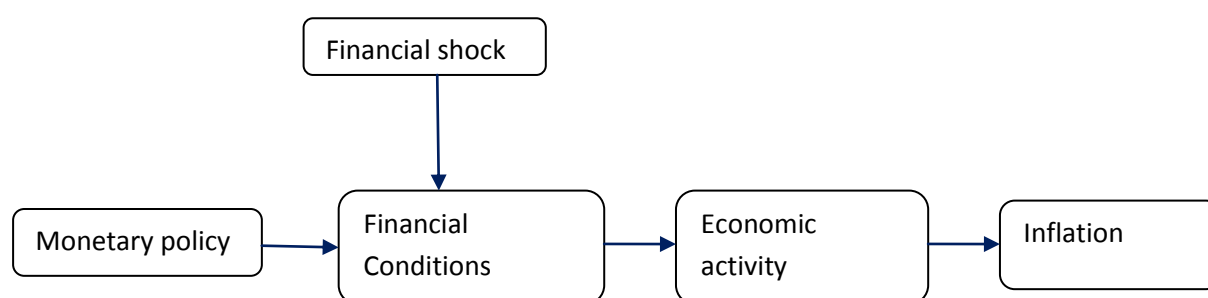
Source: Bloomberg: Financial conditions, Global financial market trends and policy

The South African investigation is motivated by Gumata et al. (2012)`s financial condition indices that showed this country's financial conditions deteriorated significantly in 2008Q4-2009Q1 and 2009Q2-2009Q4 using the principal components and Kalman filter approaches respectively. Similarly, Osorio et al. (2011) found financial conditions in the Asian countries including Korea tightened substantially during the global crisis. The finding that financial conditions were contractionary implies that monetary transmission channels through which policy rate changes are passed into real economy were not working properly as expected. This happened despite, the South African Reserve Bank reducing the interest rate drastically. Hence, this study assesses what happened to the unanticipated structural policy shocks in 2008-2010 periods, given that financial conditions deteriorated significantly. Another question, this chapter investigates relates to whether monetary authorities responded the same

way to economic episodes such as recessions by comparing estimated policy shocks to the expected or systematic response. I am not aware of any study that has applied this approach to these countries, to examine the stance of structural monetary policy shocks in different macroeconomic events such as recessions.

I use Korea for comparative purposes as an emerging market economy based on institutional differences in dealing with global crisis since 2007. The Bank of Korea (BOK) during the crisis tried to arrest decline in market confidence, responded to difficulties in financing international trade and small medium enterprises by injecting both the won and dollar liquidity into markets, and reduced interest rates (Willet, 2009; Alp et al., 2011). In contrast, South African monetary authorities reduced interest rate significantly and did not embark on swap lines arrangements. Alp et al. (2011) reported that, the BOK authorities set aside $55 billion in foreign exchange reserves to provide as swaps or loans to banks and trade related businesses. The policy initiatives included setting up a bank recapitalisation and a toxic asset fund to shield the banking system from the downturn and prevent an abrupt deleveraging. In addition, the authorities initiated bilateral swaps facilities of varying amounts around $35 billion with US Federal Reserve, nearly $26 billion with People`s Bank of China, and about $20 billion with Bank of Japan. To ensure adequate liquidity in the domestic market, the BOK also broadened the list of eligible counterparties and collateral in its repurchase operations and relaxed banks` liquidity requirements.

Alp et al. (2011) using counterfactual simulations found the downturn would have been worst, if the BOK had not implemented the countercyclical and discretionary interest rate cuts. The finding suggested that exchange rate flexibility and the interest rates cuts by BOK helped to soften the impact of global financial crisis on the Korean economy. This motivates me to investigate, to what extent did the Korean's monetary policy effects based on structural model vary from those of the South African Reserve Bank during the period of global crisis since 2008. More importantly, there are lessons from this analysis that South Africa can learn from the Korean experience looking at period of the global crisis. The lessons can be inferred from the examination of structural policy stance during recessions and relate the difference to policy tools used during the period by the two countries. I argue that policy initiatives do account for differences in the impact of monetary policy.

Last but not least, these two countries exhibit similarities in the conduct of monetary policy. The BOK targeted M2 growth rates from 1979-1997 prior to targeting inflation in 1998 (Willet, 2009). The South African monetary authorities pre-announced M3 growth targets (Aron and Muellbauer, 2001) before adopting inflation targeting on February 2000. Aron and Muellbauer (2001) indicated that South African monetary policy regimes in 1986-1998 focused on cash reserves system together with flexible preannounced M3 targets. This changed to daily tender liquidity through repurchase transactions plus preannounced M3 targets and the core inflation. Monetary growth rates continued to be announced on three year basis rather than on a yearly basis since 1986.

This chapter is organised as follows: Section 5.2 describes the sign restriction methodology. Section 5.3 describes the data and empirical specifications. Section 5.4 discusses the main findings, shows the monetary policy structural shock during recessions and the various robustness tests are conducted in Section 5.5. Section 5.6 gives the conclusion followed by three appendices.

5.2   Literature review

The literature investigating the contractionary monetary policy effects on output using sign restriction is very small and presents mixed evidence in developed economies. Rafiq and Mallick (2008) investigated the effects of monetary policy shocks on output in three EMU countries − Germany, France and Italy − using sign restrictions, and found that monetary policy innovations were most potent in Germany. The results were ambiguous as to whether a contractionary monetary policy shock led to a fall in output in Italy. Unequivocally, a restrictive monetary policy shock did not lead to a short-run output contraction in Italy. In addition, evidence showed that monetary policy shocks play, at most, a modest role in generating fluctuations in output for the three EMU countries. Moreover, Uhlig (2005) concluded that contractionary monetary policy shocks had no clear effects on real gross domestic product (GDP) in the US.

There are few studies in South Africa that focused on the effects of monetary policy on output and reported mixed evidence. Bonga-Bonga and Kabundi (2010) used a structural vector error correction based on differenced and stationary monthly data and approximating output with manufacturing production. The results showed that output increased in response

to contractionary monetary policy shock for 6 to 7 months and fell significantly after 12 months. In addition, they find a price puzzle for more than 18 months. Gupta et al. (2010) used a factor augmented vector autoregression method using monthly series to assess whether the SARB has become more effective post inflation targeting using differenced data and repo rate as monetary policy instrument. They find that a contractionary monetary policy shock has a negative and persistent effect on real economic activity given by employment, consumption, capital formation, total production, and coincident indicator variables. They found the effect was more pronounced in the post inflation targeting periods.

Kabundi and Ngwenya (2011) used a FAVAR with using stationary and differenced data and assessed the effects of a contractionary monetary policy shock represented an unexpected rise in repo rate. The impulse response show that production, utilization of productive capacity, disposable income, fixed investment, consumption expenditure and employment reveal these variables react negatively to a rise in short term rates. They approximated economic activity with production and found it fell immediately on impact but effect is significant attaining a maximum of 0.9 percentage decline after 12 months and production recovers after 30 months. Unlike the preceding South African studies, this chapter uses a sign restriction approach and data in levels.

5.3   Methodology

This chapter uses the methodology described in detail in Chapter 3. However, the focus is on single monetary policy shock. The robustness analysis will include additional shocks. The chapter estimates a VAR sign restriction using data in levels, based on this method's merits relative to recursive and large datasets approaches. The various motivations cited in literature for using sign restrictions relative to other approaches include that the method imposes weaker prior beliefs about how monetary policy affects the economy based on economic theory. In addition, Rafiq and Mallick (2008) suggest the sign restrictions identification approach allows a similar identification across countries despite data problems.[66] The restrictions should happen despite data problems and the different ways variables are measured. Fratzscher et al. (2010) argue that the sign restriction gives results independent of the chosen decomposition of the variance–covariance matrix because different ordering does

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[66] However, Scholl and Uhlig (2008) rejected to embrace Fry and Pagan's (2007) argument related to non-uniqueness[66] of the median impulse response in sign restrictions as an issue arising generally with all identification procedures. We use the approach in same spirit.

not change the result. In addition, the approach is robust to the presence of non-stationarity (Granville and Mallick, 2010), does not impose any long run cointegration relationship and does not preclude its existence (Rafiq and Mallick, 2008).

To ensure comparability of our results to literature evidence, the analysis uses a contractionary monetary policy shock of a standard deviation size specification as done by Rafiq and Mallick (2008). This identification suggests that both the exchange rate and interest rate not to be negative, whereas both prices and money supply are restricted not to be positive. The identification in Table 5-1 defines a contractionary monetary policy shock as a shock, which does not lead to decreases in domestic short-term interest rates, appreciates the nominal effective exchange rates, decreases the price levels, and decreases monetary aggregates during the first six months or six quarters after the shock.

Table 5-1 Contractionary monetary policy shock

	GDP	Prices	Oil price index	Interest rate	M2	Exchange rate
Monetary policy	?	-	?	+	-	+

Source: Rafiq and Mallick 2008

However, the identification left unrestricted the real output and oil price index. The oil price variable captures the future anticipated inflation and is very important in defining the oil price shock in Table 5-4 under robustness analysis. This specification follows leads in Uhlig (2005) and Rafiq and Mallick (2008). Christiano et al. (1996) suggested the inclusion of commodity price index due to their information content overcame price puzzle. Kimi and Roubini (2000) using the commodity price index in structural vector autoregressive model did not find price puzzles. Both South Africa and Korea are small open economies, which cannot influence world oil price implying this variable should be exogenous rather than endogenous. However, the specification does not prejudge such outcome as the methodology has the ability to determine such an outcome. Hence, the sign restriction identification in Table 5-1 left the responses to oil price unrestricted.

These are plausible sign restrictions reflecting the weaker prior beliefs of the effects of monetary policy shocks. The liquidity effect suggests that a contractionary monetary policy shock should lead to declines in M2. Furthermore, the approach assumes that rational expectations, uncovered interest rate parity holds and prices slowly adjust to changes in excess demand at all times. The international trade component makes a significant share of these emerging-market economies' GDP, hence the nominal effective exchange rate provides

information on pass-through into the cost of imported intermediate inputs and changes in the return on assets denominated in different currencies.

By construction, the identification avoids the price puzzle often found when using recursive identification strategies. The empirical section uses the confidence bands drawn by taking draws from the posterior distribution when identifying the shocks for each case. The 16 and 84 percentiles represent error bands for the dynamic responses, which are equivalent to one standard deviation band if the distribution is normal (Rafiq and Mallick, 2008; Uhlig, 2005).

5.4 Data

This analysis uses quarterly (Q) observations beginning in 1980Q1 and ending in 2011Q3 obtained from International Monetary Fund's (IMF) IFS database. The chapter estimates a VAR using sign restrictions using data in levels. The analysis uses six variables, namely real GDP, GDP deflator, oil price index, M2, nominal effective exchange rates (NEER) and money-market interest rate (MMR).

Table 5-2 Descriptive statistics

Variable	Mean	Minimum	Maximum	Std error
South African GDP (Trillion rands)	0.86	2.99	0.06	0.81
South Africa M2 (Trillion rands)	0.48	1.72	0.02	0.52
South Africa NEER	221.83	710.20	62.90	183.47
South Africa MMR (%)	12.08	22.50	4.22	4.49
South Africa GDP deflator	58.08	157.43	6.49	43.29
Korea GDP (Trillion won)	116.36	13.82	7.39	90.56
Korea M2 (Trillion won)	541.23	17288.00	9.95	517.44
Korea NEER	124.28	202.70	69.30	34.22
Korea MMR (%)	9.57	24.47	1.88	5.51
Korea GDP deflator	68.61	116.40	21.01	28.00
Oil price index	63.91	227.00	21.80	45.34

Table 5-2 gives the descriptive statistics of all variables. It shows two distinct patterns based on the standard deviation of the variables. The South African GDP, M2 and money-market interest rates have smaller standard deviation compared to the corresponding Korean variables. However, the standard deviation of GDP deflator and nominal effective exchange rate exceed those of Korean variables.

Figure 5-2 Plot of all variables
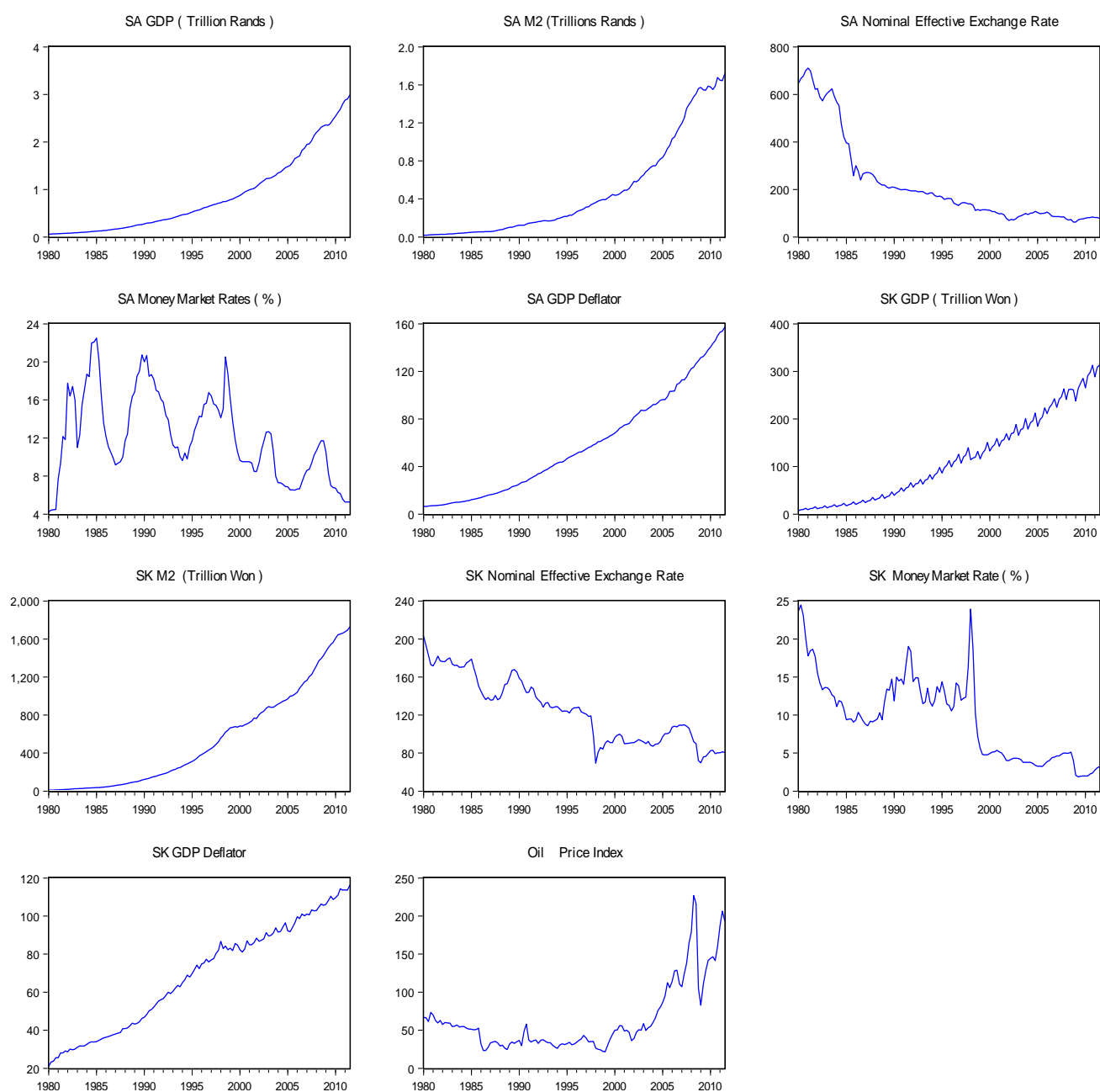
Note. SK refers to Korea an SA refers to South Africa

Figure 5-2 shows the trends of South African and Korean variables. There is an upward trend in GDP, GDP deflator and M2 variables in both countries. The nominal effective exchange rate has appreciated more significantly compared to those values at the beginning of the sample. The oil price index indicates that prices have risen considerably after 2005.

Figure 5-3 Quarterly GDP growth rates and Money market interest rates
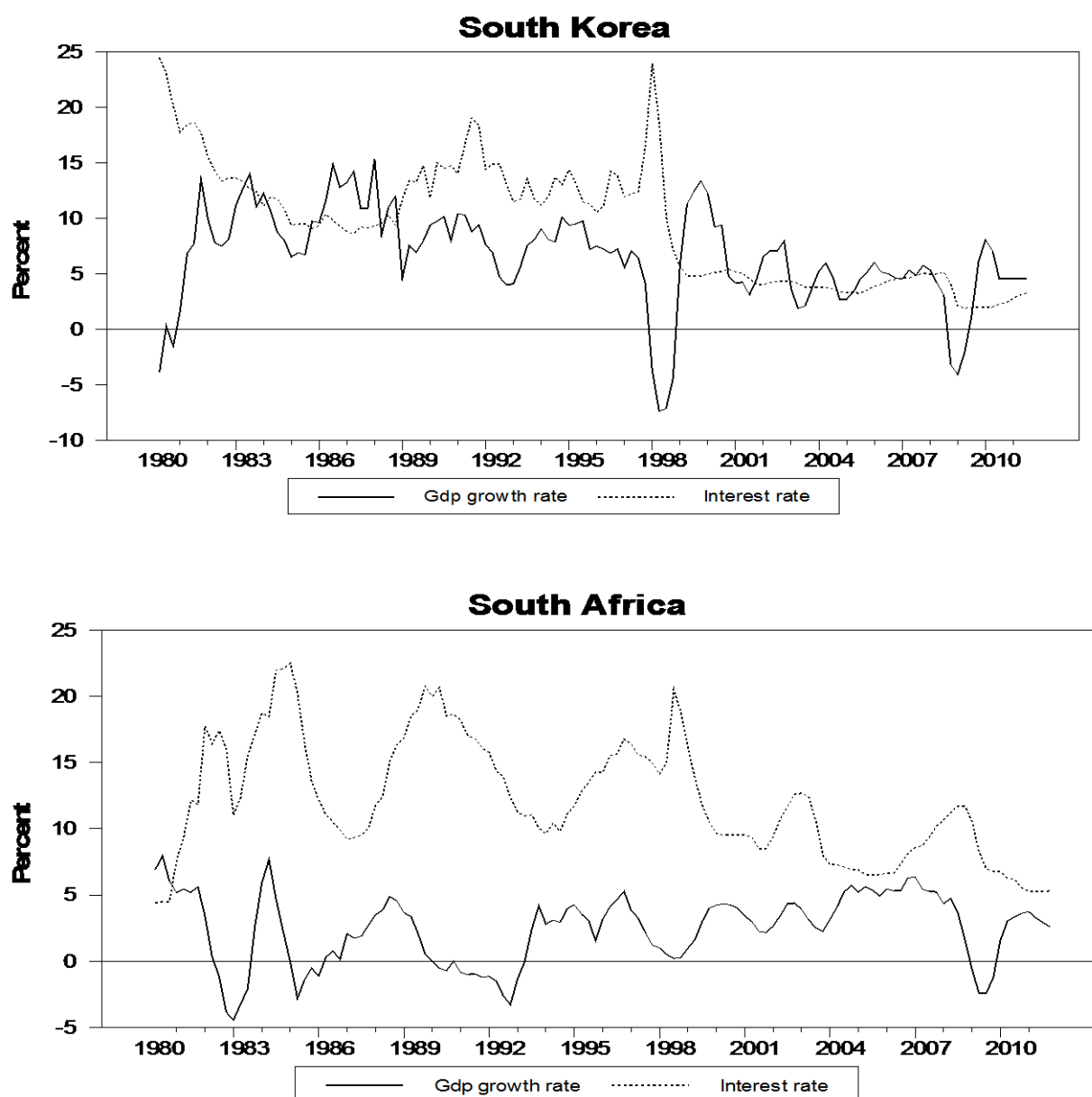
Figure 5-3 uses line graphs to assess the relationship between the movements in interest rate (dotted line) and real GDP growth rate (continuous black line) in South Africa and Korea. Real GDP (from expenditure approach) growth rates were extracted from the Organisation for Economic Co-operation and Development (OECD), calculated as a change to the same quarter of the previous year using seasonally adjusted data. The large declines in GDP growth rates coincided with the highest interest rates in the early 1980s and 1998 in Korea, whereas protracted and no GDP growth in South Africa occurred in 1991–1992 and around 1998. On the contrary, the periods of extremely lower interest rates that happened around 2004–2006 in South Africa coincided with a higher economic growth rate in the country. Some of these

127

statistical timings in the GDP and interest rate data corroborate that monetary policy changes are important generators of business-cycle fluctuations. This evidence justifies an econometric investigation to determine whether monetary policy is very potent in generating output fluctuations.

This analysis begins by looking at how all variables respond to a one standard deviation shock. Such initial responses have not been investigated in South Africa. The pre-estimation analysis starts by examining the distribution of the initial impact of all variables to the contractionary monetary policy shock before making a formal econometric analysis. Figure 5-4 shows the distributions of the impact of the initial impulse responses of all variables at horizon zero. This happens when imposing the sign restriction, for six months at the ordinary least point estimates, in the VAR with three lags selected by Akaike Information Criterion.

Figure 5-4 Shaped posterior distribution to impact responses
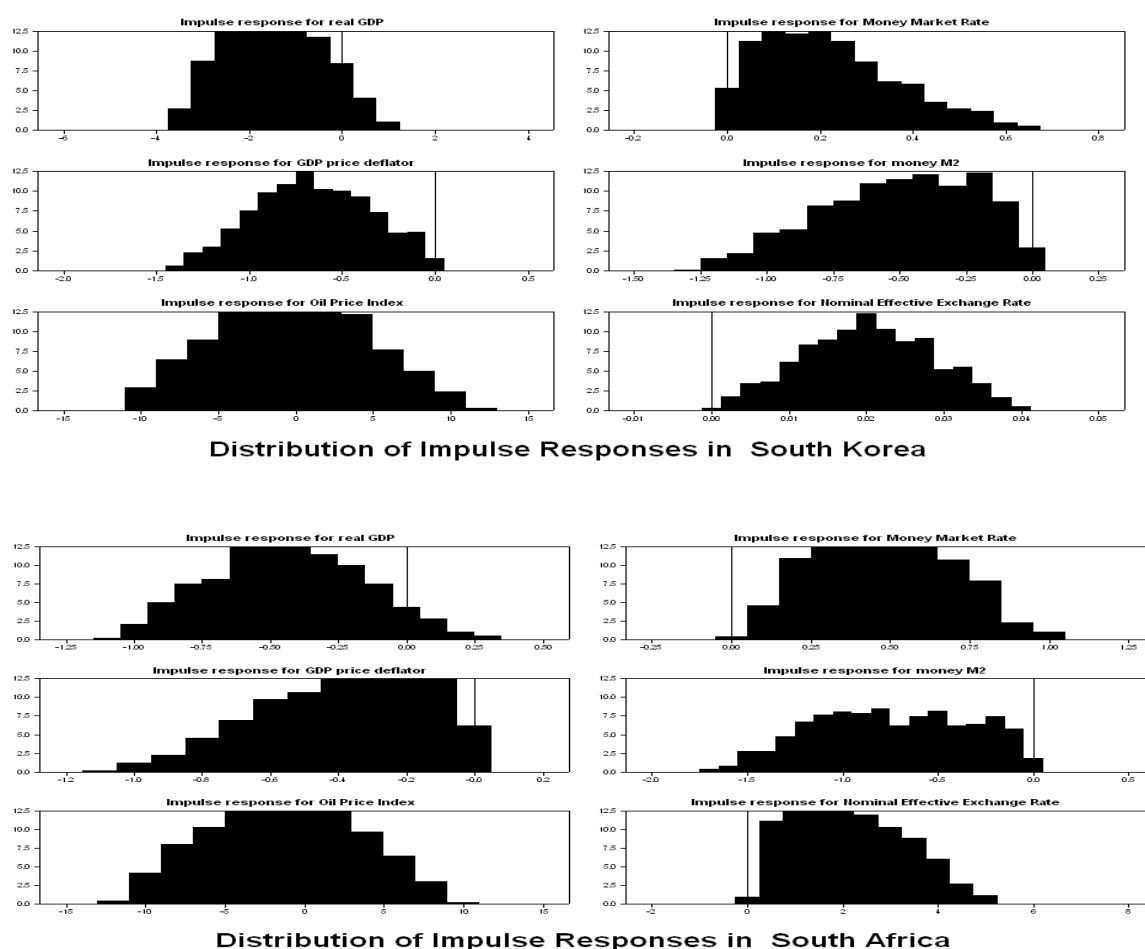
The histograms in Figure 5-4 show how the uniform draws of the orthogonalised impulse vectors and sign restrictions lead to the shaped distribution for the initial response (see Uhlig

2005; Rafiq and Mallick. 2008). The vertical axis represents the percentage of draws. Based on the histograms, there is a high likelihood that real output tends to fall in response to a contractionary monetary policy shock. The GDP price deflator, M2 and oil price variables are more likely to fall at the initial stage whereas the interest rates are likely to rise and exchange rate appreciates on impact. The study further examined the maximum and minimum bounds for K=3 to 9 quarters output responses to a contractionary monetary policy shock. Output responds the same way in both countries irrespective of choice K quarter and evidence finds no bias towards a positive response from output to a contractionary monetary policy shock.

5.5   Results

This section discuses results estimated from a VAR with three lags selected by Akaike Information Criterion using sign restrictions in Table 5-1. Figure 5-5 and Figure 5-6 show the various impulse responses for Korea and South Africa respectively. The 16 and 84 percentiles form the error bands of the impulse responses derived from a sample of 200 draws from the posterior distribution. According to Uhlig (2005), the 16 and 84 percentiles for the impulse responses would correspond to a one standard deviation band when the distribution is normal.

Figure 5-5 Korean dynamic responses
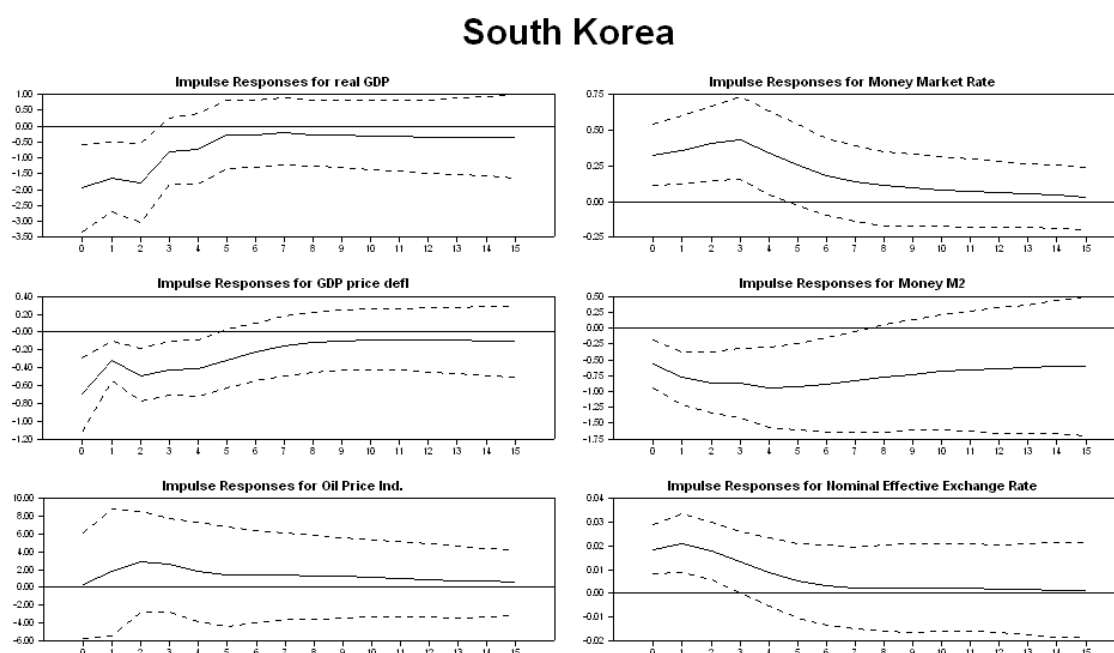
The M2 aggregates decline in both countries following an interest rate increase, which is consistent with the liquidity effect. The Korean M2 declines transitorily for about seven

129

quarters in Figure 5-5. Perhaps this indicates the importance of the liquidity channel in pulling back the output to pre-shock levels. The persistent decline in South African M2 in Figure 5-6 coincided with the persistent declines in output.[67] In addition, a contractionary monetary policy shock depressed the price levels significantly in Korea for five quarters relative to persistent contraction in South Africa. Perhaps this supports the effectiveness of monetary policy in lowering inflation and possibly a feedback from lower output to lower inflation through the short run Phillips curve relationship.[68] These dynamic responses of price-level movements seem to move together with the responses of the M2, perhaps suggesting monetary aggregates supply information in predicting future movements in prices. The Korean nominal effective exchange rate appreciates significantly for nearly three quarters (Figure 5-5) relative to the persistent South African exchange rate appreciation (Figure 5-6).[69] The interest rates rise for four quarters in both countries after a monetary policy tightening.

Figure 5-6 South African dynamic responses
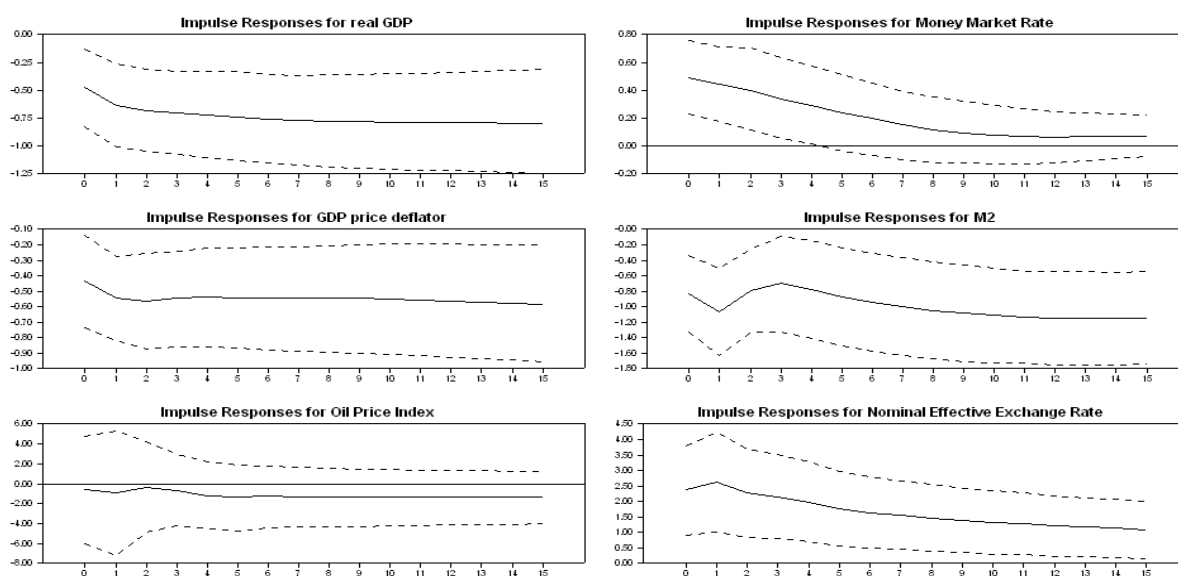
There is significant evidence showing that contractionary monetary policy shocks lead to a fall in output upon the initial impact but the full effects of contractionary monetary policy shocks are different in the two countries. In addition, the results give no ambiguous evidence

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[67] I concluded similarly that using M3 in South Africa in response to Rafiq and Mallick (2008) argument that using M2 implies that the special role of bank credit has been largely ignored thereby diluting to a certain extent and eradicating the effects of a contractionary policy shock on output in South Africa.

[68] Such sluggish price adjustment supports evidence from other VAR studies.

[69] Rafiq and Mallick (2008) suggest that the finding of an erratic exchange rate response should not be too much of a surprise. This is not surprising since there has been a shift in exchange rate regime in these countries.

about the negative output response upon the initial impact. The Korean output response is consistent with monetary neutrality. By contrast, the South African dynamic response shows persistent output contraction, which supports the monetarist view that the economy responds gradually to monetary policy shocks. Such persistent declines in South African output, may indicate, the need for policy intervention.[70] This implies South African monetary authorities may need to use other instruments that offset the persistent effects of monetary policy on output. It seems, the transitory effect of monetary policy shocks on Korean output reflects the influence of the exchange rate and liquidity channels arising from foreign-exchange rate interventions.

Appendix A 5 gives additional impulse responses from the robustness tests to various structural breaks using dummies for South Africa and Korea.[71] Similarly, the evidence concluded that contractionary monetary policy lowers output persistently in South Africa and leads to transitory declines in Korea. Thus, evidence points to the same conclusion that output response is robust to the inclusion of structural breaks. Moreover, similar conclusions are made using two samples, namely 1990Q1-2011Q3 and 1995Q1-2011Q3 (results are not reported here). Overall, the evidence suggests the results are robust to inclusion of structural breaks, sample size and changes in periods in which shocks are expected to last.

5.5.1 Discussion of results

According to Rudebush's (1998) view, the structural shocks recovered from standard VAR are unreasonable because they are unrelated to market perceptions of monetary policy shocks. In response to this criticism, Canova and De Nicoló (2002) showed that innovations in the interest rate variable carry this information. The latter authors found that the structural shocks had a significant relationship with innovations in interest rate variables. Moreover, Rafiq and Mallick (2008) responded to similar criticism by showing that the term structure of interest rates contained the monetary policy shocks. Similarly, this particular analysis adopts two approaches from the latter authors to investigate if the estimated monetary policy shocks

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[70] This analysis further investigates the response of output to varied periods (in quarters) for which imposed shocks should last and the inclusion of various known structural breaks. This comparison confirms that dynamic responses of output are indeed robust to different quarters. Similar to earlier findings, the South African real output remains persistently depressed after falling by a smaller percentage across three different quarters. Similarly, the large and highly transitory output decline in Korea is robust to imposition of the different quarters.

[71] In South Africa, I added the dummies for inflation-targeting era from 2000Q1, recession in 1991–92 and 2009Q1–3, debt standstill periods in 1985Q3–1989Q3, Asian crises in 1997Q2–1998Q3, US recession in 2001 and global recessions in 2008. However, in Korea we included dummies for inflation-targeting period, Asian crisis, global recession in 2008 and US shocks in 2001.

extracted from the estimated VAR are good approximations of true monetary policy activities.

The first approach in this particular analysis uses estimated monetary policy shocks to examine the extent to which shocks capture the conduct of actual monetary policy activities during major economic shocks. This involves relating shocks to the history of macroeconomic events over the sample period. Figure 5-7 and Figure 5-8 displays the four-quarter moving averages of the monetary policy shocks calculated from the structural shocks from the reduced form VAR.[72] These averaged shocks make interpretation easier through dampening out some noise. The monetary policy shock is classified as tight or contractionary when the policy shock is positive and loose or expansionary when it is negative. At the same time, the analysis heeds Rafiq and Mallick's (2008) caution to avoid necessarily translating a high value for the interest rate into a high value for the contractionary monetary policy. This preceding caution is based on the argument that an unexpected rise in the interest rate could be due to a positive oil price shock, positive non-monetary aggregate demand shock, any negative supply shock (e.g. wage increases) and a contractionary monetary policy.

This section investigates the response of monetary policy during the recessions and boom periods in both countries. However, the emphasis is in the recession following the global recession in 2008. The findings point to similarities related to the conduct of monetary policy activities over the business cycle in these two countries. The Korean monetary policy was loosened during the two recessions in 1998–99 and around 2009. Similarly, the South African monetary policy was loosened in both recessions in 1985–86 around 1991–92 but seems slightly tightened during the recession in 2009. Perhaps the latter reflects the difficult circumstances during the global recession in 2008 and related uncertainty, which rendered huge interest rate cuts less effective for an economy depending on international trade for nearly 25 per cent of output.

However, the Korean monetary policy is expansionary during the recession in 2009 unlike the South African counterparty. This possibly reflects that additional monetary policy intervention tools in addition to interest rate reductions to deal with recession in Korea made a difference. Despite huge international reserves, market confidence was boosted by

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[72] The structural shocks are calculated from $e_t = b'u_t$ where b is the row of A_t^{-1} and e_t is the structural shocks and u_t are the residuals from the reduced form model. A_t is made up of impulse vectors.

announcement of the creation of $30 billion dollar swap line with US Federal reserve bank, central banks of China and Japan.

Figure 5-7 Estimated monetary policy shocks and Korean GDP growth rate

GDP growth rate versus Monetary policy shocks

- - - - - - Monetary policy   ——— GDP growth rate
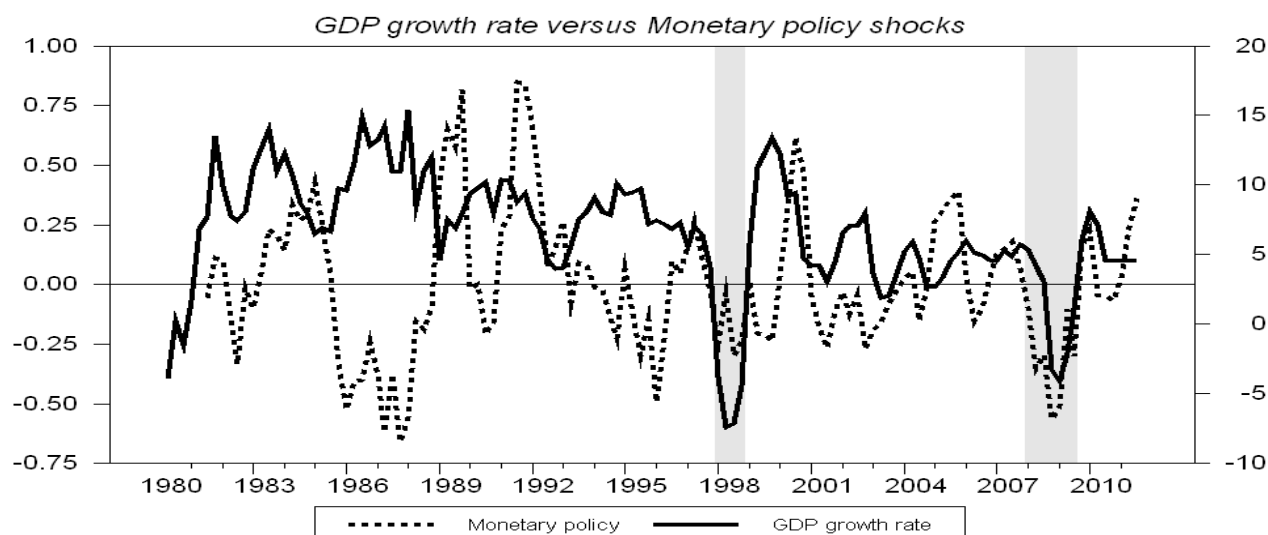
Figure 5-8 Estimated monetary policy shocks and South African GDP growth rate

Unanticipated Monetary policy shocks and GDP growth rate

- - - - - - Monetary policy shocks   ——— GDP growth rate
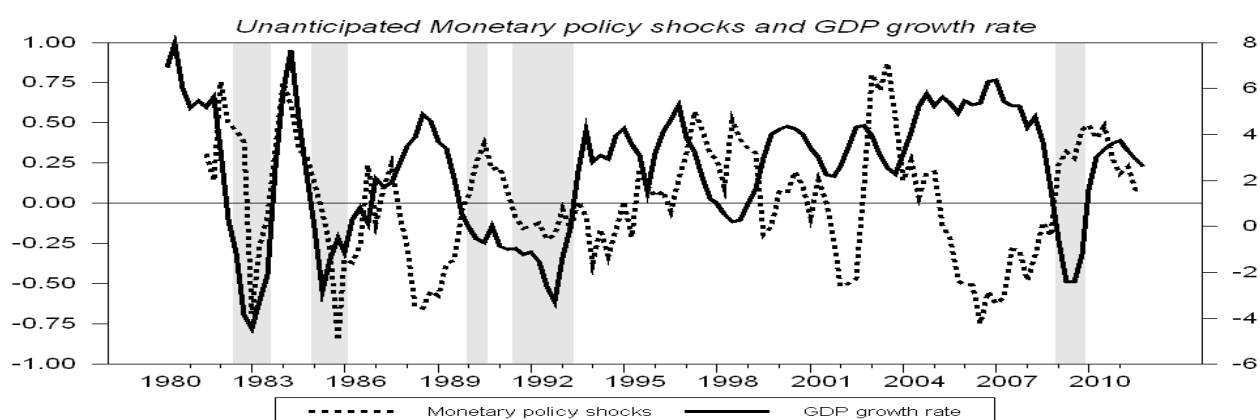
Notes. According to the dotted line, points above (below) the zero line indicate a contractionary or tight (expansionary or loose) monetary policy stance. In each figure, the left hand side is linked to monetary policy shocks and right hand side refers to GDP growth rates.

In most cases, the periods of expansionary monetary policy preceded or coincided with the peaks in output growth. For instance, the high growth rate in the South African economy coincided with expansionary monetary policy e.g. in 1988–1989, 1994-1997 and 2005–2008. A similar trend in peak economic growth happened in Korea around 1986–1988, 1995–1996 and 2001–2003 during the expansionary monetary policy phases.

This second, part investigates whether these estimated monetary policy shocks are policy driven and do not represent money demand shocks. The likelihood-based cointegration tests in Table 5-3 examine the relationship between the estimated monetary policy shocks and the term structure. The term structure is the difference between money-market interest rates and long-term interest rates on government bonds using data from the IFS database. The objective is to determine whether the exogenous monetary policy shocks were captured. Only the exogenous unanticipated components of monetary policy allow an accurate analysis of the effects of monetary policy on output (Rafiq and Mallick, 2008). Moreover, capturing the anticipated component would not provide an accurate measure of the effect of monetary policy shocks on output.

Table 5-3 Likelihood Based Analysis of Cointegration

	Rank	EigenValue	Lambda-max	Trace	Trace-95 per cent	LogL
South Africa	0					-650.01
	1	0.1667	20.24	34.92	15.41	-639.89
	2	0.1239	14.68	14.68	3.840	-632.55
Korea	0					-152.33
	1	0.0973	11.36	21.38	15.41	-146.65
	2	0.0863	10.02	10.02	3.840	-141.65

The trace statistics results in Table 5-3 (column 5) confirm the existence of cointegration relationship between estimated monetary policy shocks and the term structure in these countries. Based on Rafiq and Mallick's (2008) argument, the findings conclude that the policy shocks derived have an effect on the term structure, which is not expected if the shocks derived were indeed money demand shocks. Both approaches indicate that the estimated monetary policy shocks fairly approximate the true monetary policy activities for each country.

5.5.2 Robustness analysis

The additional sensitivity analysis uses two approaches namely the penalty function and the additional orthogonal shocks. A penalty function approach seeks for a unique monetary policy impulse vector through searching for a large initial reaction to monetary policy shock and has the additional criterion to select the best of all impulse vectors. The additional restrictions lead to possible distortions of the true direction of the impulses. However, the pure sign restriction approach considers equally likely all impulses responses satisfying the sign restriction through searching for a range of impulse vectors consistent with the signs.

The monetary policy impulse vectors and ranges from the penalty function are contained as elements in the set of vectors admitted by the pure–sign restriction approach.

This section follows the work of Uhlig (2005, see also Rafiq and Mallick, 2008) to test the sensitivity of our findings from the pure-sign restriction using the penalty function approach. These studies found that error bands for some variables from the pure-sign restriction were wider but narrowed under the penalty function. The empirical evidence is presented in Appendix B 5 finds similarities between results from the penalty function approach and the pure-sign restrictions. For instance, the initial values of the median impulse responses of the real GDP from the penalty function approach are closer to those of the pure-sign restriction approach. The Korean output declines significantly and recedes to pre-shock levels within a quarter in both the pure-sign restriction and the penalty function approaches. Both the penalty function and pure-sign restriction approaches showed that the South African output declined significantly on impact and remained depressed. The error bands are sharper under the penalty function.[73]

The second test applies the additional orthogonal shocks approach to disentangle the true monetary policy from a set of extra shocks to ascertain the policy shocks do not reflect those not identified in the model. As stated in the preceding section, the second, sensitivity analysis focuses on additional orthogonal shocks, which are estimated by the Mountford and Uhlig (2009) method.[74] First, this isolates unexpected rise in the interest rate possibly associated with a positive oil price shock, positive non-monetary aggregate demand shock, any negative supply shock (e.g. wages increase) and a contractionary monetary policy. Second, the additional orthogonal shocks disentangle true monetary policy from a set of extra shocks to ascertain the policy shocks as not reflecting those not identified in the model. The structural shocks are orthogonally drawn when deriving the impulse vectors, rendering the ordering of the shocks less important for the results. [75]

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[73] The Korean 3 per cent output decline in response to one standard deviation shock appears more responsive compared to the South African (0.6 percent), which is a similar finding from the pure-sign restriction approach

[74] Rafiq and Mallick (2008) argued that sequentially estimation procedure might lead to sampling properties problems. This implies the sequence of shocks would matter to the results. Alternatively, an adjusted step-wise procedure can be used to make sure that it results in the same probability distribution on the impulse vector.

[75] This procedure draws four orthogonal vectors of unit length using sign restrictions as done by Rafiq and Mallick (2008). Applying the orthogonality assumptions avoids problems of sequential estimation and renders the ordering of the shocks irrelevant. We draw all four vectors simultaneously (see Rafiq and Mallick, 2008, Mountford and Uhlig, 2009) and eliminate both sampling uncertainty and ordering effects arising from sequentially sampling draws.

Table 5-4 Non-monetary shocks

Shock	GDP	GDP deflator	Oil Price index	Interest	M2	NEER
Demand	+	+				
Supply	+	-				
Oil price			+			

Table 5-4 presents the summary of additional shocks discussed in Rafiq and Mallick (2008). The demand shock imposes positive sign restrictions on both the GDP and prices as predicted by standard aggregate-demand and aggregate-supply (AD–AS) framework. Under a countercyclical monetary policy stance, theory expects the interest rate to rise to dampen the rising price effects originating from the demand pressures in the economy. Moreover, this non-monetary demand shock differs from an expansionary money-supply shock, expected to have the same sign restrictions but M2 is left unrestricted.

The second, shock defined in Table 5-4 is a positive supply shock with signs predicted in the AD–AS framework. The positive supply shock suggests that an increase in aggregate supply leads to an increase in output and a decline in prices. A counter-argument holds that it is plausible that a positive supply shock could result in higher prices when supply shocks make monetary authorities loosen monetary policy by more than what is required (Rafiq and Mallick, 2008). In addition, Chamberlin and Yeuh (2006) are of the opinion that an aggregate supply shock that increases output exerts upward pressure on wages and price levels. Moreover, Table 5-4 defines a positive oil price shock as a shock in which the oil prices rise for at least two quarters.[76] According to the AD–AS framework, such unexpected negative supply shock should lower output and increase price levels but I left the two variables unrestricted to be determined in the model.

The impulse responses of the shocks in Table 5-4 are in Appendix A 5 and B 5. Output rises transitorily but the GDP price deflator rises significantly for 10 quarters in both countries following a non-monetary demand shock. While these responses are consistent with the standard textbook predictions of the AD–AS framework, they also corroborate Rafiq and Mallick's (2008) findings for the three EMU economies, that demand shocks have a transitory impact on output but persistent effects on inflation.[77] The supply shock leads to a significant and persistent increase in output in Korea only. However, the GDP price deflator declines for three quarters following a positive supply shock in both countries, which is

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[76] Oil price provide central banks with information about future inflation from the real disturbances (Sims 1992). In contrast, Leeper and Rousch (2003) noted the role of commodity prices has not been well worked out in theoretical models.
[77] GDP rises significantly on impact and reverts to pre-shock levels at least after two quarters.

consistent with the outcome predicted by the real business cycle theory that observes inflation as countercyclical (Rafiq and Mallick, 2008).

The Korean interest rate declined significantly for three quarters relative to an insignificant tightened policy rate in South Africa. The latter response perhaps suggests that monetary policy authorities increase interest rates in anticipation of future price increases associated with higher future incomes. Moreover, only a supply shock in Korea leads to a significant persistent exchange rate appreciation. This is consistent with Mishkin's (2007) suggestion that a country that becomes more productive relative to its trading partners would experience a currency appreciation. An oil price shock leads to a significant oil price inflation that lasts at least two quarters with no significant pass-through to price levels. Perhaps the persistent exchange rate appreciation (although insignificant) played a role in offsetting the pass-through of a high oil price to the GDP price deflator.

5.5.3 Variance decomposition

This section reports the fraction of the variance of the K-step ahead forecast revision in real GDP attributed to monetary policy shocks and various non-monetary demand shocks. The results refer to the pure-sign restriction approach with a k=2 quarters, with variables ordered using the sign restrictions shown in the previous tables. Additional, the investigation looks at the fluctuations of interest rates explained by monetary policy shocks and various non-monetary demand shocks.

Table 5-5 and Table 5-6 present the error variance decompositions of output explained by various shocks in the two countries. Monetary policy shocks have a very modest impact on output fluctuations and explain almost 17 per cent in both countries in longer horizons. Moreover, these values are larger than those reported for advanced economies.

Table 5-5 Forecast error variance in South Africa real GDP by various shocks in per cent

Steps	Monetary policy	Demand	Supply	Oil
1	13.9	19.0	1.9	9.4
2	14.1	18.7	3.5	10.0
3	14.4	18.7	4.3	10.5
4	14.8	18.5	5.1	11.1
8	16.1	18.2	7.9	13.4
12	16.6	18.2	9.3	14.5
16	16.7	18.1	10.1	14.9

Notes. The forecast revision calculated with K=2 (or 6 months). The variances of errors are ordered as in Table 5-1. The forecast error results reflect the sign restriction imposed and hence are not identified though a Cholesky decomposition.

Uhlig (2005) found the median response to be around 6 per cent for the US economy and a 3,1 per cent was reported by Rafiq and Mallick (2008) for Germany, and the latter linked little real effects to the central bank keeping a steady hand at the wheel. In contrast, our findings shows that monetary policy shocks induce significant output fluctuations in the long run, suggesting that these shocks are a source of business fluctuations.

Table 5-6 Forecast error variance in Korea real GDP by various shocks in per cent

Steps	Monetary policy	Demand	Supply	Oil
1	16.1	11.3	6.1	9.5
2	16.3	13.4	10.1	11.8
3	16.3	13.9	10.8	12.3
4	16.4	14.6	11.9	13.0
8	16.8	15.6	13.6	13.9
12	17.3	16.4	14.6	14.7
16	17.3	16.7	15.5	15.1

Notes. The forecast revision calculated with K=2 (or 6 months). The variances of errors are ordered as Table 5-1. The forecast error results reflect the sign restriction imposed and hence are not identified though a Cholesky decomposition.

Additionally, the chapter explores the variations in interest rate movements related to different shocks and summarise the results in Table 5-7 and Table 5-8. The South African monetary policy shocks explain a large variation in interest rates over all horizons compared to other shocks. In addition, both demand and supply shocks explain less variability relative to other shocks over all horizons.

Table 5-7 Forecast error variance South Africa interest rates in per cent

Steps	Monetary	Demand	Supply	Oil
1	13.7	9.6	9.4	10.5
2	13.8	9.9	9.6	10.7
3	14.0	10.5	10.0	11.1
4	14.2	11.1	10.7	11.5
8	15.1	12.5	12.4	12.8
12	15.4	13.0	12.8	13.4
16	15.6	13.3	13.3	13.9

Notes. The forecast revision calculated with K=2 (or 6 months). The variances of errors are ordered as in Table 5-1. The forecast error results reflect the sign restriction imposed and hence are not identified though a Cholesky decomposition.

However, the supply shock in Korea explains a large variability in interest rate fluctuations over all horizons after two quarters, perhaps reflecting the role played by industrialisation and innovation effects on the economy. The largest fraction of variance explained by the monetary policy shock in the medium term provides some support for the view that monetary policy shocks are accidental errors by central bank that are quickly reversed (Rafiq and Mallick 2008).

Table 5-8 Forecast error variance Korea interest rates in per cent

Steps	Monetary	Demand	Supply	Oil
1	13.3	11.9	13.1	12.0
2	13.8	13.1	14.2	13.0
3	13.9	13.2	14.6	13.3
4	14.0	13.4	14.8	13.5
8	14.1	13.7	15.1	14.2
12	14.4	14.2	15.4	14.7
16	14.6	14.5	15.6	14.9

Notes. The forecast revision calculated with K=2 (or 6 months). The variances of errors are ordered as in Table 5-1. The forecast error results reflect the sign restriction imposed and hence are not identified though a Cholesky decomposition.

5.6 Conclusion

Chapter 5 investigated the effects of contractionary monetary policy shocks meausered as a one standard deviation in size on output in South Africa and Korea. Evidence shows that contractionary monetary policy shocks lead to a fall in output on initial impact but the full effects are different in the two countries. Output declined persistently in South Africa in response to contractionary monetary policy shocks whereas it was highly transitory in Korea. The findings further suggest that monetary policy has significant nominal effects indicated by depressing price levels in both countries. However, it has significant and persistent real effects in South Africa only. This is in contrast to the positive US output responses reported by Uhlig (2005). Moreover, there is no mixed evidence as reported by Rafiq and Mallick (2008), with a positive output response in Italy and a negative for Germany and France. I find evidence that the estimated monetary policy shocks suggest that actual monetary policy became less expansionary between 2006Q2 and 2008Q4. Furthermore, evidence suggests that estimated monetary policy shocks actually contracted during and after the recession in 2009. The latter evidence points to the possibility that worsening global economic environment and continuous uncertainty made the South African monetary authorities' huge interest rate reductions less stimulatory. The difference in structural shocks since period of global uncertainty in 2009 implies that South African monetary policy authorities can learn from Korea that complementing monetary policy with other policy tools may help during global uncertainty times.

Appendix A 5   Robustness to structural breaks

Figure Appendix A 5-1 Robustness analysis to structural breaks
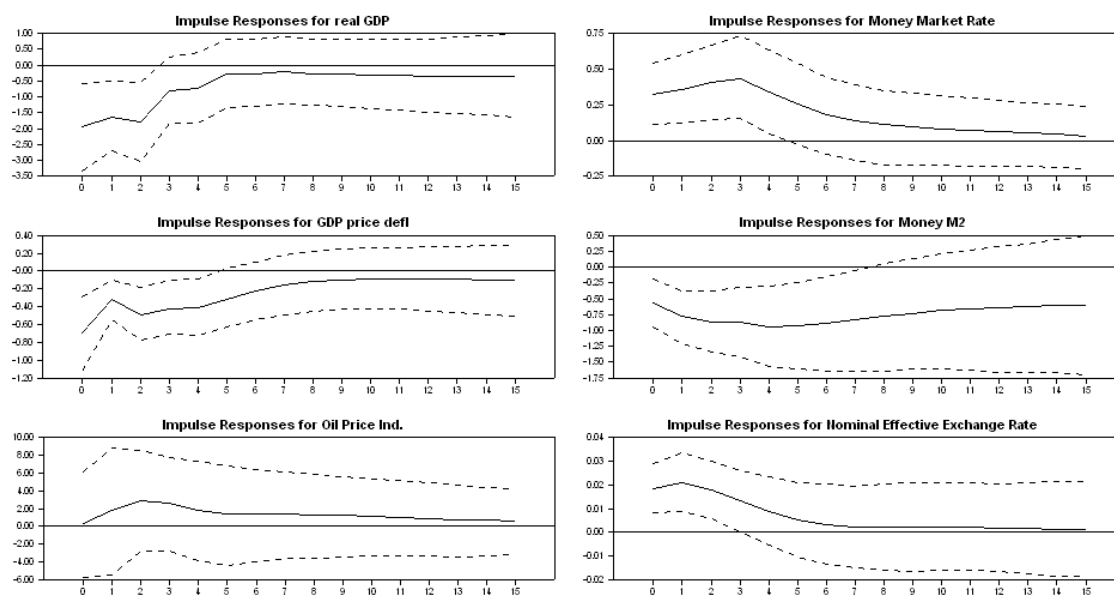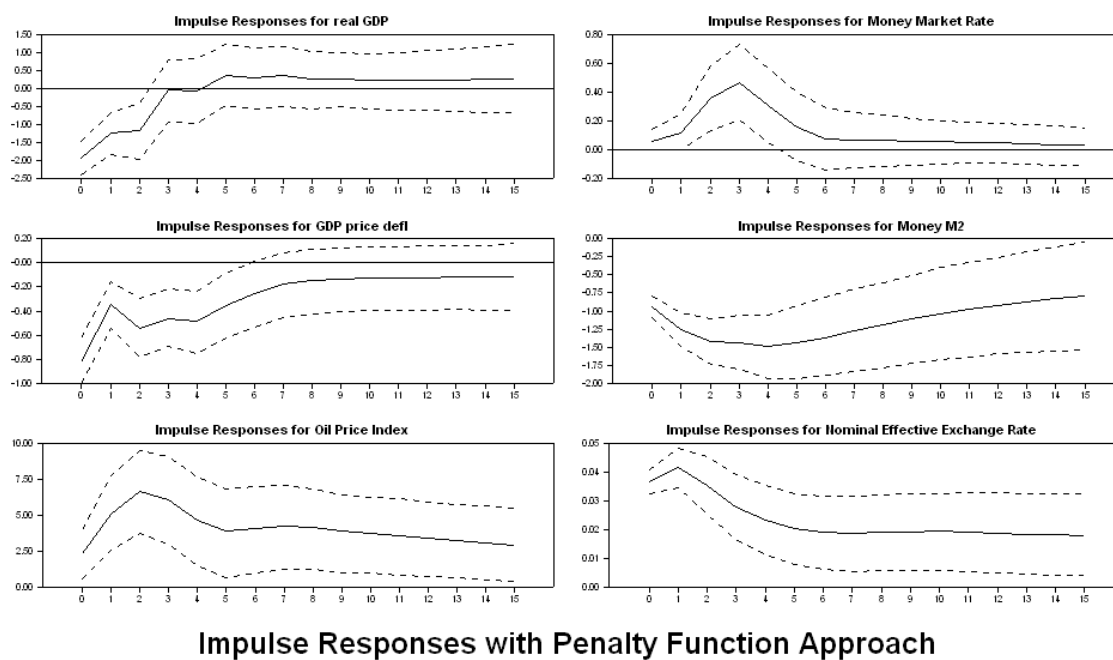

South Africa
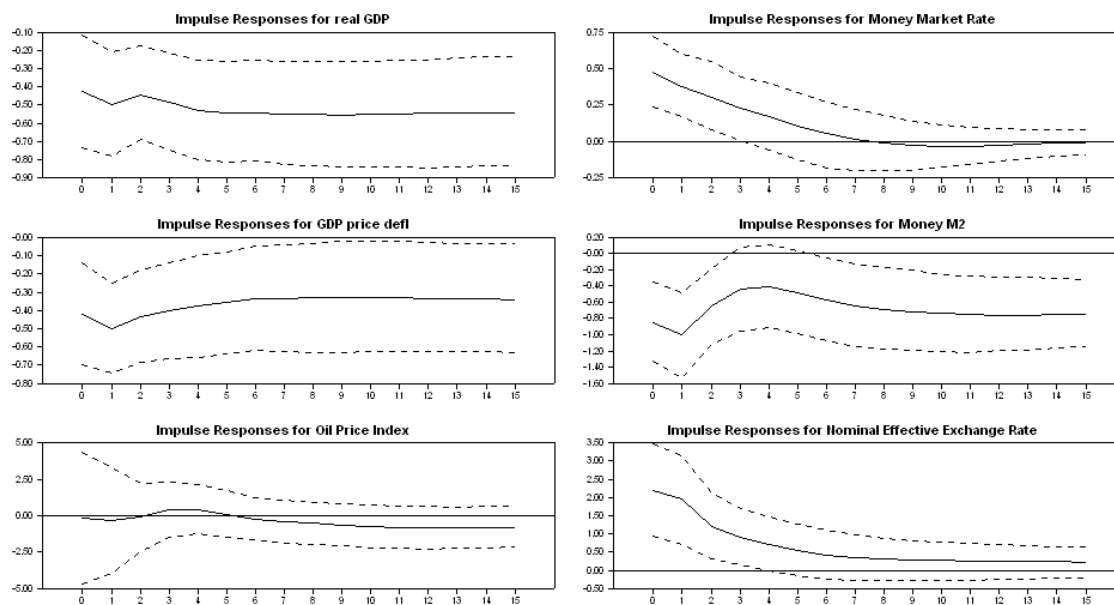
South Korea

Figure Appendix A 5-2 Penalty function approach results

Korea

Impulse Responses with Penalty Function Approach

South Africa

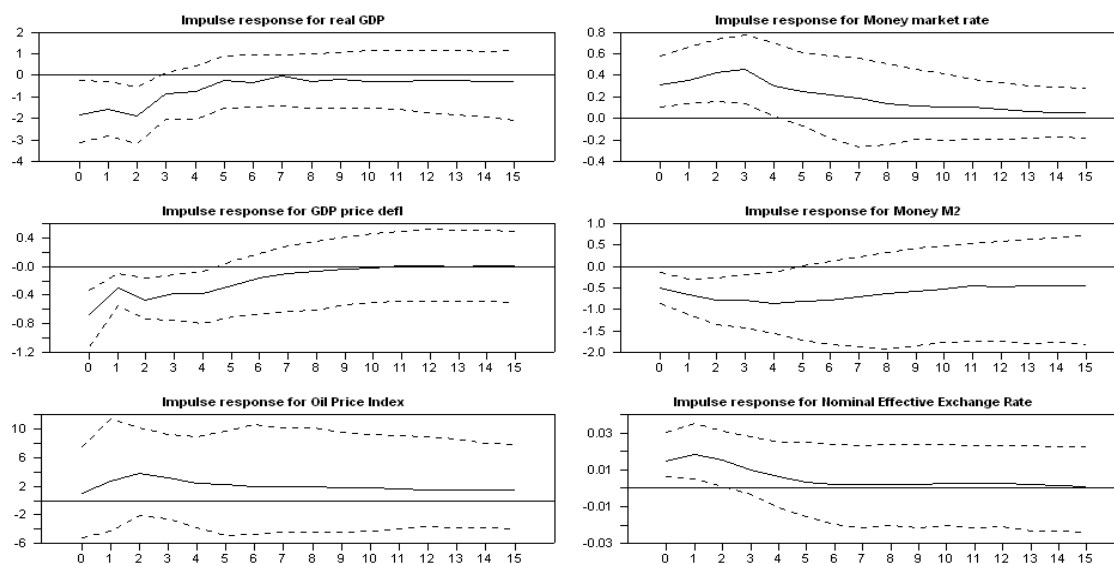Impulse Responses with Penalty Function Approach
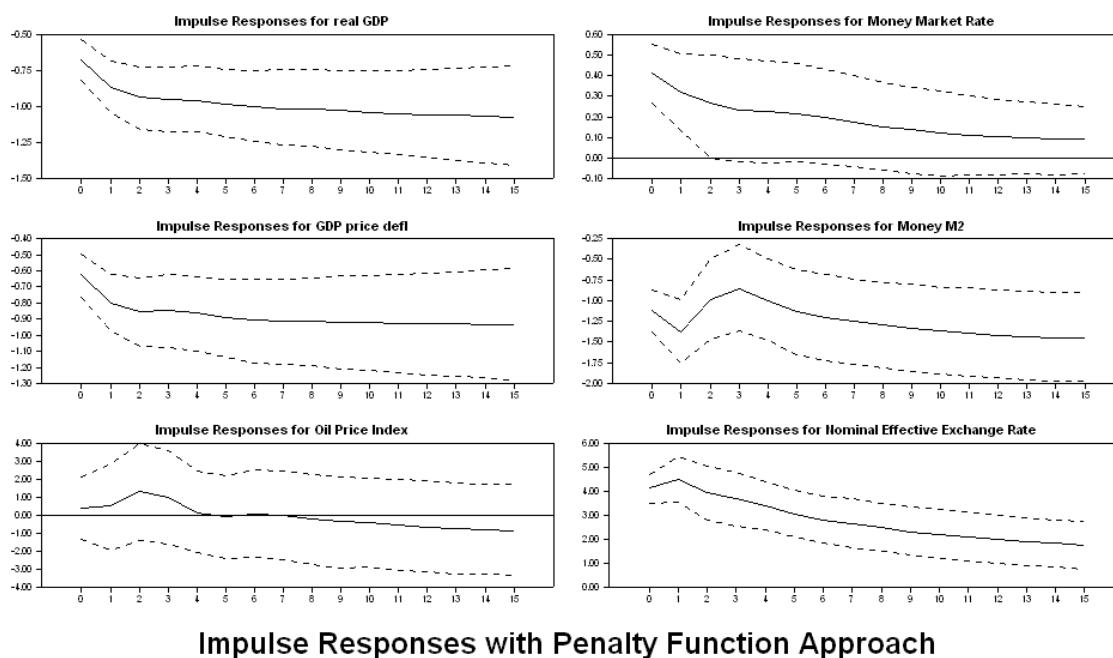
Appendix B 5 : Robustness to additional shocks

Figure Appendix B 5-1 Orthogonal impulse responses in Korea

Korea

Responses to Orthogonal Monetary policy shocks
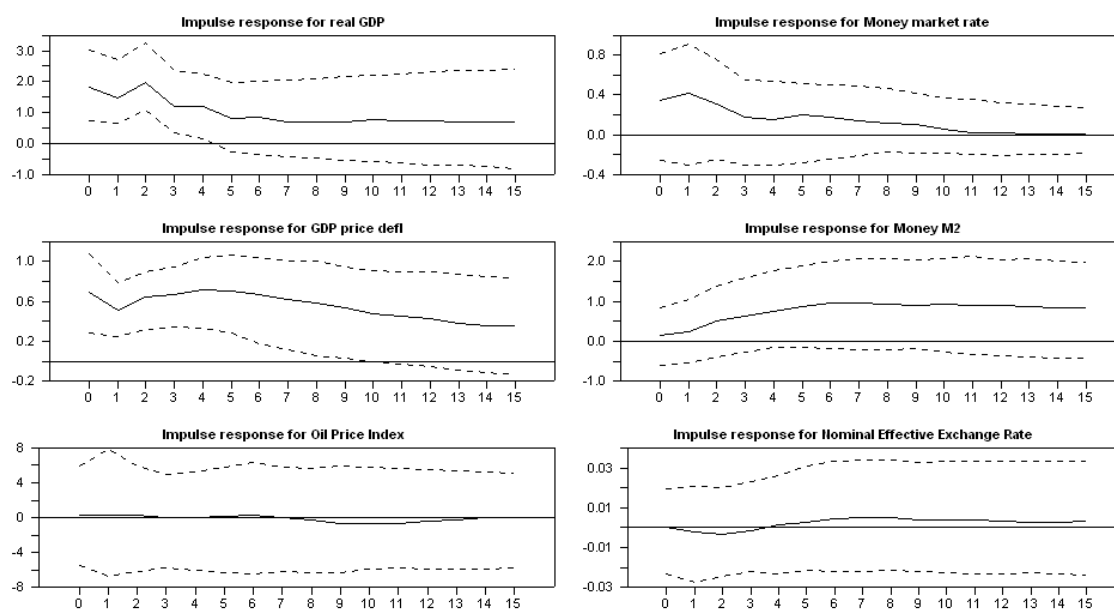
Korea

Responses to Orthogonal Demand shocks

Korea

Impulse response for real GDP

Impulse response for Money market rate

Impulse response for GDP price defl

Impulse response for Money M2

Impulse response for Oil Price Index

Impulse response for Nominal Effective Exchange Rate

Responses to Orthogonal Supply shocks

Korea

Impulse response for real GDP

Impulse response for Money market rate

Impulse response for GDP price defl

Impulse response for Money M2

Impulse response for Oil Price Index

Impulse response for Nominal Effective Exchange Rate

Responses to Orthogonal Oil price shock

Figure Appendix B 5-2 Orthogonal impulse responses in South Africa

South Africa

Responses to Orthogonal Monetary policy shocks

South Africa
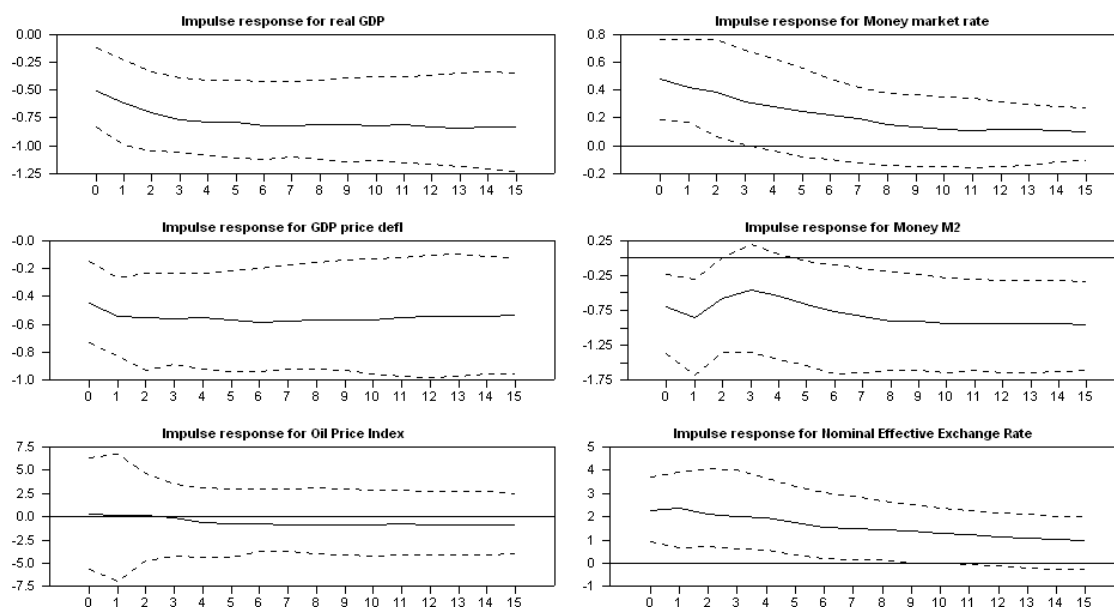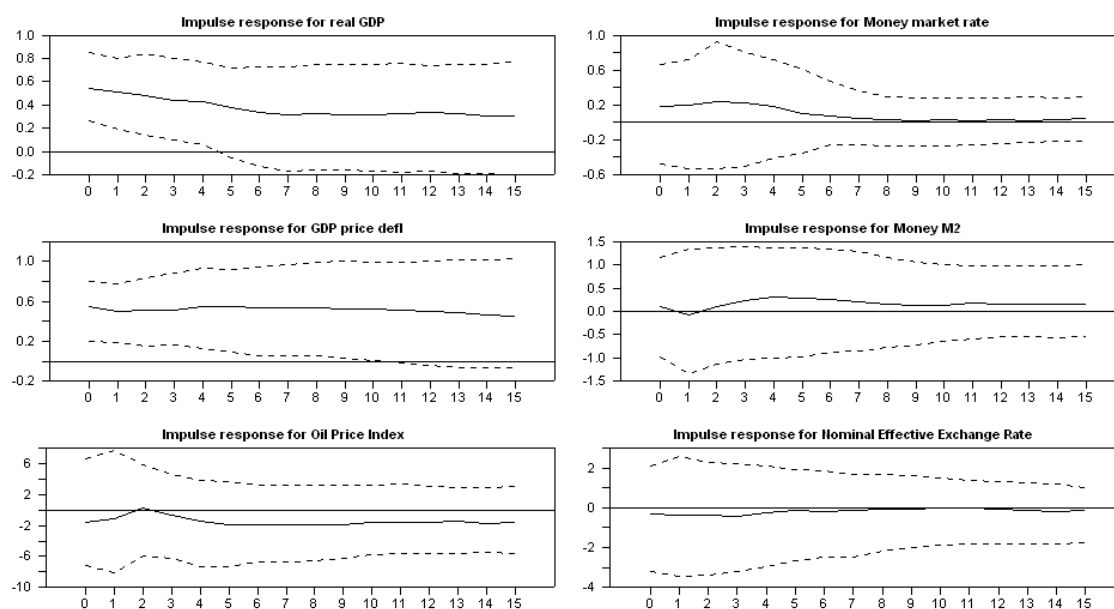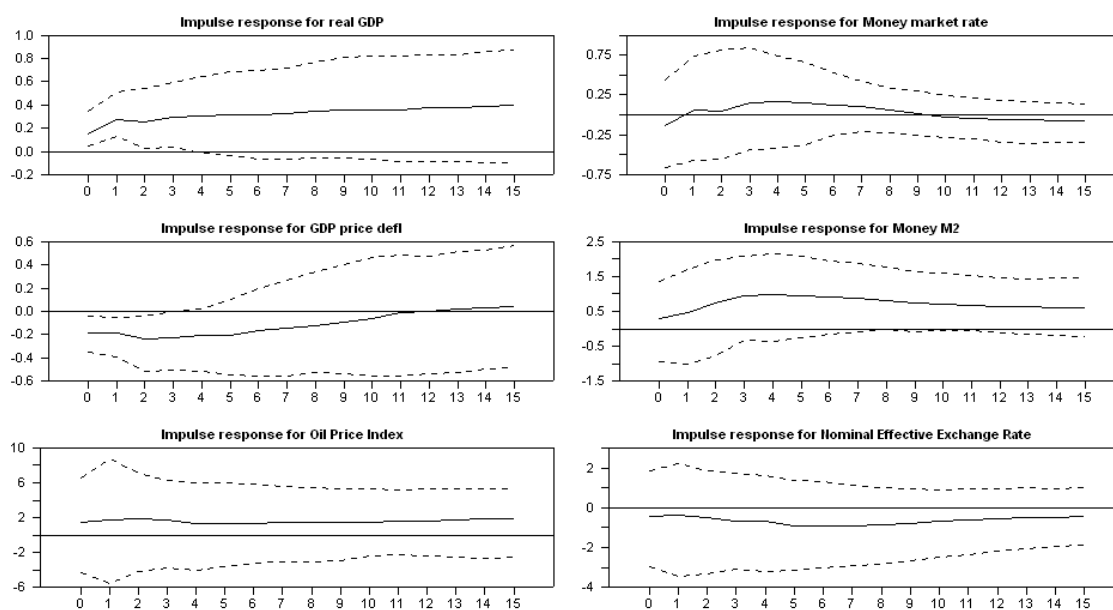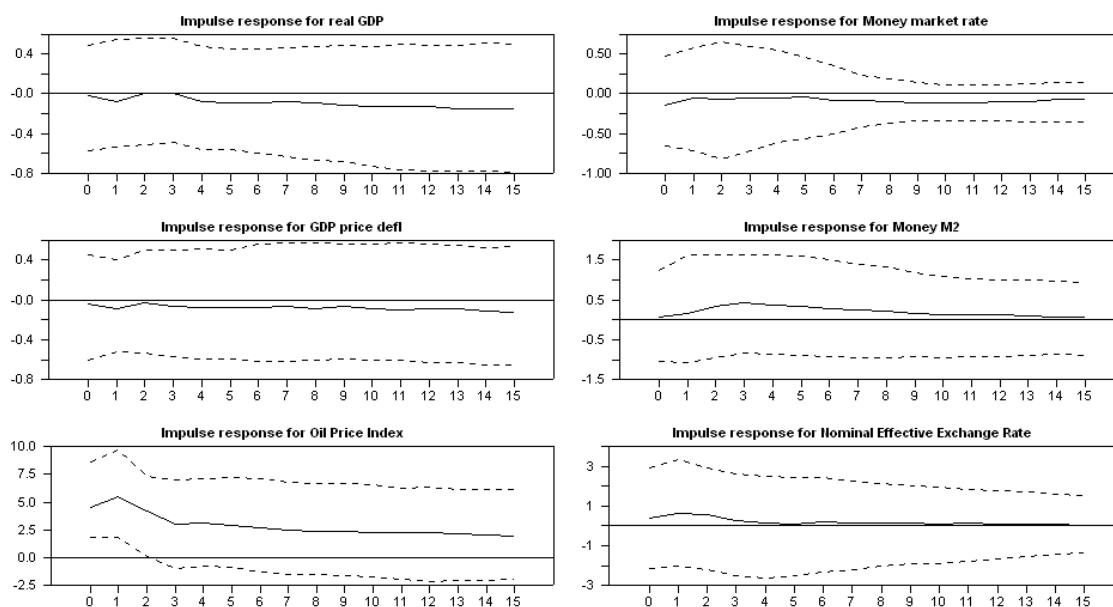

Responses to Orthogonal Demand shocks

South Africa

Responses to Orthogonal Supply shocks

South Africa

Responses to Orthogonal Oil price shock

145

CHAPTER 6 : CONCLUSION

This dissertation focuses on monetary policy in South Africa using two forms of Vector Auto Regressions (VARs) in four essays. These conclusions state the main findings and policy implications from each chapter respectively. Chapter 2 quantified the declines in the consumption expenditure attributed to the combined house wealth and credit effects due to the contractionary monetary policy shocks. The results at the peak of interest rates effects on consumption at the sixth quarter suggest that a proportion of the consumption declines due to the combined effect of the house wealth and the credit changes following monetary policy tightening of 9,8 per cent in all-size house segment. The second approach used three house sub segments rather than the main house segment. The sub segments show that declines are even much smaller reaching a 3,7 per cent in the small segment; 4,7 per cent in the medium segment and 5,3 per cent in the large segment. A third approach compared the consumption impulse response from the baseline and counterfactual (excluding house wealth) approach and found very weak evidence that house wealth propagates consumption declines. Overall, these results provided little support that the indirect house wealth channel is the dominant source of monetary policy transmission to consumption. In addition, the result suggests that monetary policy will have minimal impact on reducing inflationary pressures that arise from consumption through lowering house prices. Future areas of study would include using a structural vector error correction model to get the short run estimates and long run values.

Chapter 3 assessed how the real interest rate reacts to positive inflation rate shocks, exchange rate appreciation shocks and the existence of Fisher effect over longer periods using Bayesian VAR sign restriction approach. First, the evidence shows that the real interest rate reacts negatively to the positive inflation rate and exchange depreciation shocks. Second, there is evidence of the Fisher effect in the end suggesting interest rate increase by less than the increase in inflation rate in the short run. However, in the longer periods, interest rates increase by same change in the inflation rates. Third, the findings show that the strict inflation-targeting approach is not compatible with significant real output growth. Fourth, evidence assuming the flexible inflation-targeting framework suggests that the real effective exchange rates result in a significant real output growth given the Central Bank accumulates more foreign exchange reserves and high oil price inflation. Fifth, the results suggest that the real effective exchange rate measuring competitiveness against trading partners matters more than the rand-dollar exchange rate and nominal effective exchange rate depreciations.

Chapter 3 also examined responses of mining output and real interest rate capturing monetary authorities' response to the exchange rate depreciations. Despite exchange rate depreciations, the growth in mining output tends to drop (although significant) in certain periods. This suggest that monetary policy has a lesser stimulatory role in mining sector, which has many structural problems.

The main findings in Chapter 4 suggest that an exchange rate appreciation shock lowers the South African trade balance as a percentage of Gross Domestic Product significantly more than the contractionary monetary policy shocks. A significant deterioration in the net exports due to exchange rate appreciation shocks indicates that contributions of the net exports to GDP will remain depressed for longer periods but not permanently which is consistent with long run neutrality of exchange rate on output. Overall, this evidence suggests that policies dealing with exchange rates including competitiveness amongst trade partners rather than monetary policy would be ideal to generate economic growth but not permanently through net exports channel. In addition, the evidence indicates that the monetary policy shocks affect the trade balance through the expenditure switching channel (altering the exchange rate) rather than the income channel. The expenditure switching evidence suggests in the short run, monetary policy can change direction of demand between domestic output and imported goods through exchange rate adjustment. The findings are robust to different specification tests including redefining shocks as exchange rate depreciation shocks and expansionary monetary policy shocks. Future research will include individual commodity prices and assess how these affect trade balance.

Chapter 5 investigated the effects of contractionary monetary policy shocks on output in South Africa and Korea using a VAR sign restriction approach. Evidence shows that a contractionary monetary policy shock reduces output persistently in South Africa compared to transitory declines in Korea, which points to monetary neutrality. The persistent output declines perhaps indicate the need for different policy intervention from the South African monetary authority and other economic policy makers. The variance decomposition indicates contractionary monetary policy shocks explain large fluctuations of output than those reported for advanced countries. Additional tests, focused on how well the four quarters moving averages of estimated monetary policy shocks explain the actual monetary policy activities by focusing on major episodes of macroeconomic shocks. The four quarters moving averages of estimated monetary policy shocks suggest actual monetary policies were

expansionary in 2001 (i.e. when the US tech bubble burst and September terrorist attacks) and during the global recession in 2008. However, these policies tightened during the start of the Asian crisis in 1997 and late 2009-2010 during the US bond purchasing programme. In addition, the estimated policy shocks suggest the South African high economic growth rate under inflation-targeting coincided with more expansionary monetary policies in 2005-2006Q1. However, monetary policy became less expansionary between 2006Q2 and 2008Q4 reflecting the episodes of rising interest rates in South Africa. The further areas of future research in this chapter include using a combination of sign restrictions and factors approach.

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