Asymmetric Effects of Monetary Policy on the UK house prices: A Markov-Switching Vector Autoregression model (MS-VAR)

Rosen Azad Chowdhury

Duncan Maclennan

Abstract

Empirical studies mainly model monetary transmission mechanism and housing prices as being symmetric across business cycles. However, as the degree of asymmetric information varies with the state of the economy such notion of a symmetric impact may be incorrect. This paper using United Kingdom data captures the asymmetric shocks of macro variables on UK house price from 1980 to end of 2012, employing Markov-switching vector autoregressive (MS-VAR) model and regime dependent impulse responses. The results suggest that the effect of traditional monetary policy is not neutral and the impact varies significantly during boom and bust periods. These findings lead us to believe information asymmetry plays an important role in the economy and in monetary transmission mechanism.

Keywords: Switching regression model, monetary economics, real estate economics

JEL code: C34, E00, L85

1. Introduction

Numerous theoretical and empirical works have focused on the inter linkages between monetary policy, house prices and the macro economy. However, except a few most use a linear frame work and assume that the causal relationships between the variables are identical over the business cycle. The sharp appreciation of UK house prices during the great moderation years followed by contraction throughout the recession period even when the UK monetary policy rate was at its historical low leads us to believe that the impact of monetary policy on house prices is non-linear. We use a four variable (gross domestic product, house price, treasury bill rate and mortgage lending data of the United Kingdom) Markov switching vector auto regression model and employ regime dependent impulse responses to capture the asymmetric effects of monetary policy on UK housing prices at different points over the business cycle.

Earlier works relating monetary transmission mechanism and house price find evidence that changes in monetary policy rate have significant effect on UK house prices. Moreover, significant evidence associating house price shocks on the real economy and credit markets has been established which can be explained mainly by the wealth effects, Tobain's Q and also by bank balance sheet net worth effects (Goodhart and Hofmann., 2008, Maclennan, Muelbauer and Stephens, 2000 and Milne and Wood., 2010).

The amalgamation of nonlinear behaviors of economic agents and the macro economy were first incorporated in theoretical models proposed by Bernanke and Gertler (1989) and Kiotaki and Moore (1997). These models include agency costs of financial intermediation (financial constraint), asserts that when there is information asymmetry in the financial markets, agents behave as if they were constrained financially. Moreover, financial constraint is more likely to bind in recessionary states rather than in expansionary periods when information asymmetry problem in relatively less. Given the degree of financial frictions that varies with the business cycles it is imperative monetary policy will have dissimilar effects on the economy and house price over different stages of the business cycles. Furthermore, with the development in the field of behavioral economics the asymmetric impact of interest rate changes on house prices can also be explained by prospect theory (and loss aversion theory).[1]

This paper contributes to the existing literature in three ways. First, by employing a four variable Markov switching vector auto regression and regime dependent impulse response we look at the impact of interest rate changes on UK house prices during expansionary and recessionary states. Earlier works examining nonlinear nature of monetary policy over the business cycle either tends to ignore house price or only model bivariate relationships. Second, analyses of asymmetric impact of mortgage lending on UK house prices are also examined. Finally, feedback of house prices on the other variables during expansionary and recessionary states is analyzed. From methodological point of view our work uses a simultaneous equation framework rather than single equation Markov models which the literature mainly uses.

Results from our study exhibit monetary policy has non-linear effects on house prices, credit and on output over the business cycle. Findings illustrate negative interest rate shocks have lesser impact on the output, house prices and mortgage lending during recessionary states compared to expansionary states of the economy. In addition to this negative mortgage lending shocks have larger influence on house prices during recessions than in expansionary periods. Finally, results also suggest negative house price shocks have larger impact on mortgage lending, GDP and on interest rate during recessions than in boom periods. These finding of ours are in line with the recent occurrence that have taken place after the subprime crisis of 2007.

---

1 See more for Kahneman and Tversky (1979)

The paper is organized as follows. The next section provides a brief theoretical background and literature review for the study. Section three discusses about the econometric methodology and the data. Empirical results and impulse response functions are presented in section four. Lastly, we draw our conclusions in section five.

2. Theoretical background and literature review

While it is evident that before the 2007 financial crisis the Bank of England (BoE) did not take account of house prices (or any other asset prices) when setting the monetary policy rate (see Cobham, 2013), it is widely acknowledged altering the policy rate affects house prices which in turn affects consumption and output. Maclennan *et al.* (2000) notes, there are both *direct* (Keynesian interest rate channel) and *indirect* channels (credit channel) through which changes in monetary policy can effect house prices. According to the *direct effect* or the Keynesian interest rate channel a decrease in policy rate decreases real interest rate which in turn reduces the cost of capital, thereby leading to an increase in housing demand and house prices. The *indirect effects* or the credit channel affects house prices through the bank lending channel and the balance sheet channel. According to the bank lending channel during expansionary monetary policy banks obtain insured deposits relatively easy. Therefore, the demand of costly uninsured deposits becomes less. As a result banks supply of loans/mortgages increase. The balance sheet channel of monetary policy states that a decrease in monetary policy rate increases households net worth reducing moral hazard and adverse selection problems between borrower and lenders making it easier to obtain mortgages and hence increasing price of houses finally. The authors also note that the change in house prices due to changes in policy rate can effect consumption and output. Typically changes in house price are transmitted to GDP through the wealth channel, where an increase in house prices increases household and firms wealth thus increasing consumption and output.[2]

The existence of these channels has been proven in empirical work mainly using linear VAR/VECM framework. Aoki et al. (2002, 2004) employing a recursive VAR finds that changes in monetary policy has significant effect on UK house prices. Elbourne (2007) using structural vector auto regression (SVAR) finds that contractionary monetary policy shock reduces house prices and a positive innovation in house price significantly increase consumption and output.[3] One shortcoming of these studies is that they do not include an explicit banking sector.[4] Two notable works on UK that take account of the credit market as well as house prices are by Goodhart *et al.* (2008) and Iacoviello and Minetti (2007). Both the papers find bi-directional causality between house prices and bank lending. The later study explicitly illustrates effects of monetary policy on UK house prices are transmitted through the interest rate and the bank lending channel.

One of the major drawbacks of the above discussed studies is that the empirical works are done under a linear framework where in real world behavior of economic agents change over the business cycles. Recent empirical findings show some of the monetary transmission channels that propagate monetary policy shocks to house price may have varying effects over the business cycles. We first discuss the varying effect of monetary policy on house prices, mortgage lending and GDP over the business cycle. In normal economic conditions a decrease in monetary policy rate increases house price, GDP and lending. However, the response of a similar shock may produce a lesser effect on the variables during recession as in recessionary period net worth of

---

2 In a similar manner the transmission of house prices changes on output can also be explained by Tobain's

3 See more for Hendry (1984), Meen (1990), Muelbeauer and Merphy (1997)

4 See more for Goodhart (2008)

households and firms decline more, causing an increase in asymmetric information problem in the market. This in turn increases the risk premium which is reflected by higher lending rate spread, thus making investment more costly and reducing demand for loans and hence reducing consumption and output at a larger magnitude relative to expansionary periods. Decomposition of UK interest rate spreads by Illes and Lambardi, (2013) find significant evidence that low policy rates were not transmitted to UK households and non-financial firms in the form of low lending rates during the recent financial crisis.

The lesser response of an expansionary monetary policy shock on lending can be due to a distressed banking sector as well. Financial innovations like off balance sheet activity/securitization have pro-cyclical effect on lending and GDP. The creation of extra liquidity by these processes strengthens loan growth during expansion periods. On the contrary, the opposite happens during recessions as asset prices (including house prices) drop these securities become illiquid and net worth of depository institutions decrease. Altunbas (2009) using European and US bank level data show lending declined most in the recent crisis for those banks undertaking securitization process. Furthermore, the drop in asset prices during recessions can also reduce banks capital (Van Dan Heuvel, 2002, 2012). Given a binding capital constraint banks in situations like these will be unwilling to increase their lending even when the policy rate has been decreased. Studies by Gambacorta and Marques-Ibanez (2011) find evidence that reducing the monetary policy rate did not increase bank lending during the recent crisis there by leading to notion that the tradition bank lending channel was not so effective. Beside these, in expansionary phase if the policy rate is kept low for long periods banks' perception and attitude towards risk changes as low interests reduce borrows default probability (this is reinforced by higher collateral value during the period) and hence they invest more in risky assets and offer more loans to risky borrowers. However, on the onset of recession as portfolio risk increases banks decrease lending even when monetary policy is reduced (Adrian and Shin, 2009, Gambacorta, 2009).

Asymmetric nature of the house prices to exogenous shocks can be explained by the use of loss aversion theory which originates from the prospect theory proposed by Kahneman and Tversky (1979) who argue that people have an asymmetric attitude to gains and losses, and people obtain less utility from gaining than losing. Dobrynskaya (2008) shows real estate sellers will choose not to trade during bad market conditions because they are unwilling to recognize capital losses. The reserve price of the seller is higher than the expected price of the buyer during a depression. Thus it may take more time for house prices to recover during recession and impact of a decrease in policy rate may have a lesser impact on house prices during this period compared to normal times.

Although Maclennan *et. al.* (2000) illustrates the mechanism of house price changes on the output and consumption they do not focus on non-linear nature of the relationship. However, it is more likely a decrease in house price will have larger effects on output and mortgage lending during recessions than in expansion periods. Given the higher levels of uncertainty among households and higher financial frictions that exists among depository institutions, reinforced by already low asset prices in the recessionary state (that reduces the net worth of the households and depository institutions) can be the attributing factor to larger fall in GDP and mortgage lending during recessionary state after a fall in house prices seen in recent times.

The literature examining the asymmetric effects of monetary policy at different stages of the business cycle is relatively small. Most of the empirical work either use various form of threshold or Markov switching models. The findings of these empirical works vary, depending on the procedure and sample period. Works such as Smets and Peersman (2001), Lo and Piger (2005) find that monetary policy is most effective in recessions. Simpson, Osborn and Sensier (2001) find evidence for UK that interest rates are ineffective in combatting recessions. More recent studies by Berger and Vavra (2012) and Tenreyro and Thwaites (2013) find evidence that monetary policy is more effective in expansionary periods in the United States. Although these studies are done in a nonlinear framework they don't examine the effect on monetary policy on house prices.

However, recently Simo-Kegne *et al.* (2013) using a two variable MS-VAR analyses the impact of monetary policy on South African house prices during boom and bear market. Their results show contractionary monetary policy shocks have larger effects on house prices during bear market than bull market and positive house prices shocks substantially affect monetary policy rate during bull market rather than in bear market. The first finding of this paper is similar to our indicating the role of information asymmetry in reinforcing financial constraints in economic agents during recessionary period. Tsai (2013) uses a threshold co-integration technique and using UK house prices and money supply data from 1986q3 to 2011q4 analyze the asymmetric relationship between monetary policy and UK house prices. The paper finds evidence that house prices adjust asymmetrically to money supply shocks and it over reacts during periods of loose monetary policy and under reacts during tight money supply. The authors explain these phenomenon using loss aversion theory and downward house price rigidity. Although this paper does not explicitly show asymmetric impact of monetary of monetary policy on house prices at different states of the business cycle, it supports the notion that correction behavior of house prices towards long-term equilibrium is more significant and faster when demand is increasing which represents boom period. Chen *et al*. (2013) also using threshold VAR analyses the impact of monetary policy changes on UK house prices under different credit conditions using data for the period of 1993M4 to 2008M10. The paper using generalized impulse response function suggested by Koop *et al.* (1996) find evidence that contractionary monetary policy has slightly bigger impact on house prices during credit boom period than normal period but the persistence of the shock is much longer in the normal period

Although these studies are innovative in the sense they account for the asymmetry but they have their short comings. For example the Simo-Kegne *et al.* (2012) study only looks at the relationship between two variables; interest rate and house prices. Estimating such a small model can create unexplained outcomes in the impulse responses. The work by Chen et al. (1996) use impulse responses proposed by Koop *et al.* (1996). Yet, these impulse responses may contain less information when the regimes are persistent. Our study extends this literature first by incorporating mortgage lending and GDP in the model and then using appropriate impulse response techniques examine the shocks.

3. Methodology

3.1 Markov Switching Vector Autoregression (MS-VAR) model

Markov switching models in recent years have become a popular instrument among economists to determine asymmetries. The methodology was initially proposed by Goldfield and Quandt (1973). Later work by Hamilton (1989) and Krolzig (1998) have made important contributions by combining switching models with vector auto regression to develop a MS-VAR which is well structured to characterize macroeconomic fluctuations in the presence of regime changes.

The application of Markov switching model in housing economics is quite common and has been widely used to model house price cycles. In order to model the asymmetric impact of interest rate changes on house prices we employ a model similar to Simo-Kegne *et al.* (2012). One of the benefits of employing such a model is that it allows us to examine the feedback of house prices on other variables in the system.

For our empirical analysis we use a special case of MS-VAR also known as MSIAH(m)-VAR(p) model, in which all parameters including the autoregressive terms, intercepts and variances are allowed to vary among the regimes. In equation (1) X_t, denote a vector of four endogenous variables containing changes in UK Treasury bill rate, growth rate of UK real GDP, real house price and mortgage lending.[5]. Based on framework of Ehrmann, Ellison and Villa (2003) the joint dynamics of the four variables are given by the following four MSIAH-VAR specifications;

$$X_t = \begin{cases} \mu_1 + B_{11}X_{t-1} + \cdots + B_{p1}X_{t-p} + A_1\varepsilon_t, \ if \ S_t = 1 \\ \mu_2 + B_{12}X_{t-1} + \cdots + B_{p2}X_{t-p} + A_2\varepsilon_t, \ if \ S_t = 2 \end{cases} \quad (1)$$

Identification of monetary policy shocks and housing demand shocks have been done using a recursive or Choleski identification scheme similar to Musso et al. (2011) and Milcheva (2013). The ordering of the four variables are given in the order; growth rate in real GDP, changes in Treasury bill rate, growth rate in UK house prices and finally growth rate of mortgage lending.[6] ε_t, the fundamental residuals in equation (1) are assumed to be uncorrelated at all lead and lags and their variances are set to unity so as to ensure the identity variance-covariance matrix. In equation (1) each fundamental residual is pre-multiplied by a switching matrix A_i. Equation (2)

[5] We do not include hosing stock variable based on the fact that price elasticity of supply is very low in the UK (see more for Malpezzi and Mclennan, 2001)

[6] Other orderings have been tried and they produce similar results.

shows how consequently the variance–covariance matrix $\sum_i$ of the residuals $A_i \varepsilon_t$ will also be regime dependent.

$$\sum_i = E(A_i \varepsilon_t \varepsilon_t' A_i') = A_i E(\varepsilon_t \varepsilon_t') A_i' = A_i I_K A_i' = A_i A_i' \qquad (2)$$

In equation (1) the latent variable S_t indicates expansionary and recessionary periods corresponding to "high mean and low volatility of GDP growth rate" and "low mean and high volatility of GDP growth rate" respectively. We estimate the MS-VAR model using maximum likelihood technique.|

3.2 Regime dependent impulse response

One of the benefits of using MS-VAR is that regime-dependent Impulse Response Functions (IRF) which can be used to determine cyclical variation in the responses of variables to a particular shock. Equation (3) gives the mathematical definition of responses of the regime-dependent IRF for regime *i*. 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* (Ehrmann *et al.*,2003).

$$\theta_{ki,h} = \frac{\partial E_t X_{t+h}}{\partial \varepsilon_{k,t}} |_{S_t = S_{t+h=i}} \qquad for\ h \geq 0 \qquad (3)$$

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 $\widehat{A_i}$. Through the standard bootstrapping technique, $\widehat{A_i}$ are combined with the parameter estimates of the unrestricted VAR to derive the response vectors.

3.3 Data

For our empirical work UK GDP *(gdp)* and the Treasury -bill rate *(t-bill)* data are collected from IFS. House price *(hp)* and mortgage lending *(l)* data has been obtained from Nationwide website and from Council of Mortgage Lenders respectively. The data frequency is quarterly and the period analyzed starts in 1980 and ends in the third quarter of 2012. The variables in our analysis are in real terms and are deflated by UK retail price index *(RPI).* Except for interest rate all the data are in natural logarithms.

3.3.1 Time series properties

Augmented dickey fuller (ADF) test was performed on the data. The test results indicated null hypothesis of unit root cannot be rejected which is quit puzzling as the variables are unlikely to be non-stationary (and truly integrated) as they have a lower bound.[7] Perron (1989) shows that unaccounted breaks in data generation process can make a stationary process look non-stationary and can reduce the power of the unit root tests. Empirical economists have treated these data in mainly two ways. One group assumes that the persistence in the data is caused by unaccounted structural breaks. The other group accepts the persistence is due to some underlying economic behavior and treats the data as non-stationary and integrated. We follow the first group but rather than demeaning the data we difference the data and then proceed on running the Markov VAR.

Before proceeding to our Markov switching model we first test the stability of the variables performing Hansen (1992) stability test. Table 1 illustrates that all the variables have breaks either in mean, variance or in all the components. We also run a linear VAR and then use Andrews-Ploberger (1994) structural breaks test in linear regressions on each of the equations

[7] Results of the unit root tests can be provided on requested

separately. Results presented in table 2 show all the four equations of the linear VAR reject the null of linearity. The verdict from these tests provides us with initial support to estimate a Markov switching VAR where all are parameters of the model are switching.

4. Empirical results

4.1 Regime properties

Given the economic theory, past empirical evidence and based on the primary results obtained from the non-linearity test we run a Markov switching VAR where all the parameters are allowed to switch.[8] Prior to estimating the MS-VAR we determined the optimal lag length of the model on the basis of the Hannan-Quinn information criterion. After testing for model misspecification we find that a lag length of one is not associated with correlations.

The estimated results of the MS-VAR are presented in table 3. It is evident from table 3 that the value of the intercepts, coefficients and especially the variance of the variables vary significantly between the two regimes. The variance of growth rate of GDP, change in Treasury-bill rate, growth rate of house prices and mortgage lending are much lower in regime one compared to regime two. The intercepts of growth rate of GDP and growth rate of mortgage lending equation are larger in regime one than in regime two. Moreover, in the growth rate of GDP equation the lag of growth rate of GDP and lag growth rate of house prices terms have larger coefficients in the first regime than in the second regime. In the growth rate of house prices equation the coefficient lag growth rate of house price has higher values in regime one then in regime two. In the mortgage lending equation growth rate of mortgage lending equation and growth rate of house price have bigger values in regime one than regime two.

---

[8] We estimate the model in Rats 8.2.

While coefficients in the MS-VAR may be individually significant in each regime, there is always a probability that they may not be statistically different between the regimes. Hence we do Wald tests, which are reported in table 4. The results reinforces our earlier finding of table 3 suggesting that there is significant difference in the intercepts, lag terms and the variances between the two regimes. It can also be concluded that in regime one real GDP growth rate, house price growth rate and mortgage growth rate is high compared to regime two. Furthermore, volatility of growth rate of GDP, growth rate of house prices and change in Treasury bill rate and growth rate of mortgage lending are lower than regime one than in regime two.

The estimation results support the following transition matrix for the two regimes;

$$\hat{P} = \begin{bmatrix} 0.930^{***} & 0.070^{***} \\ 0.139^{***} & 0.861^{***} \end{bmatrix}$$

The transition matrix shows that the persistence of the two regimes is very high. The transition probability of the first regime which is the high growth and low volatility regime has a transition probability of 0.930. The transition probability of the low growth and high volatility regime has a transition probability of 0.861. The average duration of the high and low growth regimes are 14.28 quarters and 7.1quarters respectively.

Figure 1A and Figure 1B reports the estimated smooth probability of being in the first regime and UK real GDP growth rate respectively. Looking at the smooth probabilities of regime one it is apparent that since the early nineties to the recent financial crisis of 2007 UK economy has been achieving high economic growth and low volatility. The smooth probability of regime one also depicts that the UK output was low and volatility was high in the early eighties and in late eighties.

4.2 Regime dependent impulse response

Our empirical analysis focuses on regime dependent impulse as economic reasoning from the autoregressive coefficients might be difficult and misleading given that the model is essentially an *atheoretical* representation of the dynamics between the endogenous variables. . In this paper our focus is on the monetary policy shock, mortgage shocks and house price shock. Beside the regime dependent impulse responses obtained from the MS-VAR model impulse responses from a linear VAR model are also displayed in Figure 2.

4.2.1 Monetary policy shocks

Firstly, we examine negative monetary policy shocks on GDP, house prices and on mortgage lending. Monetary policy shocks are presented in Figure 2A. The first row displays monetary policy shocks on GDP. After a 100 basis points decrease in Treasury bill rate GDP starts to increase and reaches a maximum of close to 0.594 percent after three quarters and then slowly moves toward the steady state. Compared to this in recessionary state magnitude of the shock is lower, reaching a maximum of 0.20 percent after eight quarters. Secondly, we focus on the response of house prices to a decrease in T-bill rate. After a decrease in Treasury bill rate house prices rise more sharply and the magnitude of the shock is larger during the expansionary regime compared to the recessionary period. In the expansionary periods after a 100 basis points decrease in T-bill rate house prices start to increase and reaches a maximum of 0.590 percent after three quarters where as in recessionary state house prices reach to a maximum of about 0.453 percent after two quarters. Moreover, the persistence of the shock is stronger in the expansionary regime. Negative monetary policy shocks on mortgage lending are presented in final row of figure 2A. The response on a 100 basis point decrease in Treasury bill rate leads to an increase in mortgage lending in both the regimes. However, magnitude of the shock is dissimilar between the regimes. In the expansionary period two quarter after interest rate decrease mortgage lending reaches to a maximum of near 0.0175 percentages where as in recessionary state the maximum magnitude of the shock is only about 0.001 percent after nine quarters.

4.2.2 House price shocks

Negative shocks of house prices on GDP, T-bill rate and mortgage lending are presented in figure 2B. House price shocks on GDP are presented in the first row. After a one percent decrease in house prices GDP decreases in both the states. However, the magnitude of the shock is large in the recessionary state than in the expansionary state (-0.151 percent in recessionary state compared to -0.018 percent in expansionary state). The second row of figure 2B presents the house price shocks on T-bill rate. During expansionary period a one percent decrease in house price leads to only 0.081 percent decrease in T-bill rate. Compared to this in recession a one percent decrease in house prices decreases T-bill rate by 0.243 percent. Row three displays the house price adjustments after a negative a house price shock. The adjustment process is slower in the recessionary regime compared to expansionary one which displays the loss aversion behavior of the economic agents in the real estate market during the recessionary periods. The final row in figure 2B represents the response of mortgage lending to house price shocks. After a decrease in house prices mortgage lending decreases in both the states however mortgage lending reverts back to the steady state considerably faster in the expansionary state.

4.2.3 Mortgage lending shocks.

The first row of figure 2C displays the response of negative credit shocks on GDP. During expansion period a one percent decrease in mortgage lending decreases GDP by a maximum of 0.452 percent after two quarters. On the contrary, a negative mortgage lending shock in recessionary regime decreases GDP by more than 1.456 percent after two quarters. Moreover, the mean revision process of this shock in recessionary state is slow compared to in the expansionary state. Mortgage lending shocks on house price are presented in third row. In expansionary regime a one percent decrease in mortgage lending leads to maximum of 2.336 percent decrease in house prices three quarters after the shock. Contrary to this during recession a one percent decrease in mortgage leading leads to a maximum of 13.343 percent decrease in real house price after two quarters. Comparisons of the two shocks also reveal that persistence is much higher in the recessionary state. Finally, the last row of figure 2C displays the response of mortgage lending to its own negative shocks. Comparisons of the shocks show during recessionary state the shock is more persistent as it takes more time to mean revert.

5. Conclusion

This paper employing a four variable MS-VAR and regime-dependent IRF proposed by Eharmman *et al*. (2003) investigates whether the impact of the traditional monetary policy on UK house prices is asymmetric in nature over the business cycle during the period of 1980 to 2012. In doing the paper also examine asymmetric impact of monetary policy on GDP and mortgage lending. Moreover, feedback shocks of house prices are also examined.

Impulse responses obtained from our MS-VAR model display tradition monetary policy in UK, proxied by Treasury bill rate has asymmetric impacts on house prices. Impulse response functions display that expansionary monetary policy shocks have lesser influence on output, house prices and mortgage lending during recessionary periods compared to similar shocks during economic expansions. House prices shocks also exhibit asymmetric impact on the other variables at different stages of business cycle. Negative house price shocks have larger effects on output during recessionary regime. Negative house price shocks on mortgage lending are also more persistent under recessionary periods. Furthermore, reaction of Treasury bill rate to negative house price shock is much larger in recessionary times compared to expansionary periods. Negative mortgage lending shocks on house prices and output are significantly larger and more persistent in recessions than in expansionary periods.

The lesser effectiveness of tradition monetary policy in simulating GDP growth, house prices and lending during recession and the larger and more persistent negative shocks of house prices on GDP and mortgage lending during recessions can be attributable to high asymmetric information problems, financial constraints in both banks and households and also due to high levels of uncertainty that exist during recessionary periods.

Finally, we conclude the study by stating that the purpose of this paper was to examine whether traditional monetary policy instruments had asymmetric effects on UK house price during boom and bust periods and it was not our objective to evaluate whether monetary policy was effective or ineffective. Although we find significant evidence of lesser effectiveness of traditional expansionary monetary policy during recessions it would be wrong to state that traditional monetary policy is entirely ineffective as our study only compares the outcome of similar magnitude shocks across regimes. In reality monetary policy authorities usually cut interests more in recessions and this also creates further research scopes to fully examine the effectiveness of monetary policy.

Reference

Aoki, K., Proudman J. and Vileghe, G., (2004). House as collateral: has the link between house prices and consumption in the UK changed? Fed. Reserve Bnak New York Economic Policy Review. Vol. 8(1), pp. 163-177.

Aoki, K., Proudman J. and Vileghe, G., (2004). House prices, consumption and monetary policy: a financial accelerator approach. *Journal of Financial Intermediation*, vol. 13, pp. 414-435.

Bernanke, B. S., and Gertler. M. (1989). Agency costs, net worth and business fluctuations. *American Economic Review*, vol 79(1), pp. 705-744.

Chen, N., Chou, Y. and Wu. J. (2013). Credit constraints and the asymmetric monetary policy effects on house prices. *Pacific Economic Review*, vol. 18(4), pp. 431-455

Dobrynskaya, V. (2008). Reference-dependent preferences, loss aversion and asymmetric price rigidity. Working paper Centre for Advanced Studies Russia, Moscow.

Ehrmann, M., Ellison. M. and Valla. N. (2001). Regime dependent impulse response functions in a Markov-Switching vector auto regression model. *Economic Letters*, vol. 78, pp. 295-299.

Elbourne, A. (2008). The housing market and the monetary policy transmission mechanism: An SVAR approach. *Journal of Housing Economics*, vol. 17, pp. 65-87.

Goodhart, C. and Hofmann, B. (2008). House prices, money, credit and the macroeconomy, European Central Bank working paper series no. 888.

Hendry, D. F. (1984). Econometric modelling of house prices in the United Kingdom. Econometrics and Quantitative Economics. Basil Blackwell, Oxford, pp.135-172.

Iaccoviello, M., Minetti. R. (2008). The credit channel of monetary policy, evidence of housing market. *Journal of Macroeconomics*, vol. 30, pp. 69-99.

Illes, A. and Lombardi, M. (2013). Interest rate pass through since the financial crisis. BIS Quarterly Review, September, 2013.

Lo, M. C. and Piger, J. (2005). Is the response of output to monetary policy asymmetric? Evidence from regime-switching coefficient model. *Journal of Money, Credit and Banking*, vol37(5), pp. 865-86.

Maclennan, D., Muellbauer, J., Stephens, M. (2000). Asymmetries in housing and financial market institutions and EMU. *Oxford Review of Economic Policy*, vol. 30, pp. 54-88.

Malpezzi, S. and Maclennan, D. (2001). The long run price elasticity of supply of new residential constructions in the United States and the United Kingdom. *Journal of Housing Economics*, vol. 10, pp 278-306.

Milcheva, S. (2013). A bank lending channel or a credit supply shock. *Journal of Macroeconomic*s, vol. 37, pp. 314-332.

Meen, G. (1990). The removal of mortgage market constarints and the implication for econometric modelling of the UK house prices. *Oxford Bulletin of Economics and Statistics*, vol. 52, pp. 1-24.

Muellbauer, J. and Murphy, A. (1997). Boom and busts in the UK housing market, *The Economic Journal*, vol. 107 no. 445, pp1701-1727.

Musso, A., Neri, S. and Stracca, L. (2011). Housing consumption and monetary policy how different are the US and euro area? *Journal of Banking and Finance,* vol. (35), pp. 3019-3014.

Kahnemann, D., Tversky, A. (1979). Prospect theory: an analysis of decision under risk. Econommetrica, vol. 46, pp. 171-185

Kiyotaki, N. and Moore, J. (1997). Credit cycles. *Journal of Political Economy,* vol. 105(2), pp. 211-248

Koop. G., Pesaran, M. H. and Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, vol. 74, pp 119-147.

Krolzig, H. M. (1997). Markov switching vector autoregression modelling, Stastical inference and application to business cycle Analysis. Lecture notes in Economics and mathematical systems no. 454. Berlin: Springer-Verlag

Simo-Kengne. D. B., Balcilar. M., Gupta, R., Reid, M. and Aye. G. (2013). Is the relationship between monetary policy and house prices asymmetric across bull and bear markets in South Africa? Evidence from a Markov-switching vector autoregression model. *Economic Modelling*, vol. 32, pp. 161-171.

Simpson, P. W., Osborn, D. R., and Sensier, M. (2001). Modelling Business Cycle Movements in the UK Economy, *Economica*, vol. 68, pp. 243–67.

Smets, F. and Peersman, G. (2001). Are the effects of monetary policy in the euro area greater in recessions than in booms? European Central Bank working paper series no. 052.

Tsai, I. (2013). Asymmetric impacts of monetary policy on house prices: A viewpoint of house price rigidity. *Economic modelling*, vol.31, pp. 405-413.

Tenreyro, S. and Thwaites, G. (2013). Pushing a string: US monetary policy is less powerful in recession. Centre for Economic Performance, LSE discussion paper.

Table 1: Hansen (1992) stability test

	Δgdp	$\Delta tbill$	Δhp	Δl
Joint	1.00**	2.673***	1.814**	1.62**
Variance	0.461**	2.406***	0.274*	0.1042
Constant	0.51	0.030	0.077	0.875***
AR(1) term	0.50	0.066	0.70	0.235

Note: ***, **, * indicates significance level at 1%, 5% and 10% level respectively.

Table 2: Andrew-Ploberger linearity test with approximated Asymptotic P values

Equation	Andrews-Quandt test	Andrews-Ploberger test
Δgdp	17.842 (0.027)	6.758 (0.011)
$\Delta tbill$	22.6637 (0.004)	7.621 (0.005)
Δhp	15.200 (0.073)	5.334 (0.042)
Δl	18.225 (0.023)	6.286 (0.017)

Note: The tests are performed on each of equation of a linear VAR. Approximated Asymptotic P values obtained from Hansen (1997) is presented in ().

Table 3: MS-VAR results

	Δgdp_t	$\Delta tbill_t$	Δhp_t	Δl_t
		Regime 1		
Constant	0.386***	-0.133*	-0.051	-0.008*
Δgdp_{t-1}	0.407***	-0.081	0.305	0.016*
$\Delta tbill_{t-1}$	-0.049	0.222**	-0.705***	-0.017***
Δhp_{t-1}	0.357*	0.078**	0.625***	0.011*
Δl_{t-1}	0.452	-0.360	1.985	0.353***
$variance$	0.242***	0.297***	2.758***	0.003***
		Regime 2		
Constant	-0.136	0.343	-0.012	-0.001
Δgdp_{t-1}	-0.347*	0.117	-0.610*	0.002
$\Delta tbill_{t-1}$	0.039	-0.136*	-0.186	-0.002*
Δhp_{t-1}	0.105*	0.218***	0.483***	0.004*
Δl_{t-1}	0.145*	0.425	13.34	0.059**
$variance$	1.338***	0.873	6.660**	0.943**

Note: ***,**,* represents significance at 1%, 5% and 10 % respectively

Table 4: Wald test results

Equation 1	
$constant_1 - constant_2$	0.522*
$\Delta gdp_{t-1,1} - \Delta gdp_{t-1,2}$	0.754*
$\Delta tbill_{t-1,1} - \Delta tbill_{t-1,2}$	-0.088
$\Delta hp_{t-1,1} - \Delta hp_{t-1,2}$	0.252*
$\Delta l_{t-1,1} - \Delta l_{t-1,2}$	-0.307**
$variance_1 - variance_2$	-1.096***
Equation 2	
$constant_1 - constant_2$	-0.476**
$\Delta gdp_{t-1,1} - \Delta gdp_{t-1,2}$	0.198
$\Delta tbill_{t-1,1} - \Delta tbill_{t-1,2}$	0.358*
$\Delta hp_{t-1,1} - \Delta hp_{t-1,2}$	-0.140**
$\Delta l_{t-1,1} - \Delta l_{t-1,2}$	-0.785
$variance_1 - variance_2$	-0.575**
Equation 3	
$constant_1 - constant_2$	-0.040
$\Delta gdp_{t-1,1} - \Delta gdp_{t-1,2}$	0.915*
$\Delta tbill_{t-1,1} - \Delta tbill_{t-1,2}$	-0.519
$\Delta hp_{t-1,1} - \Delta hp_{t-1,2}$	0.142*
$\Delta l_{t-1,1} - \Delta l_{t-1,2}$	--3.087
$variance_1 - variance_2$	-3.901**
Equation 4	
$constant_1 - constant_2$	0.007*
$\Delta gdp_{t-1,1} - \Delta gdp_{t-1,2}$	0.014*
$\Delta tbill_{t-1,1} - \Delta tbill_{t-1,2}$	-0.015
$\Delta hp_{t-1,1} - \Delta hp_{t-1,2}$	0.007**
$\Delta l_{t-1,1} - \Delta l_{t-1,2}$	0.332**
$variance_1 - variance_2$	0.001**

Note: ***,**,* represents significance at 1%, 5% and 10 % respectively

Figure 1A: High GDP growth and low volatility regime (regime one) smooth probability

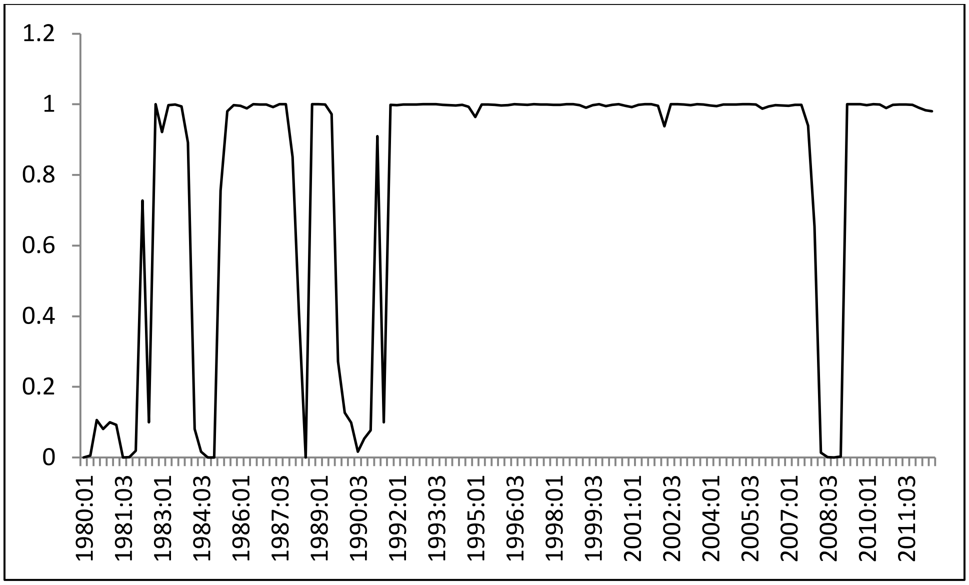


Figure 1B: **UK GDP growth rate data**

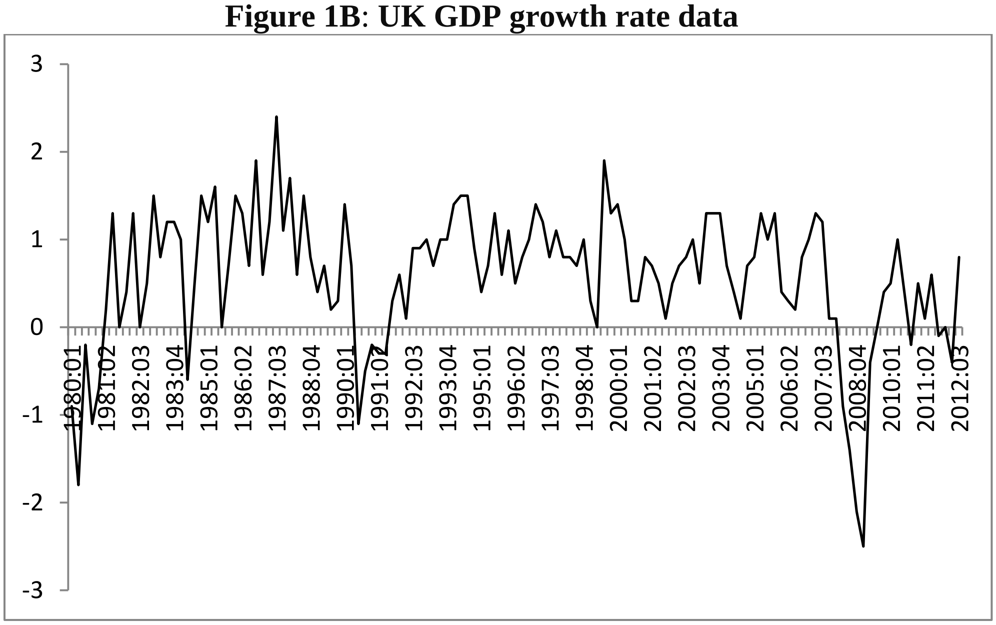
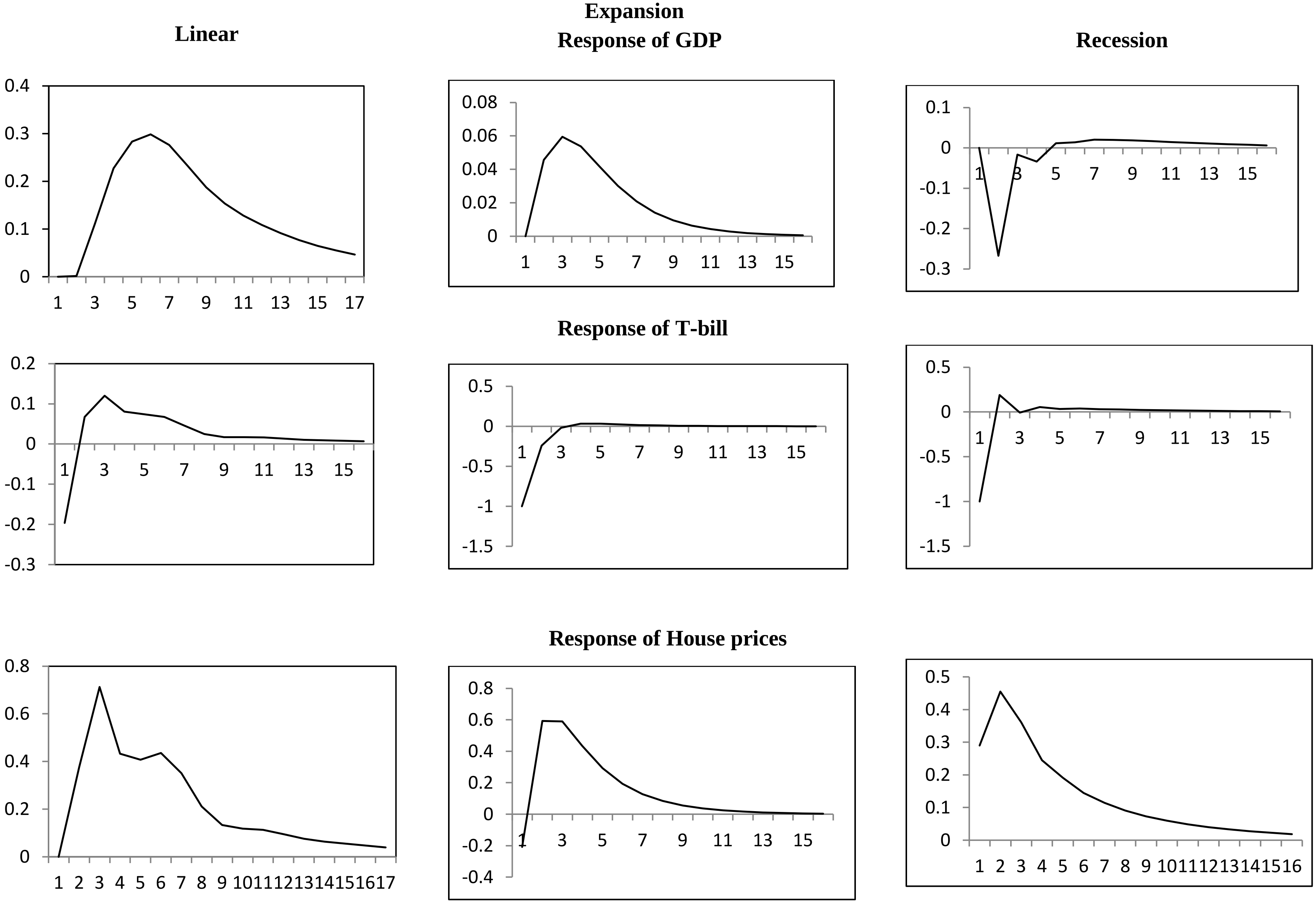


Figure2A: Impulse of negative interest rate shock



Response of Mortgage lending

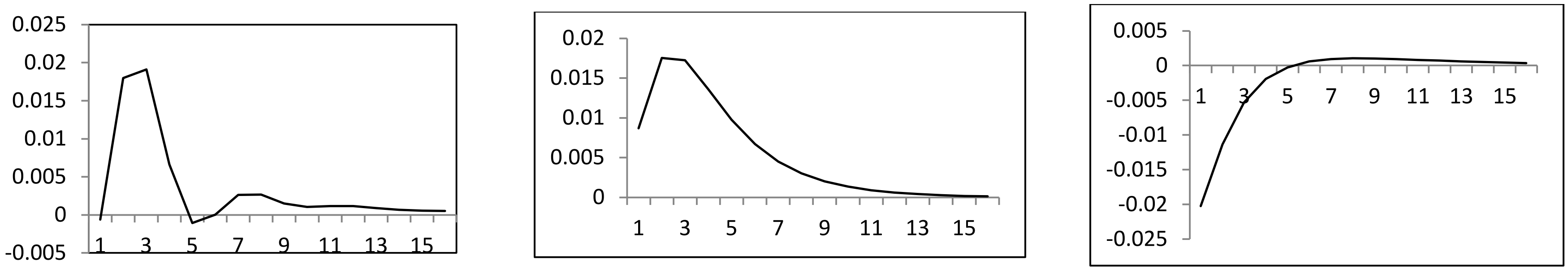
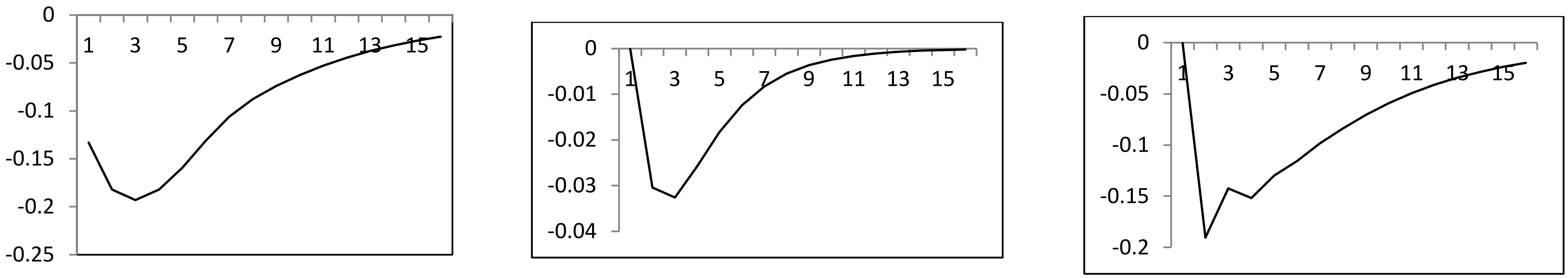
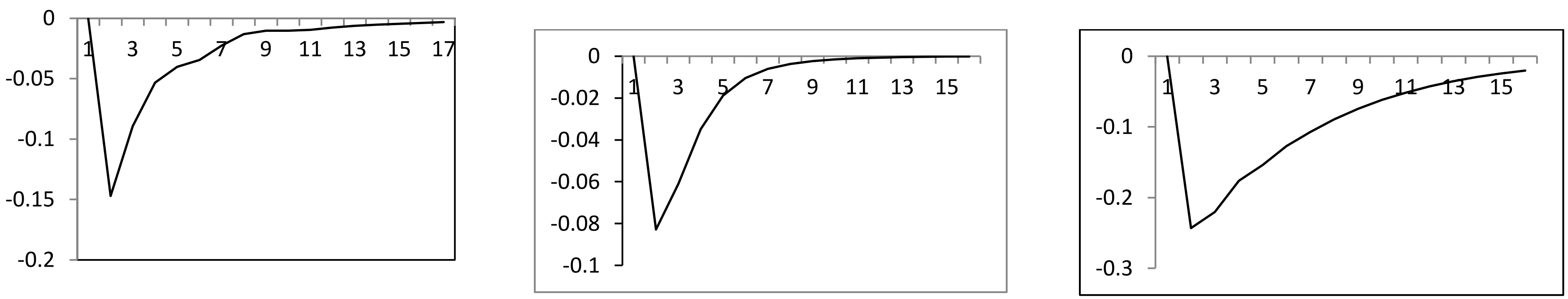


Figure 2B: Impulse of negative house price shock

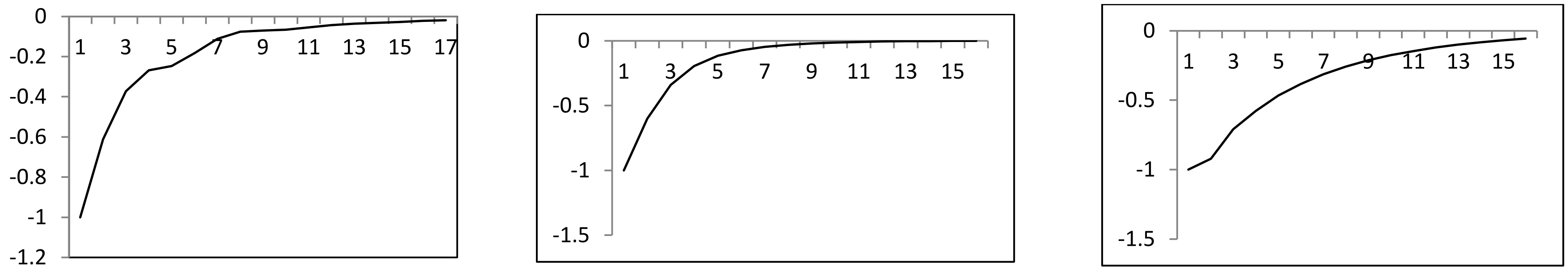
Response of GDP



Response of T-bill



Response of House prices



Response of mortgage lending

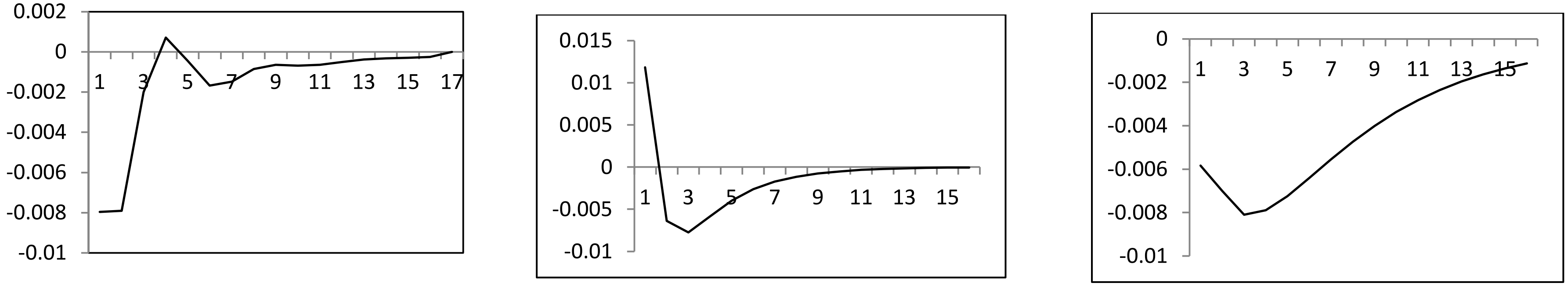
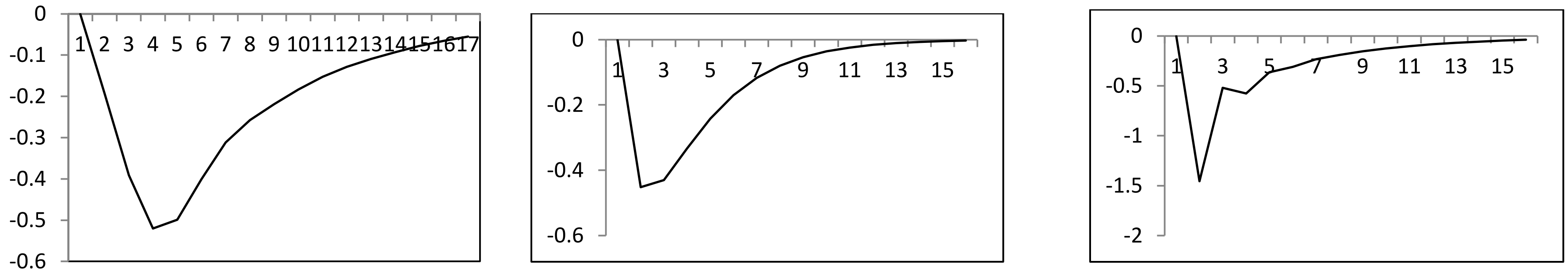
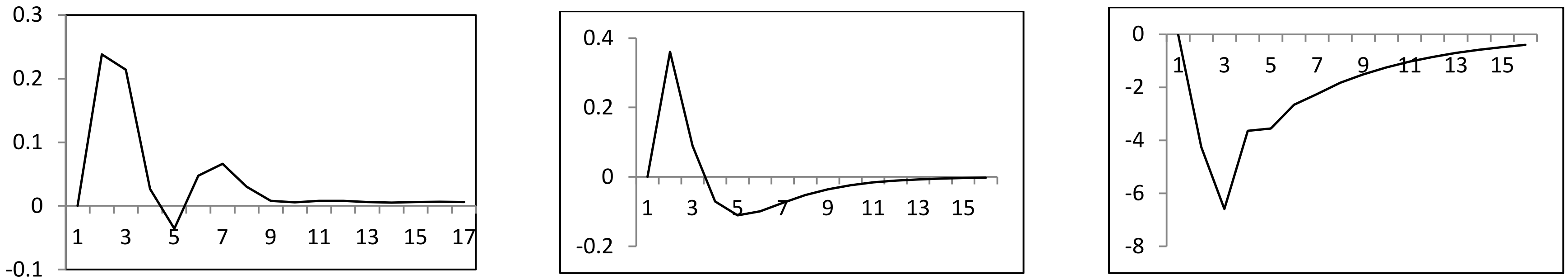


Figure 2C: Impulse of negative mortgage shock

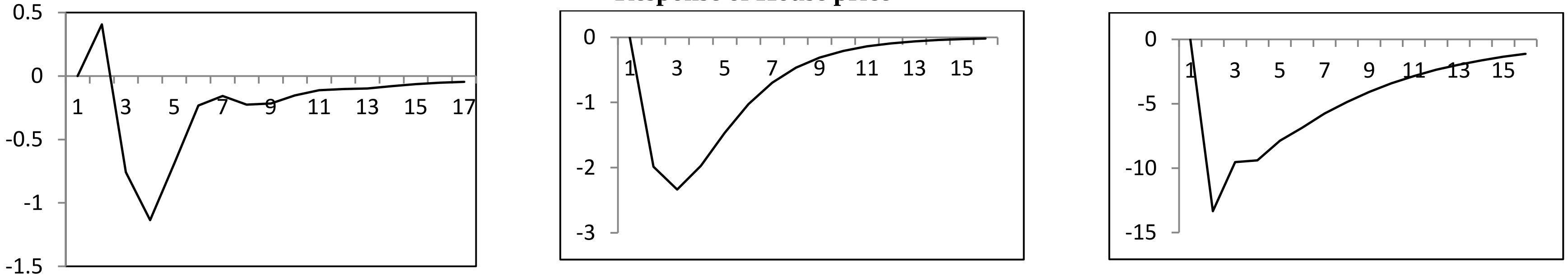
Response of GDP



Response of T-bill rate



Response of House price



Response of Mortgage lending