Monetary Policy Shock and Impact Asymmetry in Bank Lending Channel: Evidences from the UK housing sector

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Abstract

Banks play defining role in translating monetary policy shocks to pull or push-effects in the housing market. Despite growing literature on the subject, ambiguity still persists on the nature of such effects. This paper argues that monetary policy shocks, of the same magnitude, can exert asymmetric effects on housing market via a state-dependent Bank Lending Channel (BLC), particularly during expansion and recessionary phases of business cycle. We test this hypothesis for the UK housing sector using a long quarterly data (1973Q1-2015Q4) and a Markov Switching Vector Auto Regression (MSVAR) model. The MSVAR identifies the latent transition in the business cycle and produces regime-dependent impulse-responses to monetary policy shocks. Such heterogeneous impulse-responses are quantitatively differentiated to lend deep insights into the way monetary policy shocks impact housing sector. Our results show that the magnitude of the bank lending channel is dependent on the state of the economy, with a one standard deviation expansionary monetary policy shock produces a significant effect only in normal economic times. We also examine whether larger cuts in policy rates stimulate mortgage lending and whether there is an impact asymmetry to dissimilar expansionary monetary policy shocks on mortgage lending during crisis period (such as the financial crisis). Our results suggest a sharp cut in policy rate indeed stimulates the BLC more compared to smaller expansionary money policy shocks during recessions.

Key Words: Real Estate economics; Monetary transmission; Bank Lending Channel; Markov Switching VAR

JEL Classification: R30, E50, G21, C34

1. Introduction

The financial innovations during the great moderation years, followed by the housing crisis in 2008, have germinated a renewed interest in unravelling the complex interplay between the real economy, financial sector and the housing market. During both depressing and good times, monetary mechanism is often used as the primary transmission mechanism to translate impulses from policy into effective response of the real economy, in particular, the housing sector. Despite a robust body of work in this domain, significant ambiguity persists on the relative ineffectiveness of policy on this sector because there is a visible mismatch of the expected heat of policy intervention with that of the actual response. The empirically quantified effects in the extant literature appear to suffer measurably from non-distinction of state-dependent variable/asymmetric responses. This paper aims to fill the gap in the literature in this direction.

Our empirical context is UK. Indeed, in addition to be an important component of the United Kingdom (UK) economy, the volatile nature of the housing sector makes it a crucial contributor to the UK business cycle fluctuations. Extensive work has been carried out underpinning the theoretical and empirical linkage between monetary transmission mechanism and house prices fluctuations, asserting the role of both non-neoclassical and traditional neoclassical channel[1]. Among the monetary transmission mechanism channels the bank-lending channel (BLC), given its strong presence both at the source (at depository institutions) and at the destination level (households), is thought to play a vital role in the UK housing market.[2]

Considering this and given the observed sharp appreciation of UK house prices during the great moderation years followed by contraction throughout the recession, even when the UK monetary policy rate was at historical low motivates us to examines whether the BLC is state

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1 See more in MacLennan et al. (1998)
2 See Iacoviello and Minetti (2008)

dependent in the UK housing sector. Furthermore, compared to earlier recessions during the 2008-2010 crisis, the BoE reduced policy rates sharply, hence offering further motivation to examine whether mortgage supply was amplified by large expansionary monetary policy shocks during periods of recession/high economic uncertainty. Therefore, this paper tries to address two types of non-linearity. *Firstly*, impact of similar size expansionary monetary policy shock on the BLC is examined during expansion and recessionary phase of the UK business cycle. And *secondly*, response of mortgage loan supply is examined to various degrees of expansionary monetary policy shocks during the 2008-10 recessionary period.

The literature on the bank-lending channel can be divided into two strands. The first strand uses aggregate data and typically examines the effect of monetary policy on the ratio of bank credit to the sum of bank and non-bank credit. The significant response of such variable to monetary policy changes indicates an operational BLC.[3] Most findings from this strand indicate an operational BLC in the UK. The second strand and the bulk of empirical work on BLC utilizes bank specific cross-sectional heterogeneities to capture loan supply shifts arising from monetary policy changes. Overall, results from this second group suggest that banks tend to reduce more on their lending in response to a contractionary monetary policy shock when they are small, less capitalized or are illiquid. Beside the traditional bank characteristics such as size, capital and liquidity authors have also used other bank specific characteristics such as being part of a bank holding company and the amount of securitization activity undertaken to capture loan supply shifts arising from monetary policy changes.

One of the major drawbacks of using bank level microeconomic data is that they do not ascertain whether the bank-lending channel affects aggregate economic activity. Furthermore, these research use instrumental variable estimators; mainly Generalized Method of Moments

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3 See Halvorsen and Jacobsen (2014), Iacoviello and Minetti (2008), Kashyap et al. (1993), Stanimira, (2013)

(GMM) estimators, which produce biased results when there are unaccounted structural breaks in the data.[4] While there exists a substantial amount of work examining the impact of monetary policy on output over the business cycle (e.g. Lo and Piger (2003), Zheng (2013), Weise (1999) and Chen (2007)), research examining a specific monetary transmission channel is sparse. In the BLC literature most research assume that the magnitude of lending channel is identical over the business cycle and employ a linear framework. Additionally, studies that look at this important nonlinearity use bank level data and hence are fraught with the above-mentioned problems. Furthermore, due to the unavailability of historical bank level data, recent studies examine only more recent periods.

The explicit recognition of the impact of non-linear behaviour of economic agents on the macro economy was first formally incorporated in theoretical models proposed by Bernanke and Gertler (1989) and Kiotaki and Moore (1997). These models by incorporating agency costs of financial intermediation show when information asymmetry is high in financial markets, agents behave as if they are financially constrained, which is likely to be more binding in recessionary states rather than in expansionary phases of the business cycle. As financial friction varies over the business cycles, it is typical to expect channels of monetary transmission mechanism that are based on asymmetric information, such as the credit channel to also fluctuate over the business cycle[5].

The main objective of the paper is to properly identify and concurrently compare the magnitude of the BLC in the UK housing market to analogous expansionary monetary policy shocks, during boom and recessionary periods, over the period of 1973q1 to 2015q4. The work is carried out by employing Markov Switching Vector Auto Regression (MSVAR) models and regime dependent impulse response functions (IRF). In our case the benefit of using MSVAR's

4 See Chowdhury and Russell (2018)

5 The credit channel is the amalgamation of the bank lending channel and the balance sheet channel. See more in Mishkin (1995).

is, if properly modelled the latent markov process will be able to identify the UK business cycle endogenously. Results indicate, magnitude of the BLC is dependent on the state of the economy; a one standard deviation expansionary monetary policy shock produces a significant BLC only in normal economic times. Given this finding and the fact major central banks including the BoE reduced policy rates sharply in the 2008-2010 crisis (relative to previous recessions), persuades us to examine whether larger cuts in policy rates stimulated mortgage lending and by doing so the impact of dissimilar expansionary monetary policy shocks on mortgage lending during crisis period is explored. Results from this part of our study suggest sharp cuts in policy rate do indeed stimulate the BLC more compared to smaller expansionary money policy shocks during recessions.

The rest of the paper is organized as follows; overview of the BLC and the factors that can create asymmetry in the magnitude of the BLC over the business cycle is discussed in section two. Section three examines the asymmetric effects of BLC over the business cycle, compromising the associated econometric methodology, the results and the robustness tests. A small experiment is done in section four to examine the response of mortgage supply by depository institutions to dissimilar expansionary monetary policy shocks, using 2008-10 recession data. Finally, section six provides the concluding remarks and policy recommendations.

2. Bank Lending Channel and the Business Cycle

The BLC is a part of the credit channel, proposed by Bernanke and Blinder (1988). Their seminal work shows changes in monetary policy effects on banks' reserves and insured deposits and hence impacting banks' ability to generate loan. This proposition is based on two assumptions; firstly, insured and uninsured deposits are imperfect substitutes to banks and secondly, bank loans and internal sources of funds are imperfect substitutes for firms/individuals. Over the years with the advent of the wholesale funding, the dependence on retail deposits has become less in the banking sector and thus the view proposed by Bernanke and Blinder (1988) on BLC to some extent has become obsolete.[6] Disyatat (2011), taking account of these changes, reformulate the traditional BLC and emphasis the greater dependence on market-based funding. He contends that the channel operates not through the impact of monetary policy on bank deposits but through the impact of monetary policy on bank's external finance premium which is determined by its balance sheet strength and risk perception. Besides demand factor, supply of loans is determined by the willingness of banks to extend loans, which is influenced by funding conditions in the market. The impact of monetary policy changes will then be transmitted through changes in required rate of returns rather than changes in quantity of deposits. Thus, according to the two views a contraction in monetary policy can lead either to a decrease in the funding of liquidity or a disproportionate rise in the price of liquid funds. If banks cannot compensate this reduction in their balance sheet strength by changing the composition of their portfolio or by increasing debt, they ultimately reduce loan supply.

The bank lending channel can also be reinforced by the impact of monetary policy on risk perceptions, as discussed in Borio and Zhu (2008). The underlying notion is that expansionary monetary policy results in lower risk premiums, either due to a decline in the perceptions of risk or due to increase in risk tolerance, hence increasing lending. Adrian and Shin (2008, 2009) and Adrian et al. (2012) argue that investment and commercial banks respond to changes in the value of their assets almost entirely by increasing or reducing debt and keeping equity unchanged. This implies that bank lending expands when its leverage increase and vice versa. On contrary, when funding conditions worsen, bank balance sheet shrinks resulting in a decline in the willingness to lend.

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6 See Halvorsen and Jacobsen (2016)

It is also evident that changes in financial innovations can affect how the BLC works. Given the state of the economy, dependence on these innovations can either intensify or negate the magnitude of BLC. As for example, financial innovations like off balance sheet activity, securitization have pro-cyclical effects on loan supply.[7] During boom periods, in the presence of expansionary monetary policy securitization process amplifies bank's liquidity generation process and magnifies the BLC. On the contrary, the opposite happens during periods of recession and uncertainty, as asset prices (including house prices) plunge securitization process stagnates. Thus, during recession, even under an expansionary monetary policy as securitization process becomes harder, banks are unable to generate liquidity. Studies by Gambacorta and Marques (2011) using European and United States bank level data show, banks that are more dependent on securitization are most effected and reduce loan supply more during crisis periods (even in the presence of expansionary policy). Furthermore, during periods of economic uncertainty and under recessionary conditions as asset prices fall bank balance sheet become weak leading to a decrease in their net worth. The impact of a lower net worth increases asymmetric information & moral hazard problem in the wholesale funds market. Consequently, in such states the relative effectiveness of expansionary monetary policy in reducing external finance premium becomes less effective, relative to a similar sized monetary shock in normal economic times, when banks' balance sheets are in better shape.

As mentioned earlier BLC can also be influenced by the impact of monetary policy on banks' perception of risk/or willingness to bear risk. During periods of expansion if monetary policy is kept low for long periods, bank's perception and attitude towards risk changes; this is primarily due to fact that low interest rate scenarios reduce borrowers default probability which in turn increases bank's cash flow and profits and hence strengthens bank's net worth. This

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7 See Estrellsa (2002), Gambacorta and Marques (2009)

reduces funding costs and enhances the BLC. However, during economic downturns increase in default frequency among the borrows tend to not only reduce bank's net worth but also increases bank's risk perception.[8] Given the lower net worth of the banks and higher perception of risk an expansionary monetary of similar magnitude most likely be less effective in increasing loan supply during a recessionary state and thus may result in a weak BLC.

3. Evidence of non-linearity of the BLC over the UK business cycle

This section examines the magnitude of the BLC at different stages of the UK business cycle and confers the associated econometric methodology, time series properties of the data and the results.

3.1 Econometric framework

To apprehend the impact of the BLC over the business cycle we face two main difficulties; firstly, to separate the BLC from the other monetary transmission mechanism channels and secondly to use an appropriate econometric methodology to capture the non-linear effects over the business cycle. The first problem is confronted by using a methodology similar to Iacoviello and Minetti (2008) where a 'credit mix' variable is used in a succession of simultaneous equation frameworks to disentangle BLC from other monetary transmission mechanism channels (this is explained in detail later in this section). We confront the second problem by using MSVAR models in combination with regime dependent impulse responses proposed by Ehrmann, Ellison and Valla (2003) which allows us to capture and examine the state dependence of the BLC during boom and recessionary periods.

Although, Markov Switching models have been quite extensively employed in macroeconomics, real estate and in finance to capture various types of non-linearities, there use

8 See Adrian and Shin (2009), Gambacorta (2009).

in BLC literature is atypical.[9] The advantage of MSVAR over other non-linear econometric framework is that, under a MSVAR framework all components (intercept, variance and the auto regressive terms) can be permitted to switch, allowing one to capture complex dynamic patterns within the data, such as business cycles. In our case, we use MSVARs similar to one proposed by Krolzig (1997);[10]

$$X_t = \begin{cases} \mu_1 + B_{11}X_{t-1} + \cdots + B_{p1}X_{t-p} + A_1\varepsilon_t, if \;\; S_t = 1 \\ \mu_2 + B_{22}X_{t-1} + \cdots + B_{p1}X_{t-p} + A_2\varepsilon_t if \;\; S_t = 2 \end{cases} \tag{1}$$

where, X_t is the set of endogenous variables, ε_t is the fundamental residuals.[11] In equation (1) each fundamental residual is pre-multiplied by a switching matrix A_i. Equation (2) illustrates the regime dependent variance–covariance matrix, $\sum_i$ of the residuals $A_i\varepsilon_t$;

$$\textstyle\sum_i = E(A_i\varepsilon_t\varepsilon_t'A_i') = A_iE(\varepsilon_t\varepsilon_t')A_i' = A_iI_KA_i' = A_iA_i' \tag{2}$$

In equation (1) the latent variable, S_t indicates either expansionary or recessionary regime. S_t, is governed by a discrete state of a Markov stochastic process, which is defined by the following transition probabilities.

$$p_{ij} = \Pr(s_{t+1} = j | s_t = i) \quad \hat{P} = \begin{vmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{vmatrix}$$

where transition probability, P_{ij} states, the probability of state 'i' at period *t* will be followed by state 'j' at period *t+1*. Estimation of the model is carried out using iterative maximum likelihood estimation technique known as Expectation–Maximization (EM) algorithm.[12]

Interpretation of the parameters in a MSVAR model is not straightforward to reveal the dynamic relationships among the variables, hence the profile of the system's response to shocks is usually derived to visualize the dynamic relationships represented by the MSVAR model (Tillmann, 2004). Regime-dependent IRF depict the relationships between the endogenous

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9 See Simo-Kengne et al. (2012), Chowdhury and Maclennan (2014).
10 It is a multivariate generalization of Hamilton's (1989) framework.
11 The residuals are assumed to be uncorrelated at all lead and lags.
12 See Krolzig (1997)

variables and fundamental disturbances within a regime, which in turn provide a convenient way to track down the magnitude and the persistence of each variable's response to shocks over time. Following, Ehrmann *et al.*, 2003 equation (3), provides the mathematical definition of the response of regime-dependent impulse. It traces the expected path of endogenous variables at time $t+h$ following a one standard deviation shock to the k-th initial disturbance at time t, conditional on regime i ;

$$\theta_{k,i,h} = \frac{\partial E_t X_{t+h}}{\partial \varepsilon_{k,t}} |_{s_t = s_{t+h=i}} \qquad for\ h \geq 0 \tag{3}$$

In order, to make structural inferences restrictions are imposed on, A_i. Sufficient restrictions are imposed on the parameter estimates in order, to derive structural form for each regime, from which regime dependent IRF are then computed. A recursive identification scheme based on which the estimated variance covariance matrix, $\widehat{\sum_i}$ obtained by Choleski decomposition is used to identify the matrix, $\widehat{A_i}$. The confidence bands of the impulse response functions are obtained by Markov Chain Monte Carlo (MCMC) simulation with Gibbs sampling of 5000 draws with a burn-in of 2000.

Changes in monetary policy tend to have simultaneous effects on loan supply and loan demand, creating a simultaneity problem when researchers try to identify the BLC. To isolated loan supply from loan demand shocks we use the 'credit mix' variable which is the ratio between mortgage holding by depository institutions and the sum of mortgage holding by depository institutions and market-based financial intermediaries. Given the assumption that managed liabilities are imperfect substitute of retail deposits (and the cost of wholesale funds is higher than retail deposits), a contractionary monetary policy will tend to reduce depository institutions mortgage lending. In these conditions if the decline in mortgage supply is not compensated by alternative sources of funding then the mix variable will decrease, hence advocating an effective

BLC.[13] One of the benefits of using the mix variable is that it remains unaltered by mortgage demand shocks since such shocks typically effect both depository and non-depository market based institutions in the same magnitude.[14] In Iacoviello and Minetti (2008) the mix is used in a succession of linear VAR's first to identify the credit channel and then disentangle the credit channel; separate BLC from the Balance sheet channel (BSC). We use MS-VARs instead of linear VAR models as our main objective is to identify the magnitude of the bank lending during normal and recessionary periods. The MSVARs that we estimate are as follows.

a) First MSVAR

The first MSVAR includes Δ*gdp, inflation,* Δ*total mortgage loans,* Δ*house prices and* Δ*UK policy rate.* As changes in total mortgage after a monetary policy change can be explained by either a Keynesian interest rate channel or by the credit channel or by both, this MSVAR is uninformative in detecting the credit channel or the BLC. Nevertheless, this model enables one to capture the overall nonlinear effects of monetary policy on house prices, GDP and mortgages during expansion and recessionary periods of the business cycle.

b) Second MSVAR

The second MS-VAR includes Δ*gdp, inflation, mortgage spread,* Δ*house price index and the* Δ*UK policy rate.* A rise (*decrease*) in mortgage spread after a contractionary (*expansionary*) monetary policy can capture the increase (*decrease*) in the external finance premium which is associated with the credit channel. However, due to lack of detailed data on the mortgage rates, charged by different types of lenders precludes us from further using the model to disentangle the BLC from the BSC. Therefore, the model enables one, only to identify the magnitude of the credit channel during boom and recessionary periods.

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[13] Conversely, during periods of expansionary monetary policy if depository institutions increase lending more compared to non-depository market-based institutions then the mix variable will increase.

[14] See Iacoviello and Minetti (2008) and Milcheva (2013).

c) Third MSVAR

The third MSVAR incorporating *Δgdp, inflation, Δmoney market spread, Δhouse prices index and ΔUK policy rate* allows one to examine how banks funding costs respond to monetary policy changes during recession and expansionary phases. A significant rise (*decrease*) in money market spread after an increase (*decrease*) in short term policy rate can capture the increase (*decrease*) in the external finance premium that banks face can be associated with the new bank lending channel theory, proposed by Disyatata (2011).[15]

d) Fourth MSVAR

The fourth MSVAR includes, *Δgdp, inflation, Δhouse prices, ΔUK policy rate and* the *mix variable.* Given our earlier discussion, if the BLC is operational then after a contractionary (*expansionary*) monetary policy there will be a significant decrease (*increase*) in the *mix* variable and by comparing the response of the *mix* during boom and recessionary periods one can validate the magnitude of the BLC in the two regimes. Nevertheless, one might argue even if there is a significant decrease (*increase)* in the *mix* after a contractionary (*expansionary)* monetary policy, then that only demonstrates a relative increase in the mortgages provided by depository institutions over non-depository institutions. Henceforth, to accentuate the effect of a significant change in the *mix* on housing demand the analysis of the *mix* entails two steps, firstly to analyse whether monetary policy affects the *mix* (fourth MSVAR) and if so to analyse whether changes in the *mix* affects house prices (fifth MSVAR).

e) Fifth MSVAR

If monetary policy has significant effect on the *mix*, we run the fifth MSVAR which includes, *Δgdp, inflation, Δhouse prices and the mix variable*. This model examines the effects of an exogenous increase in *mix* (also known as external finance shock) on house prices, during boom

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15 Since both depository and non-depository market based financial institutions depend on the wholesale funds market one might argue the changes in the external finance premium can be contributed to the balance sheet strength of both type of institutions. However, since market share of non-depository institutions is the UK is relatively small, their contribution towards the change in the spread is likely to be negligible (Scanlon et al., 2000).

and recessionary periods. If the *mix* has any explanatory power on house price in a reduced form regression which includes Δgdp and inflation, it's incremental explanatory power will support the existence of an independent BLC.[16]

3.2 Data characteristics

Our data is quarterly and covers the period: 1973q4 - 2015q4. Hansen (1992) stability test reported in table 1 show that variables possess breaks in the mean, variance or in both components jointly and hence validates our rational of using a MSIAH-VAR type of MSVAR.[17] Linearity tests represented in table 2 further show that linear VARs are rejected in favour of the MSIAH-VARs in all five models.

Figure 1 represents the smoothed transition probability of regime 1 obtained from the MSIAH-VARs. The smooth transition probabilities of five models tend to exhibit high similarities. They all tend to capture the late 70's and early 80's recession, the Lawson boom and the volatile period during the ERM crisis. More recent events such as the 2008 financial crisis and the great moderation era are also well captured in all the models. Observing the smooth transition probabilities, it become evident that regime 1 represents expansionary phase of the UK business cycle in all the models. The transition probability and average duration of the regimes are presented in table 3 show the duration of the expansionary phase of business cycle (regime 1) is about 9.5 to 11 years which is similar to the recent findings by Drehmann *et al.* (2012) and Bario (2014).

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16 Following Ludvigson (1998), we don't include short term interest rate as it indicates monetary policy. Including it (policy rate) would mean changes in the *mix* marginally reflect non-monetary effects. If the bank-lending channel is operative, then monetary policy should affect the *mix*, and the *mix* should affect house prices, but there should be no reason to expect that the *mix* affects house prices when some variable that captures monetary policy stance is included in the VAR. Therefore, the innovation in the *mix* captures both monetary policy shocks and non-policy induced shocks, like, for instance, credit crunch episodes.

17 In a MSAIH-VAR the intercepts, mean, autoregressive parameters and the variances switch.

3.3 Regime dependent impulse response

a) First MSVAR

Regime dependent impulse responses from model one, presented in figure 2A, illustrate the magnitude of an expansionary monetary policy shock on *Δhouse price, Δgdp* and on *Δmortgage credit* is much larger and more persistent during normal economic times than compared to a similar magnitude shock during recessions. Although, this MSVAR is unable to separately identify the transmission channels, the impulse responses clearly exhibit the state dependent effect of expansionary monetary policy on the variables over the business cycle. Relatively lesser impact of expansionary monetary policy during the recessionary phase can be contributed higher level of financial friction, uncertainty and binding financial constraints caused by lower net worth (of both borrower and lenders).[18] More recent studies have used loss aversion theory to explain the reduced effectiveness of monetary policy during recessionary period.[19]

b) Second MSVAR

Figure 2B, represent regime dependent impulse responses from the second MSVAR. The impulse responses exhibit that after an expansionary monetary policy shock the increase in *Δgdp* and *Δhouse price* is much larger and more persistent during expansionary periods compared to a similar shock during recessions. Moreover, after a decrease in policy rate, mortgage spread decreases significantly during expansionary phases of the business cycle, whereas a shock of similar magnitude produces insignificant results during recessionary periods. The significant decrease in the mortgage spread (representing the external finance premium) during normal

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18 See Kiotaki & Moore (1997), Bernanke & Gertler (1997).

19 See more in Santoro *et al*. (2014)

economic times indicate the existence of an operational credit channel. During recession net worth of households and firms decline, causing asymmetric information to rise between agents and mortgage lenders and hence increasing the overall external finance premium in the market. Subject to the presence of this higher level of asymmetric information, the impact of expansionary monetary policy shock become less effective in reducing mortgage spreads during recessionary periods compared to a similar shock during expansionary period.

c) *Third MSVAR*

Figure 2C represent regime dependent impulse responses from the third MSVAR. The responses of *Δgdp* and *Δhouse price* to expansionary monetary policy shocks are analogues to the earlier models; larger and more persistent during periods of expansion than in recession. After inspection of the expansionary monetary policy shock on the money market spread it is apparent, the decrease in the spread is only significant in the expansionary phase of the business cycle and hence indicating a Disyatat (2011) type BLC in normal economic times only. During expansionary phase of the business cycle mortgage default frequency is typically low in the economy. An expansionary monetary policy shock during this period increases house prices and cash flow of borrowers. This reduces default frequency further, surging up bank's net worth and subsequently assisting in reducing asymmetric information between the participants in the money market and resulting in external finance premium to fall significantly. Contrary to this in recession due to the higher default rates among borrowers tend to make a bank's balance sheet weak. This intensifies the asymmetric information problem between money market participants and raises the external finance premium. Subject to the existing high levels of asymmetric information an expansionary monetary policy of a similar magnitude tends to be less effective in reducing external finance premium during this period.[20] The findings tend to

[20] Tsai (2013) showed due to downward price rigidity during recessionary period housing market tends to dormant.

corroborate with that of Bouis *et al*. (2014) & Scanlon *et al*. (2011) who find traditional monetary policy was ineffective in reducing the money market spread during the 2008 financial crisis.

d) Fourth MSVAR

Responses of expansionary monetary policy shocks from the fourth MS-VAR are presented Figure 2D. Similar to the earlier models the impact of expansionary monetary policy on *Δgdp and Δhouse price* are larger and more persistent during periods of economic expansion. Examining the response of expansionary monetary policy shock on the *mix* variable shows both in normal and recessionary phase the shock is significant. However, the magnitude of shock is much larger and more persistent during expansionary times. The significant increase of this *mix* illustrates the relative increase in the mortgage supply by depository institutions over non-depository market-based institution, after an expansionary monetary policy shock. The larger magnitude of the shock during the expansionary phase of the business cycle can be attributed to the better access of liquid funds (either from retail deposits, wholesale funds or through securitization process) by the depository institutions enabling them to generate more mortgages. Given the results from the third MSVAR and our earlier explanation in section 3.1, a significant response of the *mix* to an expansionary monetary policy shock gives the indications of an operational BLC and initiates us to run the fifth MSVAR, which tests the explanatory power of the *mix* variable on house prices.

e) Fifth MSVAR

The regime dependent impulse response function from this MSVAR exhibits that after a one standard deviation shock of the *mix*, house prices tend to increase both in expansionary and in recessionary periods. However, the response is only significant in expansionary phase of the business cycle. Thus, in the case of the UK the impulse response functions tend to support the hypothesis that subject to similar size expansionary monetary policy shocks, BLC is only effective during expansionary phase. One positive characteristic in first four MSVARs is that we don't observe any price puzzle's, suggesting monetary policy shocks have been identified accurately.[21]

Our findings of an operational BLC only in normal economic times can be explained by certain factors. Firstly, after an expansionary monetary policy access of retail deposits increase in depository institutions thus increasing mortgages. However, during recessions due to increased financial uncertainty depository institutions may not increase mortgage supply significantly enough to cause economic activity to increase, even if they have sufficient funds (see Baum *et al*. (2013), Talavera *et al*. (2012)). Secondly, the pro-cyclical impact of securitization on liquidity generation amplifies the BLC in the presence of expansionary monetary policy during normal economic times (Altunbas *et al.* (2009), Loutskina (2011)). Thirdly, results from our third MSVAR show among two comparable sized expansionary monetary policy shock, policy is only effective in significantly reducing money market spread in normal economic times and hence enabling access to cheap non-reservable labilities to depository institutions and in turn may facilitates in the increase of mortgage.[22] Finally, commercial bank's perception of risk increases during periods of recessions compared to normal economic times. Given the higher risk perceptions an expansionary monetary policy may be less effective in stimulating loan supply during recessions and hence making the BLC relative less effective compared to normal economic times.

3.4 Robustness

We conduct two robustness tests to validate our findings. The first test re-estimates the approach

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21 Champagne and Sekkel (2018) show unaccounted breaks in linear VARs can be one of the reasons behind price puzzels.

22 See Milcheva (2013)

taken in section 3.1 using an alternate monetary policy measure, a shadow policy rate which takes account of both conventional and unconventional policy. The second test is undertaken to nullify the existence of the "flight to quality hypothesis" and hence further validate the existence of the BLC.

Since 2008, the BoE beside using conventional policy has been using unconventional policy, such as quantitative easing (QE). Recent studies by Buttz *et al*. (2015) find evidence that QE created 'flighty deposits' in the UK banking system which led to diminished effectiveness of the BLC during the during the 2008-10 crisis. Contrary to this, Bowmen *et al*. (2011) find evidence of QE increasing lending in Japanese banks during the period of 2000-09, by improving their liquidity position. Furthermore, work done by Salachas *et al*. (2017) illustrate during 2008-2010 crisis, in spite of traditional monetary policy being ineffective in stimulating the BLC, QE had significant impact on the BLC. Thus, it appears the impact of QE on the BLC is time and location specific. However, rather than assessing the cumulative effect of conventional and unconventional policy on the BLC, the main focus of the above stated studies is to examine the impact of unconventional monetary policy on the BLC. Thus, the use of shadow policy rate not just works as a robustness test, but it allows to examine the aggregate impact of monetary policy on the BLC. Here we use the shadow policy rate proposed by Xu and Xia (2016) in the methodology proposed in section 3.1.

The smooth transition probabilities obtained from the MSVARs using shadow policy rate presented in figure 3 are analogous to the earlier models (presented in figure 1). The regime depended impulse responses obtained from these models presented in figure 4, are similar in magnitude and persistence to the earlier ones (presented in figure 2). After a one standard deviation cut in shadow policy rate the response of Δgdp and Δhp are significant and larger in the normal economic phase in all the MSVARs. Also, the decrease in both mortgage and money market spread is more and only significant in the expansionary regime. Finally, response of the *mix* is much larger after a one standard deviation cut in the shadow policy rate, in the expansionary phase of the business cycle. The magnitude of the *mix* responses to the shadow policy rate shock is very similar to that of tradition policy rate shock. The results validate our prior finding that after an expansionary monetary policy shock magnitude of the BLC is larger and significant only in the expansionary phase of the business cycle. This also implies QE may not have any addition effects on the BLC.

One criticism of using the *mix* variable in the BLC identification process is that some might argue it does not completely solve the endogeneity problem because a change in the *mix* can capture a change in the quality composition of borrowers (Oliner and Ruebusch, 1996). Given the traditional idea that banks specialize in funding households with relatively weaker balance sheet, a decrease in the *mix* after a contraction in monetary policy may reflect a "flight to quality" from risky households to households with stronger balance sheet strength, thus indicating a BSC rather than a BLC. In order, to test whether non-depository institutions fund less riskier households than depository ones we run equation (4) where we regress the number of repossessions as a fraction of total mortgages on the *mix* and on the cyclical indicators of the housing market which include *Δhouse prices, Δgdp and inflation*.

$$\left(\frac{rep}{tot\ mort}\right)_t = \begin{cases} \mu_1 + B_{11}inf_{t-1} + B_{12}\Delta gdp_{t-2} + B_{13}\Delta hp_{t-2} + B_{14}mix_{t-1} + A_1\varepsilon_t,\ S_t = 1 \\ \mu_2 + B_{21}inf_{t-1} + B_{22}\Delta gdp_{t-2} + B_{23}\Delta hp_{t-2} + B_{24}mix_{t-1} + A_2\varepsilon_t,\ S_t = 2 \end{cases} \quad (4)$$

Under the hypothesis that non-depository institutions fund less risky assets, number of mortgage repressions and arrays as a fraction of total mortgages will fall (*increase*) if the *mix* decreases (*increase)*. Results presented in table 4 show during normal economic times the mix is insignificant and in recessionary period it has negative sign, hence nullifying the "flight to quality" hypothesis and strengthening our earlier finding about the operational validity of the BLC.

4.1 Mortgage supply and dissimilar expansionary monetary shocks during recession

This section of the paper focuses on another aspect of nonlinearity, comparing small versus large expansionary monetary policy shocks on mortgage supply by depository institutions. Although, previous studies (e.g. Lo and Piger (2003), Barnichon and Matthes (2014) and Zheng (2013)) have compared the impact of large and small expansionary monetary policy shocks on output during recessionary periods, none have focused on the mortgage supply. Additionally, compared to earlier recessions, during the 2008-2010 crisis BoE reduced policy rate much sharper (see figure 6), motivating us to examine whether the large cuts in policy rate amplified mortgage lending by depository institutions during this period. In order to properly capture the amplification of mortgage supply to expansionary monetary policy shocks we employ the methodology proposed by Kilian and Vigfusson (2011).[23] The advantage of the procedure is that it produces consistent and valid impulses response when censored variables are used to capture asymmetries in VAR's at it takes account of both the history of the series in question and also the magnitude of the shocks.[24] We estimate the following model;

$$\Delta r_t = \alpha_{10} + \sum_{i=1}^{p=10} \alpha_{11,i}\Delta y_{t-i} + \sum_{i=1}^{p=10} \alpha_{12,i}\Delta r_{t-i} + \sum_{i=1}^{p=10} \alpha_{13,i} inf_{t-i} + \sum_{i=0}^{p=10} \alpha_{14,i}\Delta mix_{t-i} + \varepsilon_{1,t}$$

$$\Delta y_t = \alpha_{20} + \sum_{i=1}^{p=10} \alpha_{21,i}\Delta y_{t-i} + \sum_{i=1}^{p=10} \alpha_{22,i}\Delta r_{t-i} + \sum_{i=1}^{p=10} \alpha_{23,i} inf_{t-i} + \sum_{i=1}^{p=10} \alpha_{24,i}\Delta mix_{t-i} + \sum_{i=0}^{P=10} \alpha_{25,i}\,\Delta r^{\#}_{t-i} + \varepsilon_{2,t}$$

[23] The Killian Vigfusson (2011) methodology is explained in detail in the appendix

[24] For more see Gallant and Rossi (1993) and Koop *et al.* (1996)

$$\Delta inf_t = \alpha_{30} + \sum_{i=1}^{p=10} \alpha_{31,i}\Delta y_{t-i} + \sum_{i=1}^{p=10} \alpha_{32,i}\Delta r_{t-i} + \sum_{i=1}^{p=10} \alpha_{33,i} inf_{t-i} + \sum_{i=1}^{p=10} \alpha_{34,i}\Delta mix_{t-i} + \sum_{i=0}^{P=10} \alpha_{35,i}\, \Delta r^{\#}_{t-i} + \varepsilon_{3,t}$$

$$\Delta mix_t = \alpha_{40} + \sum_{i=1}^{p=10} \alpha_{41,i}\Delta y_{t-i} + \sum_{i=1}^{p=10} \alpha_{42,i}\Delta r_{t-i} + \sum_{i=1}^{p=10} \alpha_{43,i} inf_{t-i} + \sum_{i=1}^{p=10} \alpha_{44,i}\Delta mix_{t-i} + \sum_{i=0}^{P=10} \alpha_{45,i}\, \Delta r^{\#}_{t-i} + \varepsilon_{4,t}$$

where Δr_t, Δmix_t and $\Delta r^{\#}_t$ is the change in policy rate, change in the mix variable and the nonlinear transformation of policy rate proposed by Mork (1989) respectively. In the above model changes in policy rate is assumed to be predetermined with respect to the, '*mix'* variable. While, the official UK recessionary period is from 2008q2 to 2009q2, we choose our sample from Sept. 2007 to the end of 2012. Due to the "Northern Rock crisis" Sept2007 is selected as the start date, whilst the last negative growth in this volatile period occurred in 2012q4. In accordance with earlier studies, we use one and two standard deviation expansionary monetary policy shocks. The non-linear impulse responses presented in figure 7 illustrate large expansionary monetary policy shocks do indeed have larger magnitude and more persistence on the *mix*, when compared with smaller expansionary shocks. The cumulative impact of large expansionary monetary shock on the *mix* after 36 months is twice as large when compared with the small expansionary monetary shock (4.651 compared to 1.954).

5. Conclusion

This paper first and foremost examines state dependence of the BLC in the UK housing sector by employing MS-VARs and regime-dependent IRFs. Impulse responses obtained from our MS-VARs illustrate, given similar sized expansionary monetary policy shocks magnitude of BLC is much more in normal period than in recessions which can be contributed to the amalgamated effects of increased risk perception (by the depository institutions), increased cost of liquid funds and the breakdown of the securitization process. Afterward, response of mortgage supply by depository institutions to various degrees of expansionary monetary policy shocks is examined during periods of economic uncertainty and for this 2007-08 financial crisis period is chosen, as the policy rate was reduced sharply during this period compared to earlier recessions. Results suggest sharp cuts in policy rates essentially do stimulate mortgage lending more compared to minor reductions.

These findings have significant policy implication, especially concerning whether central banks should continue with an orthodox policy or peruse a more Leaning Against The Wind (LATW) strategy. While, studies by Dokko (2009, 2011) and Bean (2010) using counterfactual simulations show a LATW policy is not feasible, as the magnitude of policy rate increase needed to stabilize a housing bubble may eviscerate the rest of the economy; these studies have been criticised for their methodology.[25] Furthermore, proponents of the LATW strategy argue that the main objective of a LATW policy is not to "prick bubbles" but to reduce output and inflation volatility.[26] Our findings tend to support the need for perusing a LATW policy on two grounds. Firstly, since the magnitude of the monetary transmission channels including the BLC is relatively weak during the recessionary phase, makes it difficult for central bankers to stimulate economic activity and hence the logical conjecture will be to peruse a LATW tilt, reducing the probability of such scenarios in the very first place. Secondly, we find aggressive expansionary policy do indeed stimulate mortgage lending by depository institutions during recessionary periods which we support should be the ideal strategy during recession. However, the existing low level of policy rate curtails the leverage for the Bank to undertake such policy. In addition, studies have shown that if the policy rate is kept too low for too long it may exacerbate risk taking

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25 See Cobham (2013)

26 See Wadhwani (2008) and Cecchetti, Genberg and Wadhwani (2002)

nature among banks and hence endanger future financial stability. Therefore, an optimal policy will be a LATW tilt.

Appendix

To examine the responses of variable y to innovations in variable x we estimate the following simultaneous equation model via OLS, equation-by-equation;

$$x_t = a_{10} + \sum_{j=1}^{j=p} a_{11,j}\, x_{t-j} + \sum_{j=1}^{j=p} a_{12,j}\, y_{i,t-j} + \epsilon_{1t}$$

$$y_t = a_{20} + \sum_{j=0}^{j=p} a_{21,j}\, x_{t-j} + \sum_{j=1}^{j=p} a_{22,j} y_{t-j} + \sum_{j=0}^{j=p} g_{21,j}\, x^{\#}_{t-j} + \epsilon_{2t}$$

Since the corresponding impulse response functions are nonlinear functions of the parameters $g_{21,0}, g_{21,1}, \dots g_{21,p}$ as well the other parameters of the model the impulse response functions are computed by Monte Carlo integration. In the first step the impulse response functions are calculated to an innovation of the size δ in ϵ_{1t} for a given horizon h conditional on the history Ω^t. The conditional impulse response function, $I_y(h, \delta, \Omega^t)$ is then averaged over all the histories to obtain the unconditional IRF, $I_y(h, \delta)$. In a similar manner for a negative shock of the size $-\delta$, the condition impulse response function, $I_y(h, -\delta, \Omega^t)$ is first computed and then average over all histories to obtain the unconditional impulse response function, $I_y(h, -\delta)$.

Table 1: Hansen Stability test

	Δgdp	$\Delta house\ price$	$\Delta tbill$	mix	inf	$mortgage\ spread$	$wholesale\ spread$
Joint	2.112 (0.00)	1.462 (0.00)	3.045 (0.00)	1.451 (0.00)	12.71 (0.00)	3.646 (0.00)	1.524 (0.015)
Variance	0.700 (0.01)	0.160 (0.35)	2.957 (0.00)	0.563 (0.03)	3.35 (0.00)	1.532 (0.00)	0.898 (0.06)
Mean	1.219 (0.00)	1.318 (0.00	0.059 (0.81)	0.876 (0.00)	9.98 (0.00)	2.367 (0.00)	0.4129 (0.07)

Note: P values in the parenthesis

Table 1: Linearity test

Model	LR linearity test	Davis approximate upper bound
1st MS-VAR	$\chi^2(47)$=4018.7 [0.0000] **	[0.0000] **
2nd MS-VAR	$\chi^2(47)$=2610.4 [0.000] **	[0.0000] **
3rd MS-VAR	$\chi^2(47)$=2655.4 [0.0000] **	[0.0000] **
4th MS-VAR	$\chi^2(47)$=2198.2 [0.0000] **	[0.0000] **
5th MS-VAR	$\chi^2(32)$=1916.5[0.0000] **	[0.0000] **

Table 3: Transition probabilities

Model	Transition probabilities		Duration of regime
	P(1|1)	P(1|2)	
1st MS-VAR	0.975	0.025	40
2nd MS-VAR	0.974	0.025	38.5
3rd MS-VAR	0.977	0.022	43.5
4th MS-VAR	0.976	0.023	43.5
5th MS-VAR	0.974	0.026	38.5

Note: P(1|1) is the probability of staying in regime 1. P(1|2) is the probability of moving to regime 2 from regime1

Table:4: Flight to quality test

	Boom	Recession
	$\frac{repossion}{total\ mortgages}$	
$inflation_{t-1}$	0.010^{*}	0.001
$\Delta house\ price_{t-2}$	-0.092^{***}	-0.152^{***}
Δgdp_{t-2}	0001.	-0.01^{**}
mix_{t-1}	0.005	-0.056^{**}
$constant$	0.010	0.100^{**}
$variance$	0.003	0.004

Transitory probability

$$\begin{vmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{vmatrix} = \begin{vmatrix} 0.966 & 0.031 \\ 0.033 & 0.843 \end{vmatrix}$$

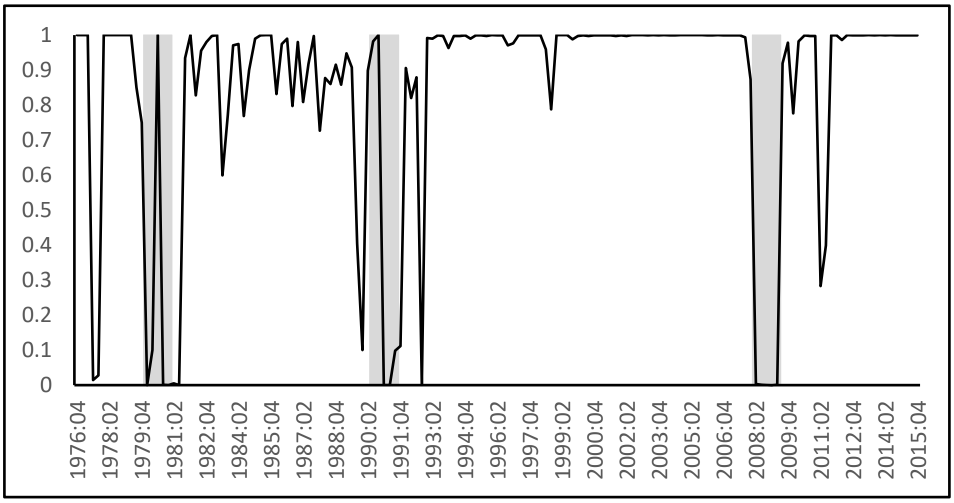
Linearity test

LR-test $\lambda^2(8) = 33.189[0.001]^{**}$, $approximated\ uperbound: [0.000]^{**}$

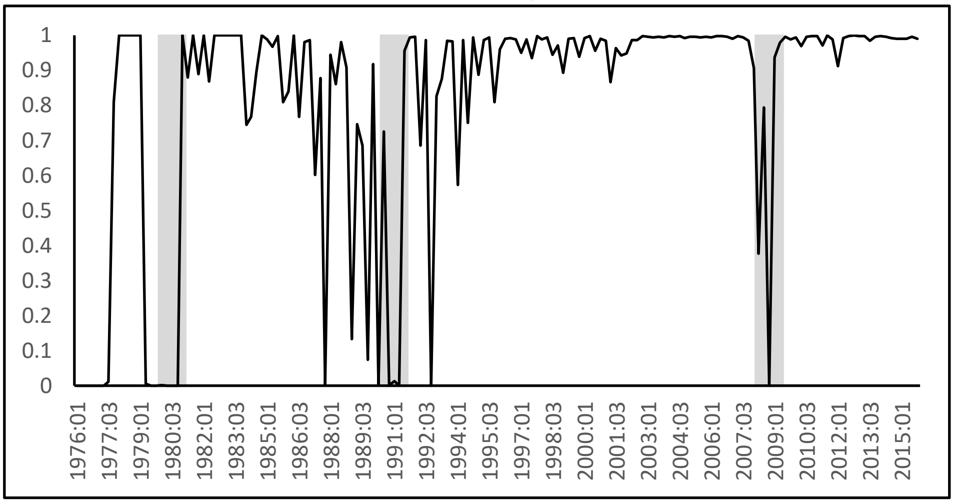
Figure 1: Smooth transition probability (Regime1)

(Shaded area represents recessionary periods**)**

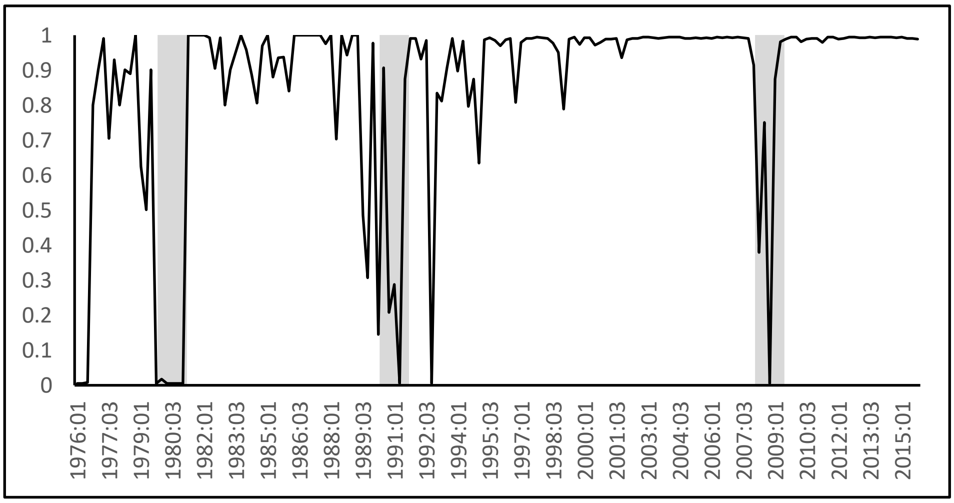
First MSVAR



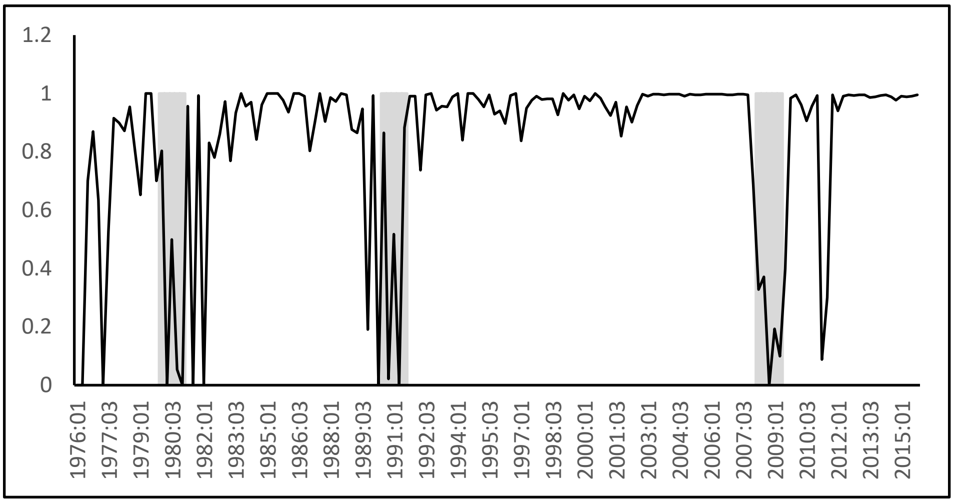
Second MSVAR



Third MSVAR



Fourth MSVAR



Fifth MSVAR

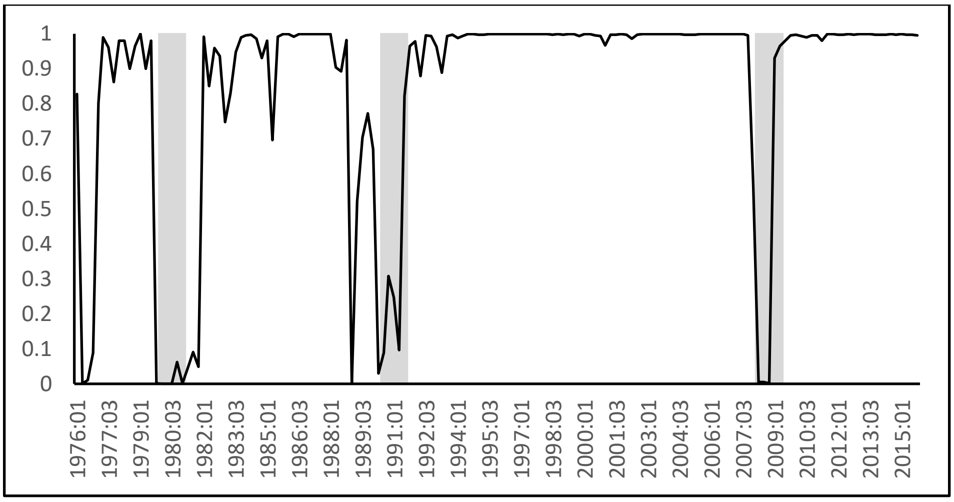
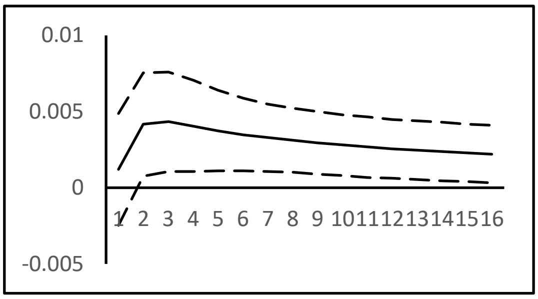
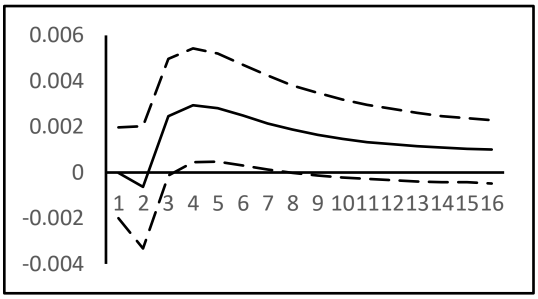


Fig: 2A First MSVAR (Monetary policy shock)

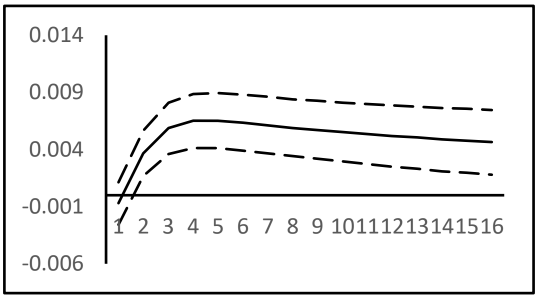
Boom **Recession**

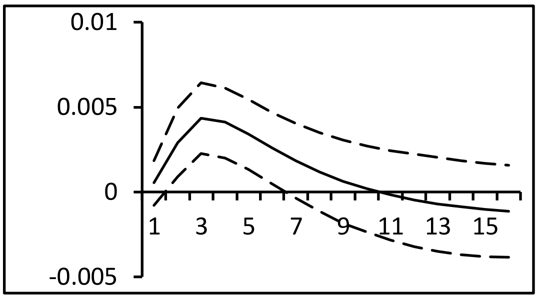
Response of GDP



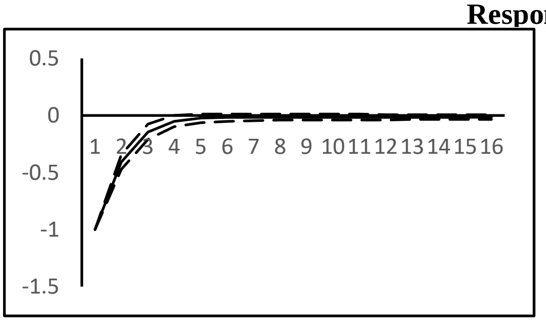


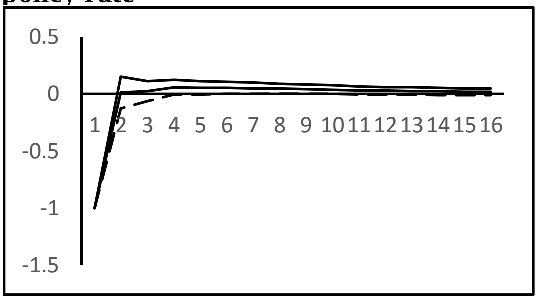
Response of inflation



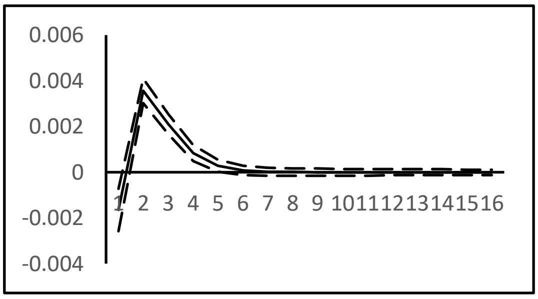


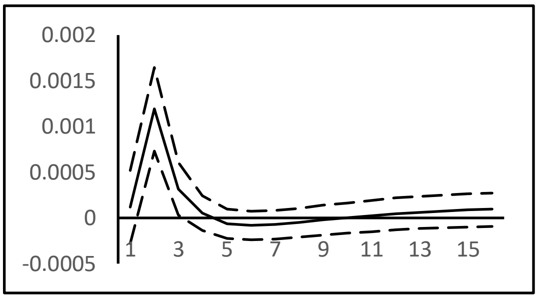
Response of policy rate



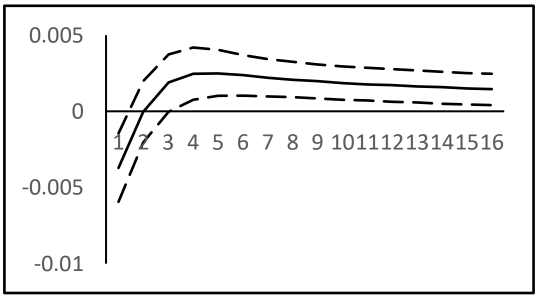


Response of Credit





Response of house prices



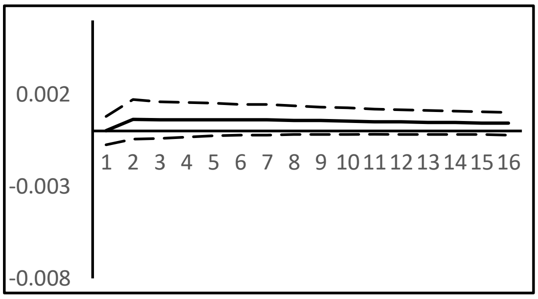
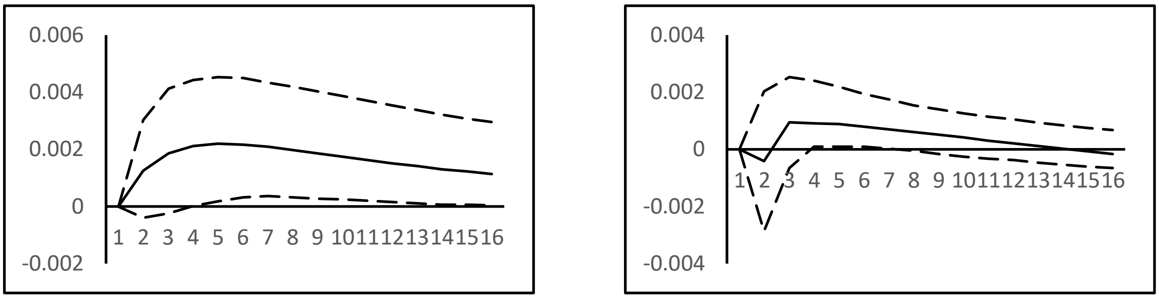


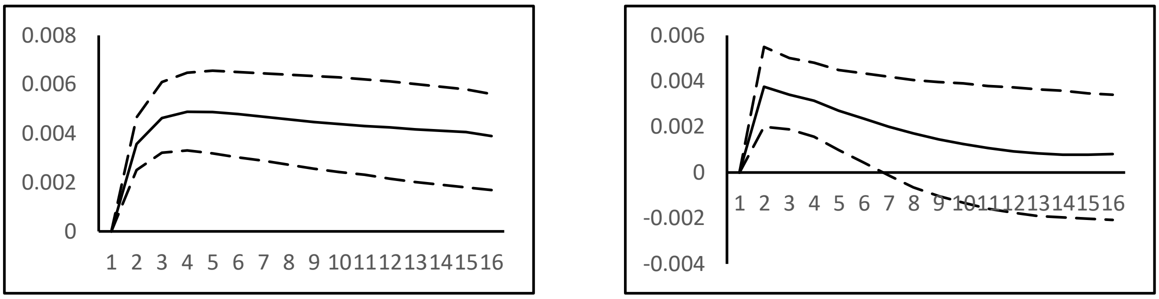
Fig 2B: Second MSVAR (Monetary policy shock)

Boom | **Recession**

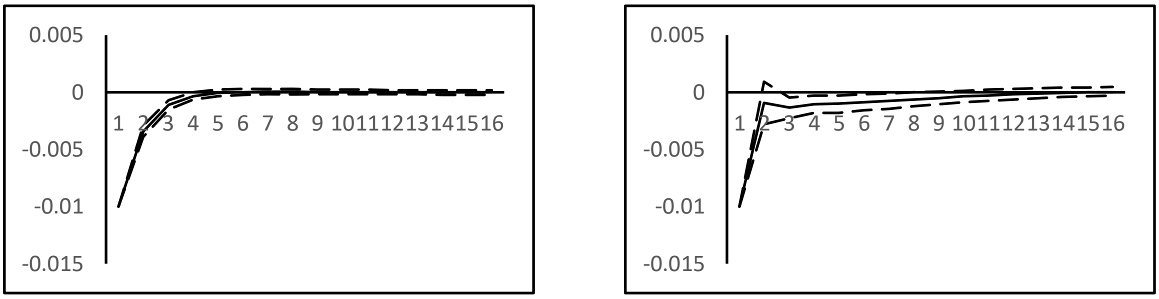
Response of GDP



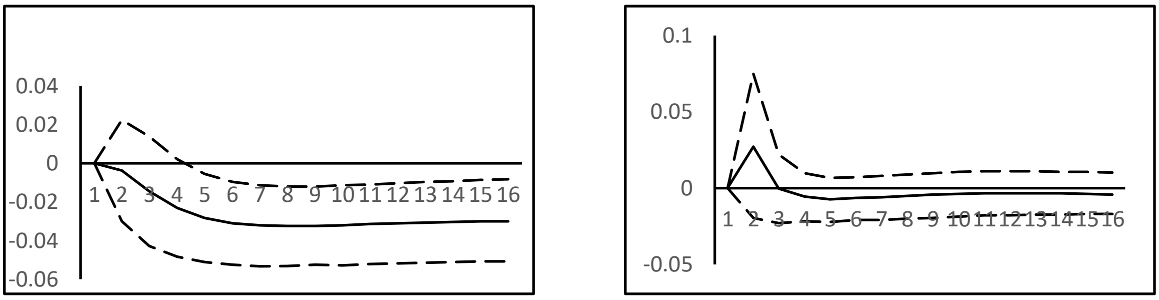
Response of inflation



Response of policy rate



Response of mortgage spread



Response of house prices

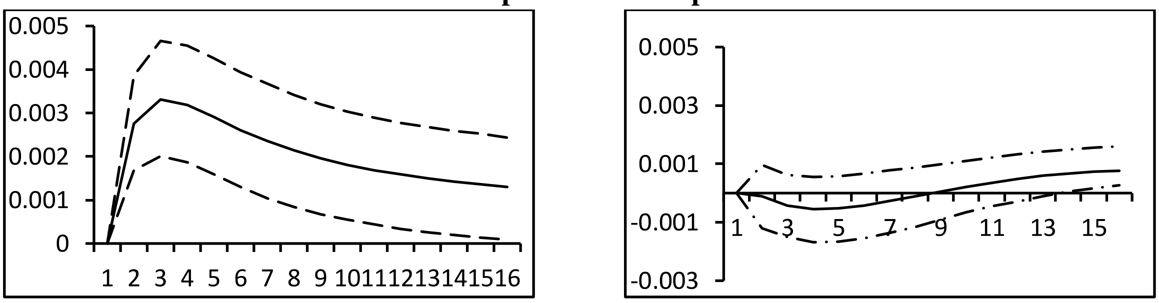


Fig 2C: Third MSVAR (Monetary policy shock)

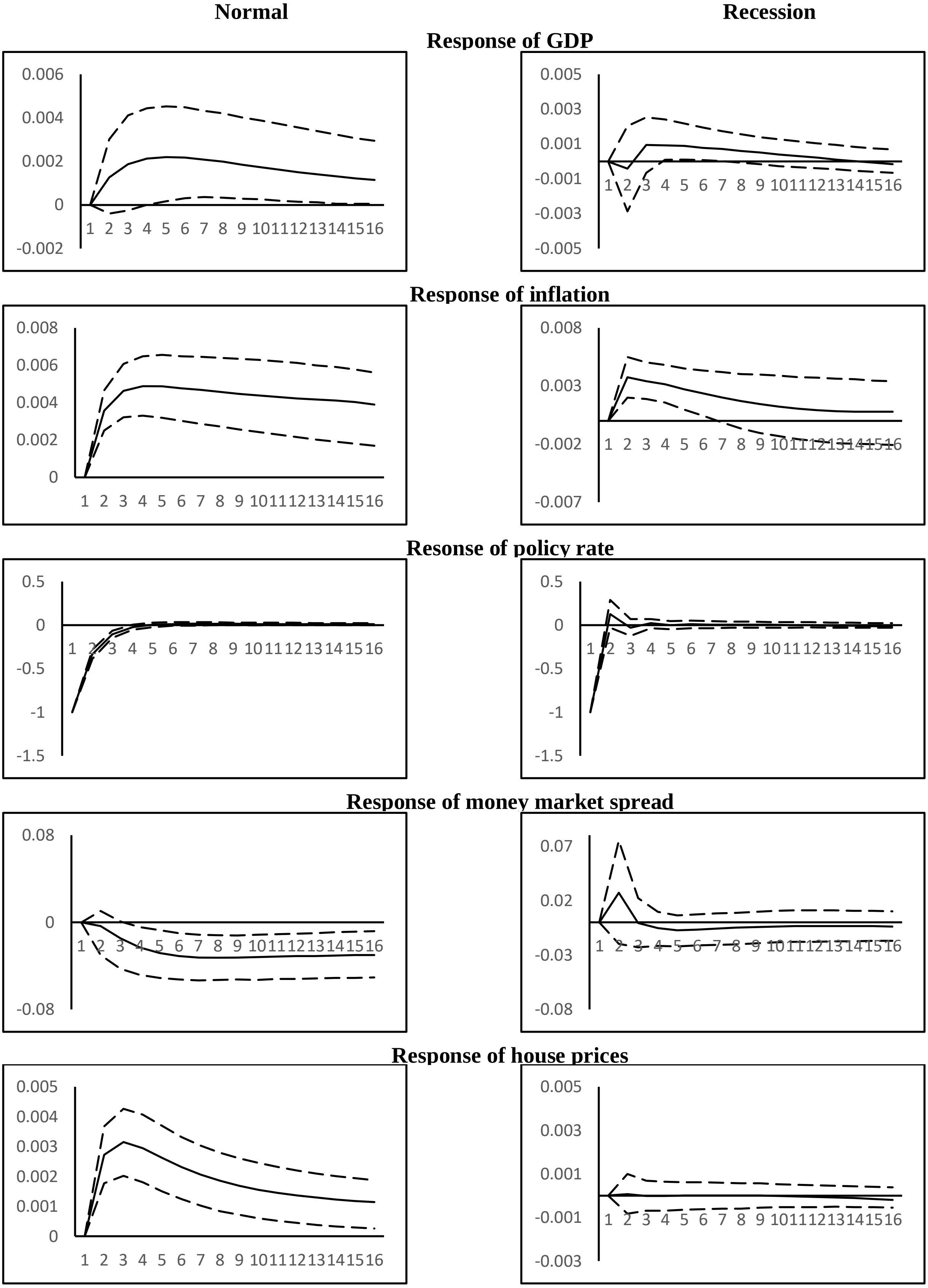
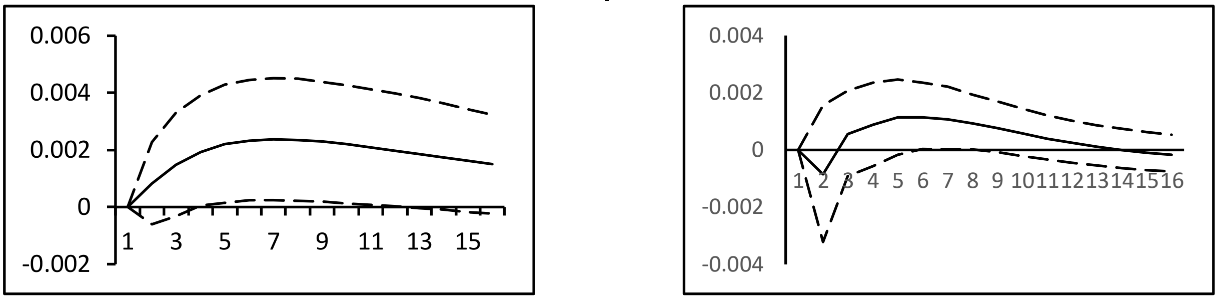


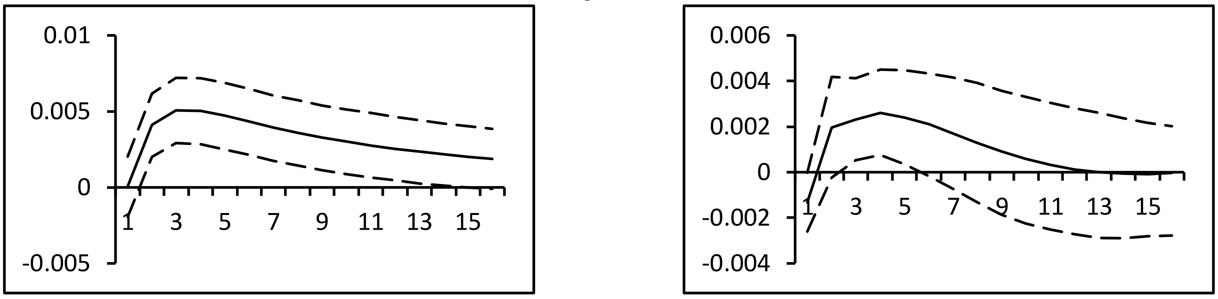
Fig 2D: FifthMSVAR (Monetary shock)

Booom **Recession**

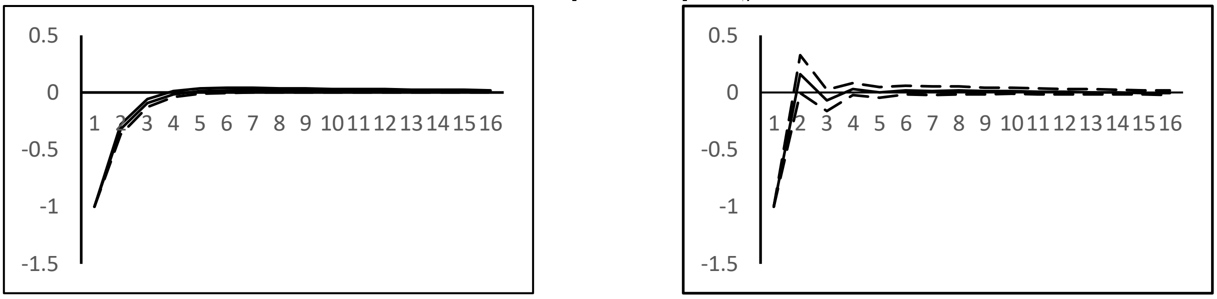
Response on GDP



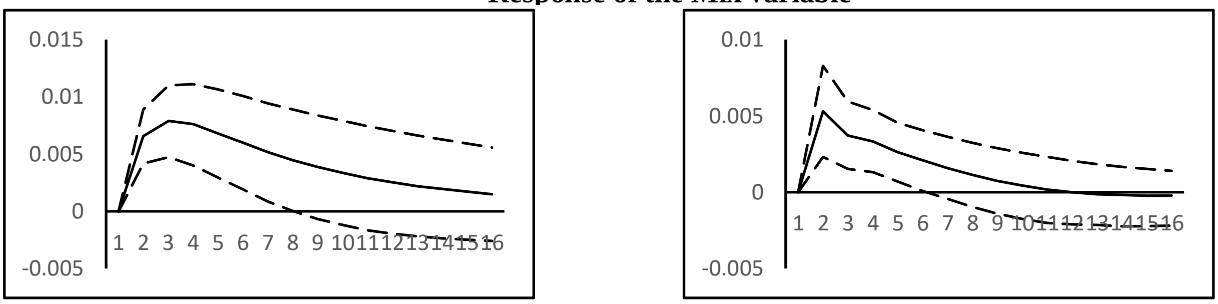
Response of Inflation



Response of policy rate



Response of the Mix variable



Response of house prices

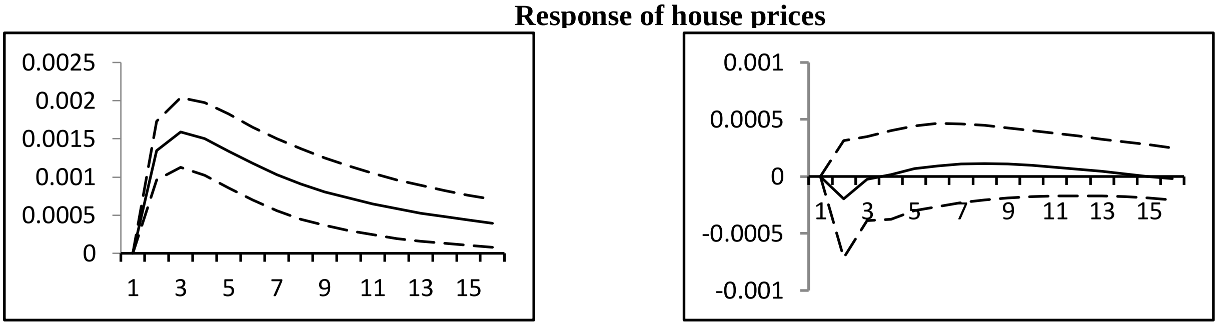
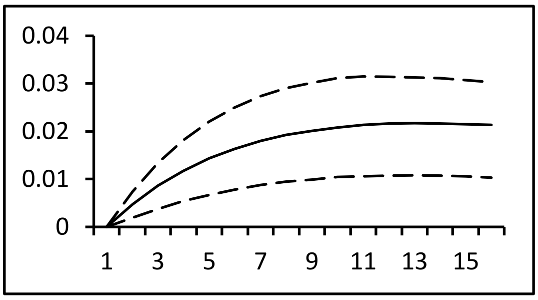
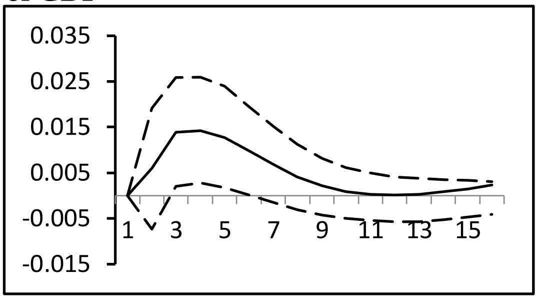


Fig 2E: FifthMSVAR (Mix shock)

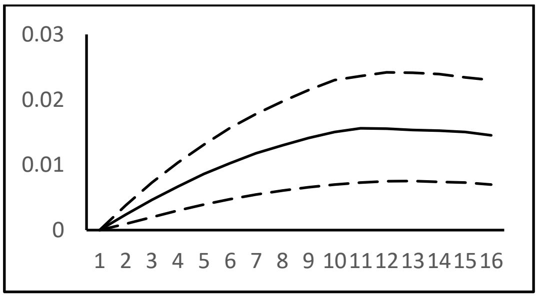
Normal | **Recession**

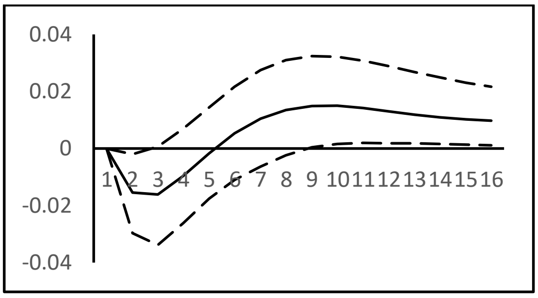
Response of GDP



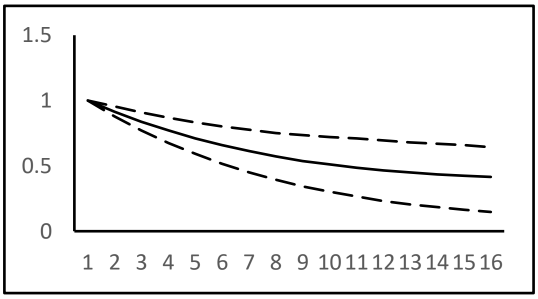


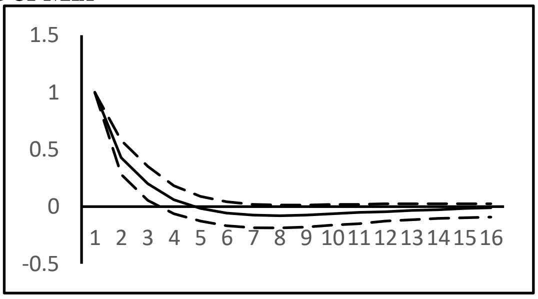
Response of inflation



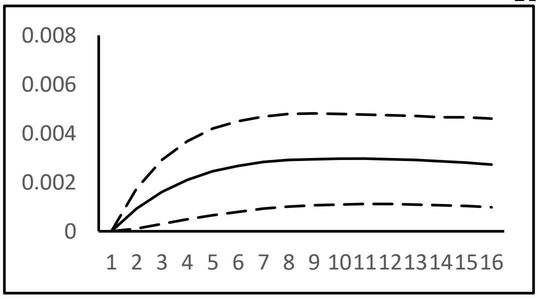


Response of Mix





Response of house prices



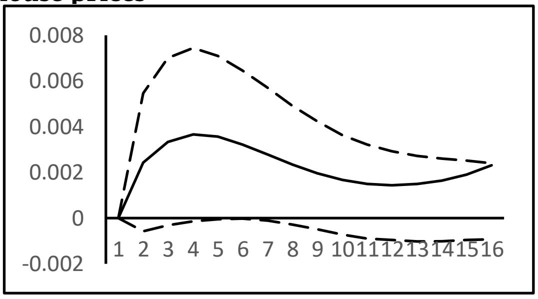
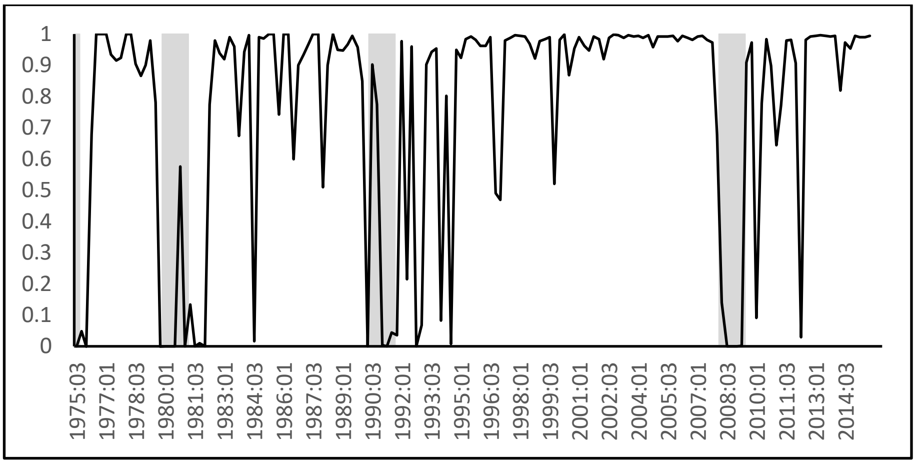
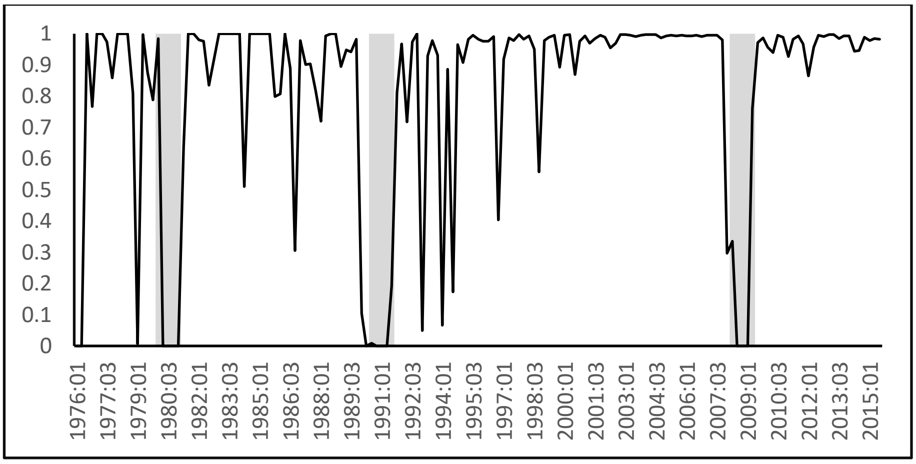


Figure 3: Smooth transition probability (Regime1)
(Models using Shadow policy rate)
(Shaded area represents recessionary periods**)**

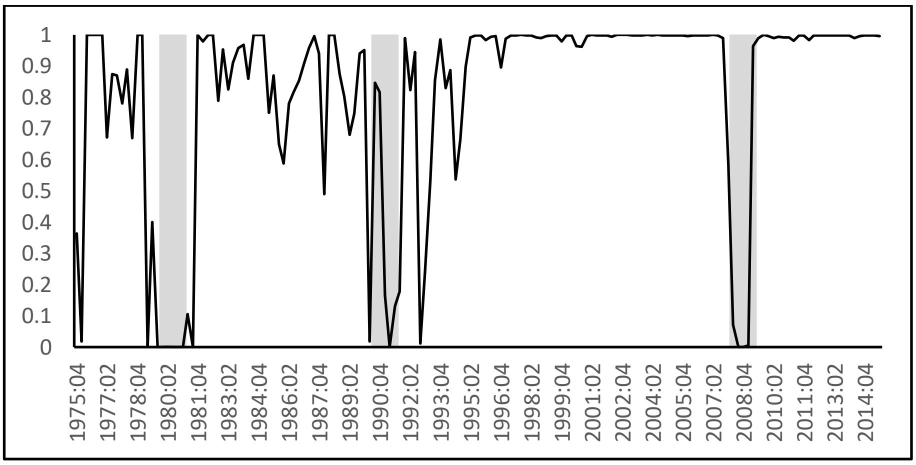
First MS-VAR



Second MS-VAR



Third MS-VAR



Fourth MS-VAR

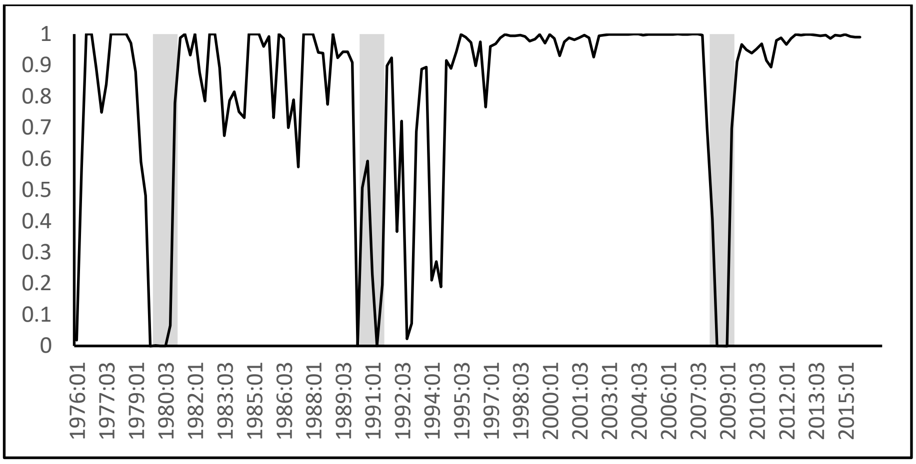
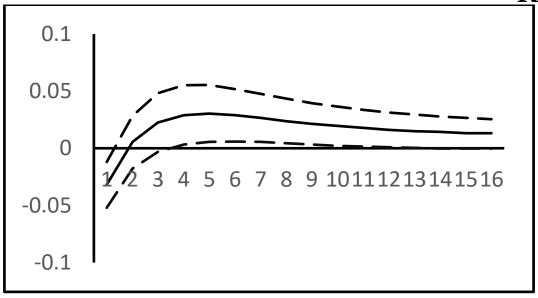
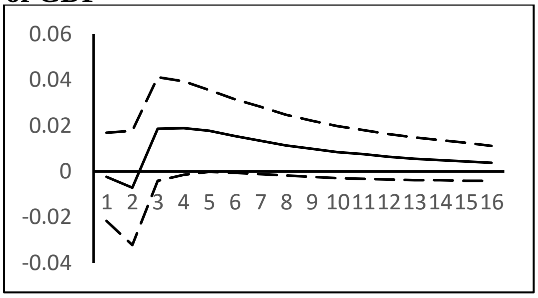


Fig 4A: First MS-VAR (Shadow policy shock)

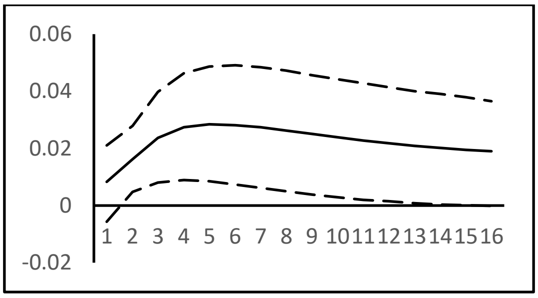
Boom | **Recession**

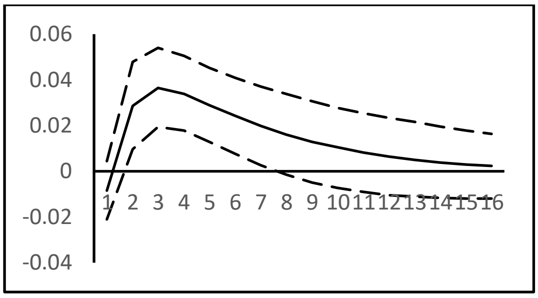
Response of GDP



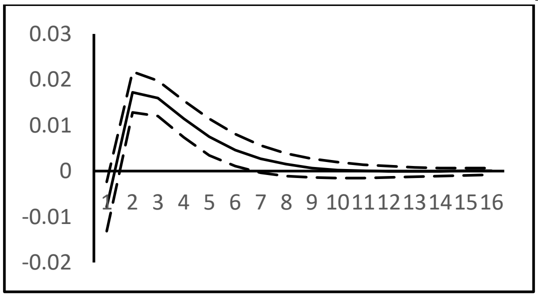


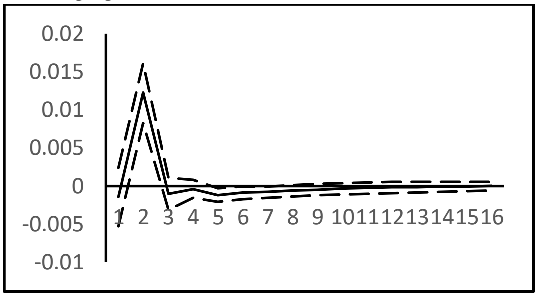
Response of Inflation



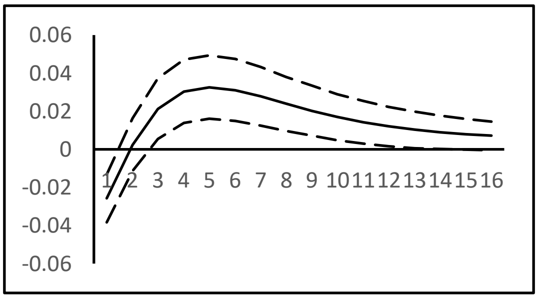


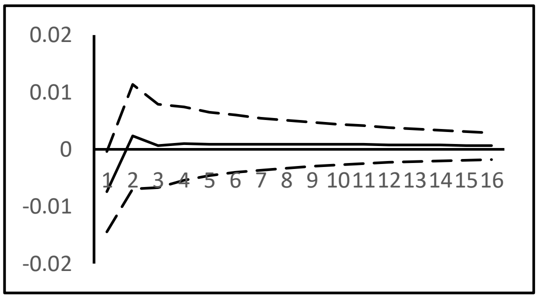
Response of mortgage



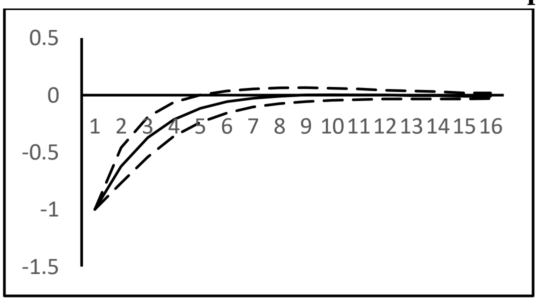


Response of house prices





Response of policy rate



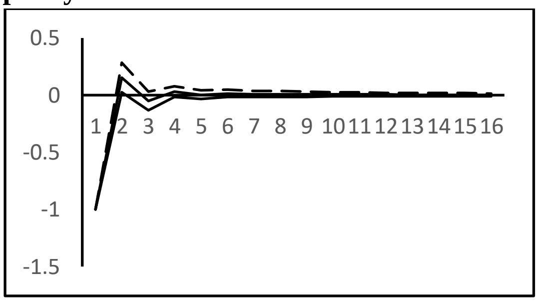
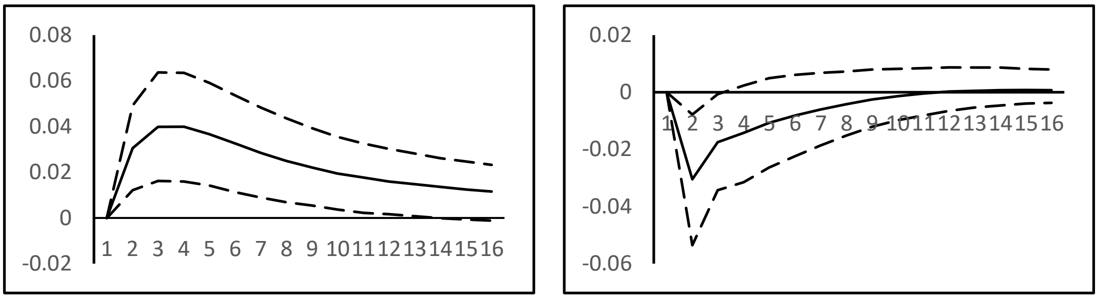


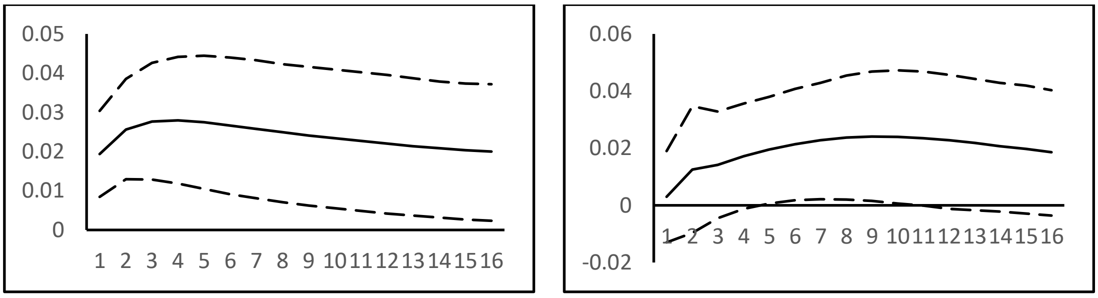
Fig 4B: Second MS-VAR (Shadow policy rate policy shock)

Boom | **Recession**

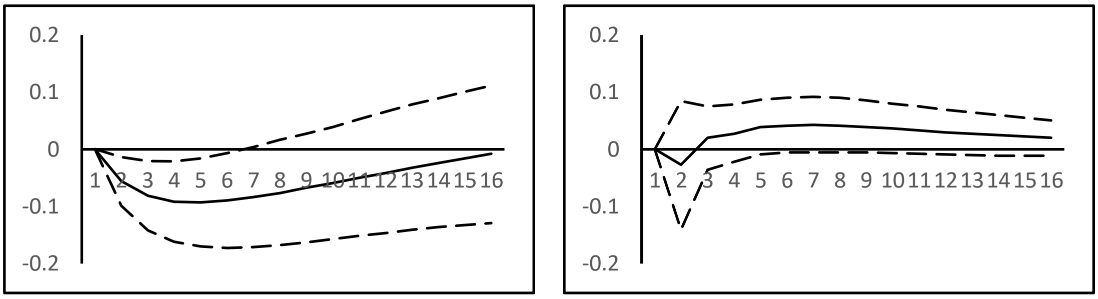
Response of GDP



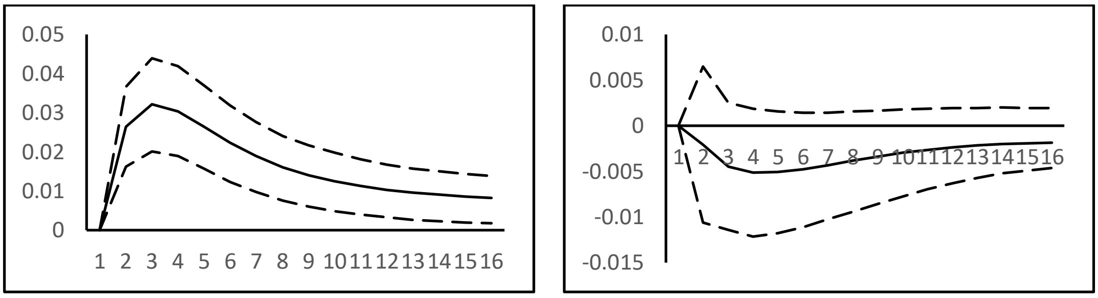
Response of inflation



Response of mortgage spread



Response of house prices



Response of policy rate

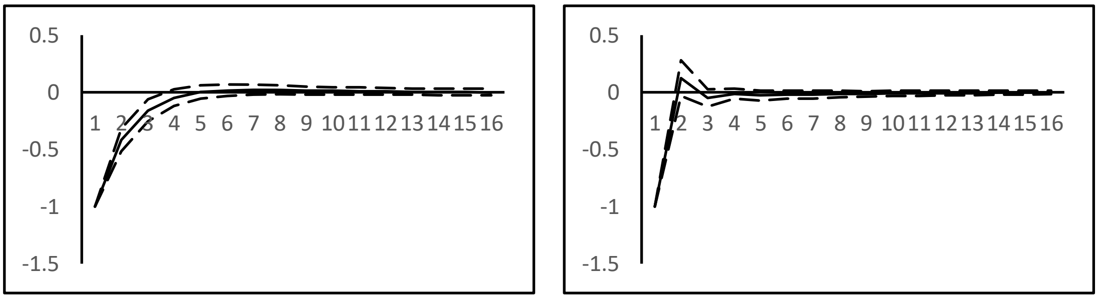
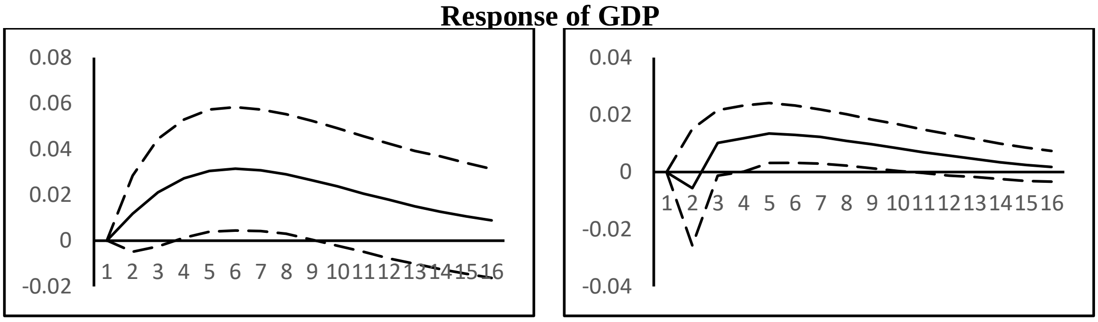


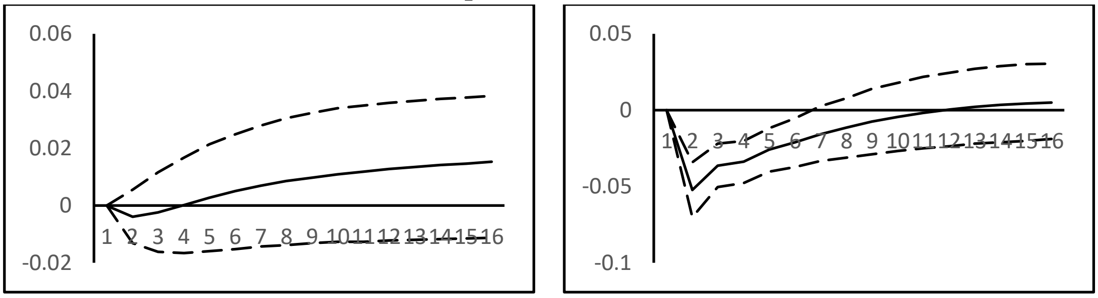
Fig 4C: Third MS-VAR (Shadow policy rate policy shock)

Boom | **Recession**

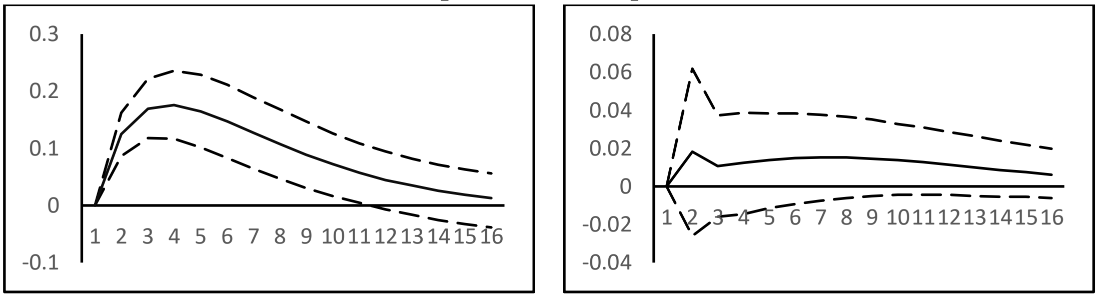
Response of GDP



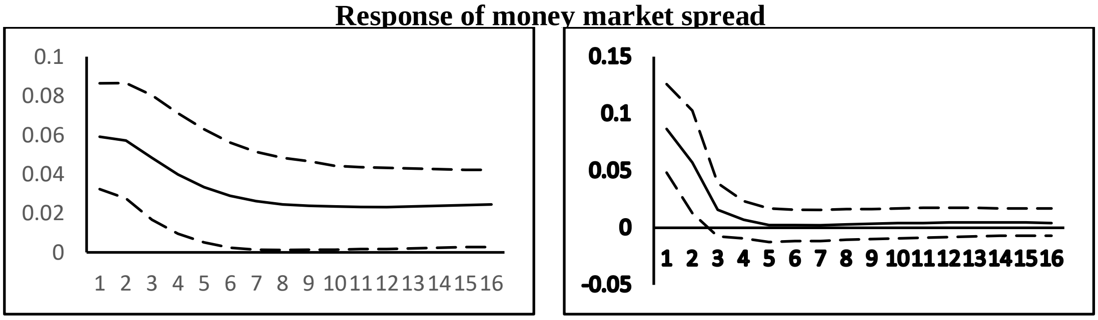
Response of inflation



Response of house prices



Response of money market spread



Response of policy rate

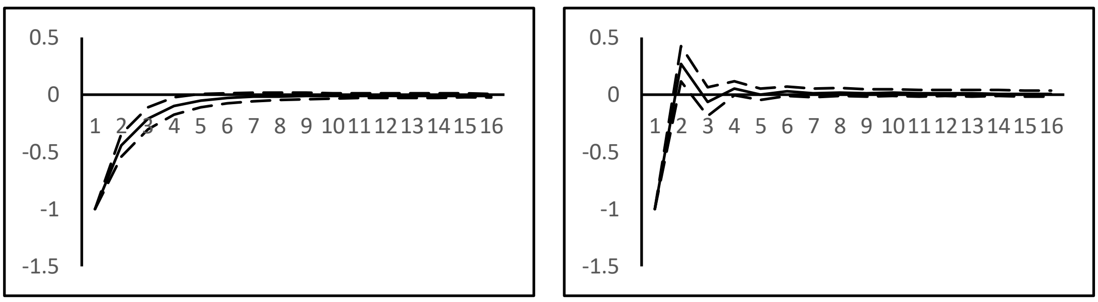
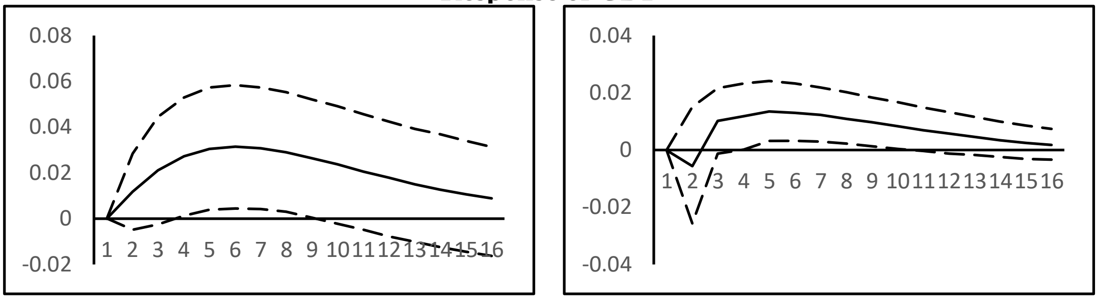


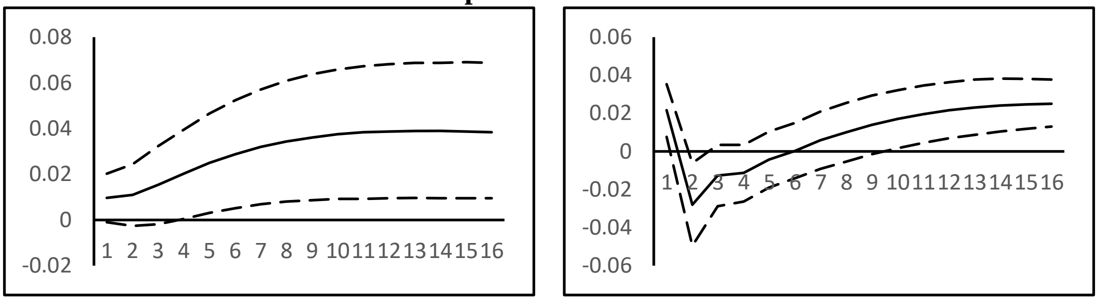
Fig 4D: Fourth MS-VAR (Shadow policy rate policy shock)

Boom **Recession**

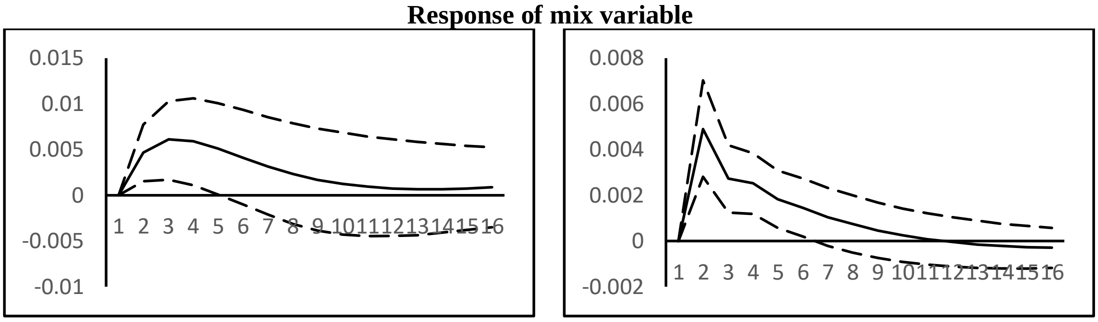
Response of GDP



Response of inflation



Response of mix variable



Response of house prices

Response of policy rate

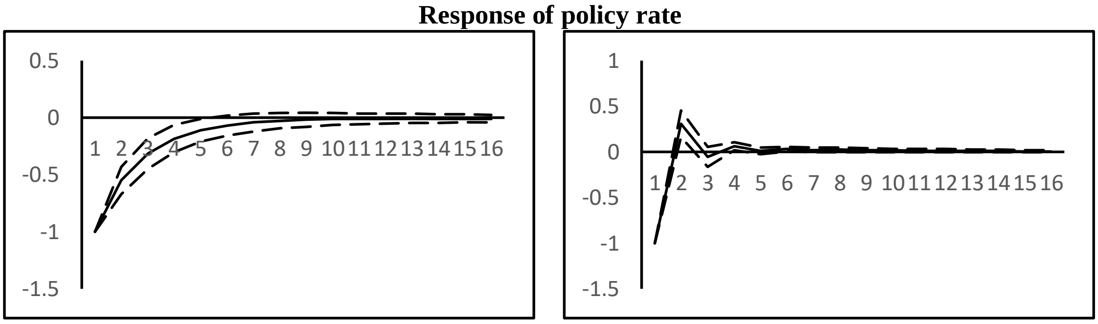


Figure 5: Smooth Transition probability of model demonstrating "flight to quality" test
(Shaded area represents recessionary periods)

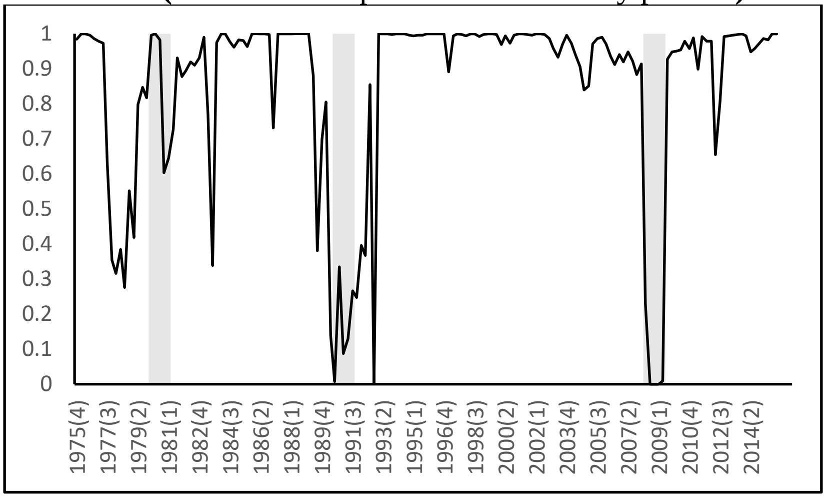


Figure 6: BoE policy rate during recessions

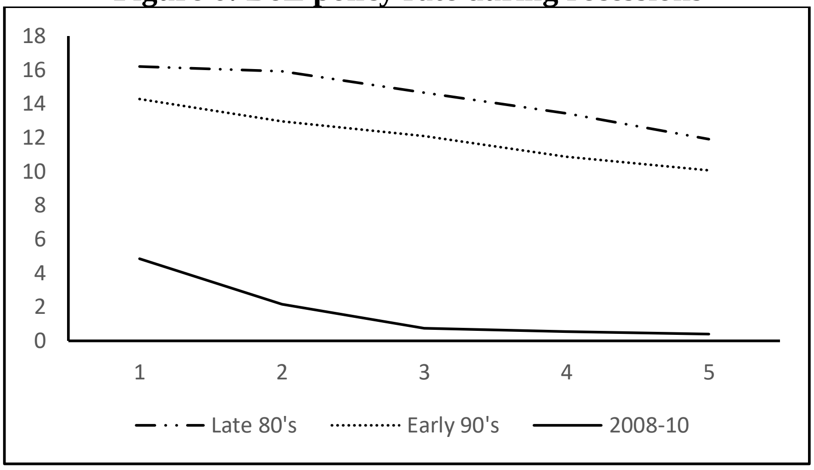
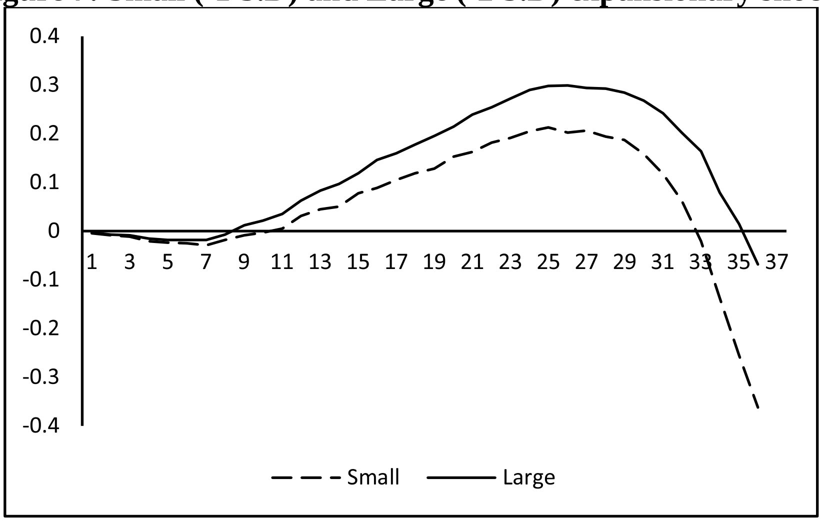


Figure 7: Small (-1 S.D) and Large (-2 S.D) expansionary shocks



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