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The Effects of The Key Policy Rate on House Prices and Banks' Mortgage Lending: Evidence from Norway Using a Structural VAR Model

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Preface

This master thesis is written in the spring of 2019 as the end of a two-year Master's Program in Business at Nord University with specialization of Finance and Capital Budgeting. The choice of the topic is justified by my interest in investigating the key policy rate changes undertaken by Norwegian Central Bank on house prices and banks` mortgage lending. Working with this topic required an in-depth knowledge about economic concepts and econometrical analytical tools that are not devoted much time during the macroeconomics and econometrics courses at Nord University Business School.

The structural VAR model is used as an analytical tool to answer the research questions as it is considered the most common tool to analyze the effect of monetary policy shocks on economic variables. The writing process around the chosen topic has contributed to increasing my experience regarding the use of dynamic multivariate time series analysis in macroeconomic modeling for monetary policy transmission mechanism, in addition to the use of Gretl to perform the required data analysis.

This thesis is written in a monograph-based format that includes five chapters and a conclusion. The first chapter gives a brief introduction that includes the motives and objective of the work. The second Chapter provides a theoretical framework, while the third one reviews the previous empirical related studies. The fourth chapter explains the data construction and the methodology, while the last one discusses the empirical result of the study.

Highlights

• This research examines the effects of the key policy rate changes in Norway on house prices and banks` mortgage lending.

• A shock in the key policy rate has a negative impact on the banks` mortgage volume.

• A shock in the key policy rate has a negative impact on house prices

• A shock in house prices has a negative impact on banks' mortgage volume.

• The response of the banks` mortgage volume is stronger to a shock in the key policy rate than to a shock in house prices.

Abstract

This paper examines the responses of house prices and Mortgage volume to the key policy rate changes in Norway. The results from a structural VAR model with Cholesky identification scheme of zero short run-restriction used in this paper show that a positive shock in the key policy rate reduces house prices in the short-run and banks` mortgage lending gradually in the long-run. However, the response of house prices varies depending on the location and type of houses. The response is stronger for Oslo and Akershus than the whole country, and stronger for multi-dwellings than detached houses. Moreover, a positive shock in house prices, reduces banks` mortgage lending gradually in both short and long-run. However, the response of banks` mortgage lending is much stronger in the long-run to a shock in the key policy rate than to a shock in house prices. Hence, the banks' mortgage lending is expected to keep increasing in 2019 and decline gradually thereafter.

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Keywords: Structural VAR; key Policy Rate; House Prices; Mortgage Lending

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Chapter 1. Introduction

1.1. Overview

The Central Bank key policy rate is defined according to Norwegian Central Bank as "the interest rate banks receive on deposits up to their individual quotas in Norges Bank, also referred to as the sight deposit rate." (Norges Bank, 2019). This interest rate is considered the most important rate in the Norwegian banking system and one of the most effective conventional tools through which the Central Bank exercises its monetary policy and affects the cost and volume of lending and thus the credit cycle, business cycle, and economic activities.

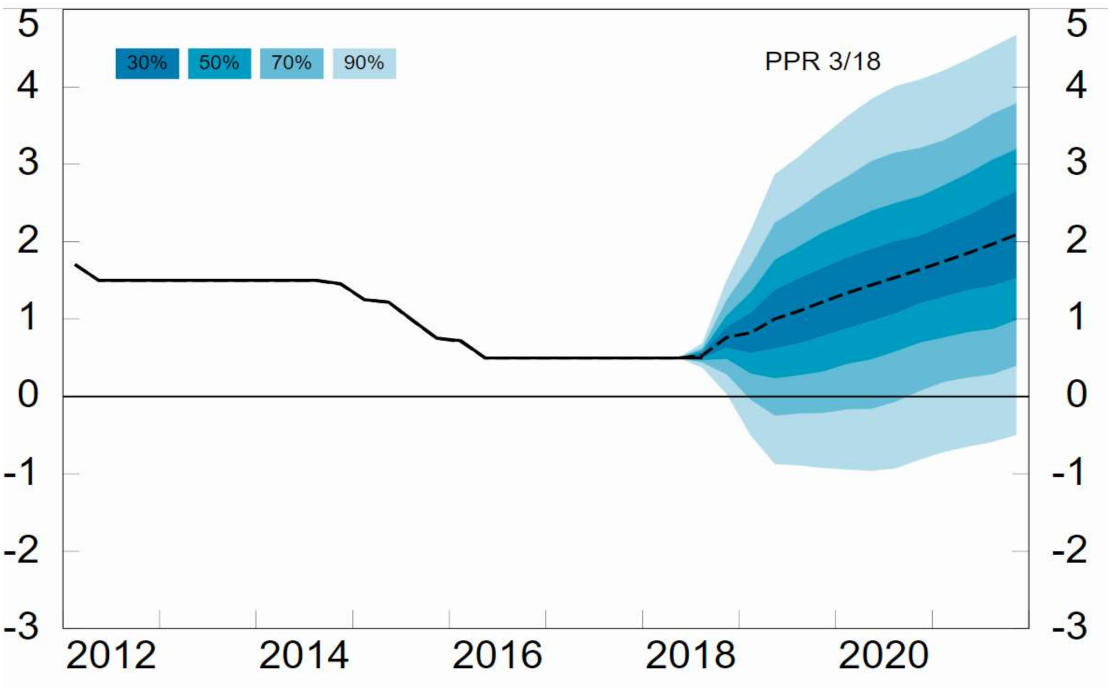
"It is generally believed that changes in the policy rate and money market rates can be transmitted into the retail bank interest rate (e.g., deposit rate and loan rate), which can ultimately influence the opportunity costs of consumption and investment and hence the aggregate demand and output." (Xu, Han and Yang 2012, p 461). Hence, when the Central Bank increases the monetary policy rate, this raises up the burden on households and companies and thus affects both demand and supply in the real economy. "The process by which monetary policy actions influence interest rates varies somewhat for different types of loans and securities. In the case of bank loans to businesses and consumers, for example, the effects of monetary policy are relatively straightforward. Changes in monetary policy affect the supply of bank reserves and the cost of bank funds, and banks tend to pass on these cost changes to loan rates" (Sellon 2002, p 7). Moreover, Gregor and Martin (2018) point out that the pass-through of the monetary policy rate to retails rates may vary at different levels of bank competition, bank leverage, borrower credit risk, foreign exchange intervention and spread between the government bond yield and the monetary policy rate.

The effect of interest rates changes on the total consumption in the real economy depends on the households' debt. According to Gerdrup and Kjersti (2018, p 1), "debt in Norway has risen substantially over the past 15-20 years relative to both disposable income and bank deposits. An increase in interest rates will, therefore, reduce disposable income for Norwegian households more than previously". The high households' debt in Norway as Solheim and Vatne (2018) mentioned is closely associated with the financing of home purchases and has long been cited as a financial stability risk. Hence, the influence of Norges Bank key policy rate changes on mortgage lending can be considered as a crucial factor for financial stability. The impact of households` disposable income changes on total savings and consumption varies with the consumption propensity. This means that the impact of interest rate changes on house prices and mortgage lending depends not only on the interest rate change itself, but also on how households react toward this change. Additionally, the change in house prices may affect household consumption propensity. Lower house prices mean that people who want to buy houses need to save less. This may motivate them to increase their consumption and take loans, although the cost of the loans is higher as the access to the loans becomes easier.

1.2. Motivations of the study

The Norwegian Central Bank raised its key policy rate on September 20th, 2018, for the first time in seven years, from 0.5 percent to 0.75 percent. Moreover, the Norwegian Central Bank stated that it is planning to continue increasing the current policy rate from 0.75 to 2 percent by 2022.

Figure.1: Key policy rate changes



Source: https://www.norges-bank.no/en/Monetary-policy/Key-policy-rate/

These planned increases would influence banks' deposit and lending rates given that other macroeconomic and financial factors are unchanged. This would affect the bank's mortgage supply and demand. Additionally, the increase in key policy rate would have ,as previously discussed, an impact on households disposable income and house prices. Gerdrup and Kjersti (2018) mention that in 2004, one percent increase in Norwegian deposit and lending rates would have reduced household disposable income by 0.6 percent. Meanwhile, a similar increase in 2015 would have reduced household disposable income by 1 percent. A change in households' disposable income would change both the households' consumption and savings and as a result, housing demand and house prices. Hence, this research which is motivated by the importance of monetary policy transmission mechanism in financial stability, tries to investigate what impacts the adopted key policy rate changes would have on house prices and banks' mortgage lending.

1.3. Problem Statement:

Changing the Central Bank key policy rate means driving the monetary policy toward more tightening or lean. When the Central Bank policy rate increases, this increases the interest rate on overnight loans between banks and thus lending and deposit rates. Banks usually pass through the increased cost to retail rates, including mortgage rate. Hence, the mortgage demand and supply may decrease as mortgages would become more expensive for the lender, and riskier and less profitable for mortgage suppliers. Moreover, the increase in Mortgage rate may increase house prices by increasing the user cost of capital. This would affect the volume of mortgage lending positively by increasing households' wealth. However, the impact of interest rate on households' wealth and households' disposable income would be positive if the households' deposits are higher than households' lending and negative otherwise. Moreover, the impact of disposable income changes on mortgage lending depends on its influence on saving and consumption that depends, in turn, on households' consumption propensity. The change in house prices may affect the households' consumption propensity since it affects mortgage credit accessibility. Low house prices may encourage people who want to buy houses to increase their consumption by taking loans to finance their purchase of houses, although the cost of these loans is higher as it becomes more accessible. However, higher house price will not necessarily lower the mortgage lending volume since the households could compensate for the higher saving requirements by decreasing their consumption propensity. The previous discussion makes a theoretical basis to investigate the multidirectional relations between the key policy rate, house prices, and banks' mortgage lending in order to determine the impact of the key policy rate changes on house prices and banks' mortgage lending.

1.4. Objectives of the study:

The main objective of this research is to examine the impact of key policy rate changes on house prices and banks, mortgage lending. This impact can be determined in light of a group of interrelations on the macroeconomic level, where interaction between the key policy rate and banks' mortgage lending plays an important role. Answering the following research questions is relevant in achieving this objective:

What effect do changes in key policy rate have on house prices?

What effect do changes in key policy rate have on mortgage volume?

What effect do changes in house prices have on mortgage volume?

1.5. Significance of the study:

The importance of investigating the influence of Norway's key policy rate changes on banks' mortgage lending comes from the fact that mortgages are the largest component in Norwegian banks' loans portfolio, and it affects the real state sector since the price of mortgage considers a crucial factor when one wants to make decisions related to building and constructions activities. Hence, the changes in mortgage volume may affect the real economic activity and growth of the gross domestic product. On the other hand, house prices are considered according to many economists a very important factor in monetary transmission mechanism and financial stability. Furthermore, houses are considered, as Bjørnland and Jacobsen (2010) mentioned, essential assets for households in industrialized countries because it has a dual role of being both a store of wealth and a durable consumption good. Thus, a shock in house prices may affect the wealth of homeowners. When house prices increase, the value of the collateral will rise, and consequently, the availability of credit for borrowing-constrained agents will increase, and housing construction may be simulated. Hence total shock to house prices may affect real growth and ultimately, consumer prices.

The significance of this study emerges from that it is one of few studies that use a structural VAR model to investigate the impact of monetary policy on house prices in Norway. Additionally, it uses banks' mortgage lending as an indigenous credit variable in the structural VAR model to identify the effect of the key policy rate on the mortgage lending. Moreover, it examines whether the impact of key policy rate on house prices varies depending on the location and the type of houses.

Chapter 2. Theoretical framework

The monetary policy transmission mechanism is one of the most popular concepts in economics, and it refers to the mechanism by which the monetary policy affects other macroeconomic variables. A pure money version of the monetary transmission, according to Kashyap and C. Stein (1994) implies that a decrease in reserves reduces the banking sector's ability to issue demand deposits. Most macroeconomics textbooks include detailed clarifications and discussions about how monetary policymakers use the short-term interest rate as an instrument to influence the cost of capital and consequently spending, investment, and housing. The main instrument that Norwegian Central Bank (Norges Bank) uses to influence the short-term interest rate is the interest rate on banks' deposits up to a certain quota in Norges Bank. According to the Norges Bank website, this rate is set with a view to stabilizing the inflation rate close to the target in the medium term. The key policy rate changes influence the inter-day market interest rate through its impact on liquidity demand and supply curves. This impact can vary depending on the liquidity management system that is used by Central Banks. This chapter briefly overviews liquidity management systems in light of Bernhardsen and Kloster (2010).

2.1. Liquidity Management Systems:

Most macroeconomic textbooks classify liquidity management systems into the floor system and the corridor system.

<u>Floor system:</u>

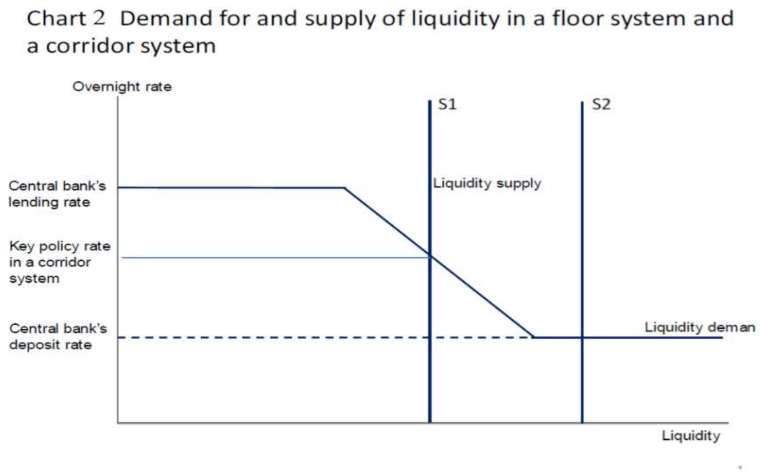
In the floor system, the Central Bank sets a key policy rate tha is equal to its deposit rate and then provides the banking system with so much liquidity that the overnight interest rate approaches its deposit rate. This implies that the Central Bank uses the interest rate and the amount of liquidity provided to the banking system as two independent tools to implement its monetary policy. The main advantage of the floor system is that the Central Bank can increase the supply of liquidity in the banking system without pushing short-term market rates below the key rate. The amount of the liquidity supplied is determined in light of the required amount of money for clearing purposes. This amount varies with requirement reserve changes. In the floor system, banks do not have good incentives to trade reserve balance with each other since the liquidity in the market is supplied at a rate only slightly higher than the Central Bank's deposit rate. Hence, it is neither much costlier to deficit banks to borrow money from the Central Bank, nor much less profitable for the surplus banks to use the Central Bank`s deposit facility. This means that almost any changes in the Central Bank key policy rate would have a significant influence on the liquidity short-term market equilibrium.

<u>Corridor system:</u>

In the corridor system, the Central Bank sets first the rate on banks` deposit and the rate of its banks` lending. And then it provides the banking system with so much liquidity that the overnight interest rate becomes higher than the Central Bank's deposit rate and lower than the Central Bank's lending rate. The main advantage of this system is that banks will have a stronger incentive to trade reserve balances with each other than in a floor system. Banks with a deficit in their balance after clearing settlement can either use Central Bank facility or borrow money from banks that have liquidity surplus.

Similarly, banks with liquidity surplus can either lend money to other banks or deposit the surplus in the Central Bank. In the corridor system, surplus banks prefer to lend money in the market to other banks rather than using Central Bank facility because it is more profitable since the Central Bank`s deposit rate is lower than the market rate. Meanwhile, deficit banks prefer to borrow money from the surplus banks rather than using Central Bank facility because it is cheaper since the Central Bank`s lending rate is higher than the market rate. Hence, if surplus banks have enough money to lend deficit bank, no bank will have incentives to use Central Bank facility. This means that changes in the Central Bank rates would have no influence on the market equilibrium unless these changes imply that Central Bank`s lending rate would become lower than the current market rate or Central Bank`s deposit rate would become higher than the current market rate.

Figure.2: Demand and supply for liquidity in the floor and corridor systems



Source: (Bernhardsen and Kloster, 2010, p 6).

As it appears, in the figure the provided liquidity by the Central Bank to the banking system in the corridor system, S1 equals what banks need for clearing purposes. Meanwhile, the provided liquidity by the Central Bank in the floor system S2 equals the amount of liquidity that is needed to be provided to make the market rate equal to Central Banks' deposit rate. Hence the key policy rate in the corridor system differs from the key policy rate in the floor system. The key policy rate in the floor system equals the Central Bank's deposit rate. However, the Central Bank in both systems influences the short-term interest rate by controlling the supply of liquidity in the short-term liquidity market. Hence, the effectiveness of the key policy rate as an instrument by which Central Bank can implement its monetary policy depends highly on the Central Bank's ability to control the supply of liquidity in the short-term liquidity market.

The liquidity management system in Norway:

Norges Bank uses an adjusted floor system where the key policy rate is the interest rate on banks' deposits up to their individual quotas in Norges Bank. The interest rate on bank's deposits over their individual quotas in Norges Bank is one percent under the key policy rate, while the Central Bank's lending rate is one present over the key policy rate. Hence the Norwegian liquidity management system combines corridor and floor systems. In the Norwegian monetary system, there is no reserve requirement, although banks need liquidity for the inter-day activities with each other. At the end of each day, banks with liquidity deficit try to borrow money from banks with liquidity surplus. Banks with a liquidity deficit will borrow from the Central Bank only if they cannot cover their deficit by borrowing in the inter-market since the Central Bank's lending rate is higher than the market rate for lending. For banks, there is no significant difference between lending their surplus reserves to other banks or deposit these reserves in the Central Bank as they do not exceed their individual quotas. However, it is more profitable to lend the surplus reserve over the banks' individual quota to the other banks with liquidity deficit in the liquidity inter-day market.

2.2 The pass-through of Central Bank key policy rate to lending rate:

As it has discussed previously, the Central Bank plays an essential role in determining the short-term interest rates by controlling the supply of liquidity in the short-term liquidity market using one of the liquidity management systems. Hence, it is expected that the Central Bank would be able to use its key policy rate as an instrument to influence the cost of capital and consequently spending, investment, and housing. However, this influence depends on the pass-through of the Central Bank key policy rate to lending rates. The main research objective is to examine what effects have the key policy rate on mortgage lending. Thus, the scope of theoretical discussion of the pass-through of the key policy rate to lending rates will be focused only on the pass-through of the key policy rate to the mortgage rate.

The monetary policy literature includes several studies and researches that discussed the pass-through of the key policy rate to lending rates. Rousseas (1985), as cited in (Gregor and Martin, 2018, p 72), "proposed a simple theoretical model for interest rate pass-through based on the marginal cost theory. Assuming perfect competitive markets, banks' lending rates would change one-to-one with the monetary policy rate". This means that one percent increase in key policy leads to a similar increase in the mortgage rate. This perfect competitive markets assumption seems to be unrealistic for banking and financial structures since these structures, according to Gregor and Martin (2018) shows more monopolistic competitive or even oligopolistic behaviors. Various potential factors may influence the pass-through of the key policy rate to lending. Van Leuvensteijn et al. (2013) and Mojon (2000) investigate the pass-through of the monetary policy rate to lending rate using different measures of bank competition. According to their findings, the pass-through at higher levels of bank competition is faster and more complete. Additionally, Gregor (2018, p 73) cited that "Cottarelli and Kourelis (1994), Mester and Saunders (1995), Mojon (2000), Bondt (2005) point also to other market factors distorting the pass-through such as the non-elastic loan demand, as well as the existence of asymmetric information, menu costs, and switching costs". Hence, it can be concluded that the direct influence of the key policy rate changes on mortgage rate depends on several factors such as the level of competition between banks, elasticity of mortgage demand, the existence of asymmetric information and the switching cost. Garriga, Kydland, and Šustek (2013) classifies mortgage lending into an adjustable- rate mortgage (ARM) and fixed- rate mortgage (FRM) and argues that the real effect of the monetary policy varies depending on whether the mortgage is (ARM) or (FRM). Garriga (2013) points out that monetary policy affects housing investment more under ARM than under FRM. Garriga (2013) finding goes in line with Calza (2007) empirical findings that imply a stronger impact of monetary policy shock under flexible mortgage markets since the path-through of key policy rate changes would be stronger in such markets.

2.3 The effect of key policy rate changes on house prices:

The impact of housing wealth on economic activity is recently considered by many raesearchers and policy makers as an attractive research area. The effect of key policy rate on house prices has an important role in determining the effect of the key policy rate on mortgage volume due to the interrelation between house prices and mortgage volume.

According to Mishkin (2007), monetary policy affects the housing market directly through interest rate effects on the user cost of capital, expectations of future house prices movements, and housing supply; and indirectly through standard wealth effects from house prices, balance sheet and credit-channel effects on consumer spending, and balance sheet and credit-channel effects on housing demand.

Assuming a pass-through of the key policy rate to the mortgage rate, an increase in the key policy rate raises the cost of capital and consequently reduces the housing demand and thus house prices. Similarly, an expected increase in key policy rate raises the expected cost of capital and thus reduces the expected appreciation of house prices. The low expected appreciation of house prices increases the current cost of capital and thus reduces the house prices. Moreover, an increase in the key policy rate, assuming a pass-through of the key policy rate to mortgage rate increases the cost of building new houses and thus reduces the houses supply. Hence, an increase in the key policy rate drives the housing supply and demand curves toward a new equilibrium at a lower level of house prices.

According to Miskin(2007), The impact of the key policy rate changes on household's wealth and disposable income varies depending on household's deposits and debt. An increase in the key policy rate will have a positive impact on a household's wealth and disposable income if household's deposits are larger than the household's debt and negative otherwise. This implies that the impact of an increase in key policy rate would lead to an increase in house prices if household's deposit is stronger than household's debt as it would increase the aggregated demand through the wealth channel of the monetary policy transmission mechanism.

The indirect effect of monetary policy on house prices through balance sheet credit channel effect on both consumer and house demand spending implies that the higher house prices increase the value of the collateral and reduce the asymmetric information problem in the credit market consequently. Asymmetric information problem according to Mishkin(2007, p11) implies that it is difficult for lenders to determine "whether a prospective borrower has the resources to repay the loan and, if the loan is made, whether the borrower will engage in risky behavior that will lower the probability that the loan will be repaid”. The existence of this problem in the credit market may make lenders ask for a higher risk premium that increases mortgage rates. Hence, households will have higher interest payment, higher spending, and saving. Additionally, higher interest payment means a reduction in the current cash flows that reduces, in turn, the housing demand.

2.4 The effect of house price on mortgage volume:

House prices affect mortgage markets indirectly through credit and balance sheet effect on consumer spending. As mentioned previously, the increase in house prices increases the value of potential collateral for house owners and reduces the asymmetric information problem in the credit market since it makes lenders less reluctant to make loans because it reduces the credit risk related to loans repayment. This reduces the gap between the default-free interest rate and effective interest rate facing the homeowner and increases the amount of mortgage credit available for the householder. Basten, Koch (2016,) suggest a causal effect running from house prices to the mortgage market via mortgage demand. They point out that "when house prices have grown faster than household financial wealth, households need to demand larger mortgages as they cannot finance the increased cost for a given size and quality of housing only out of their savings. Besides, amongst households looking at housing as an investment rather than solely as a consumption good, higher current house prices may Furthermore, trigger expectations of prices staying at current levels or increasing even more conditional on their balance sheets and regulatory requirements". Hence, if the inflation rate is so high, the households would demand larger mortgages as they cannot finance the increased cost of buying houses only out of their saving. However, the mortgage' s loan-to-value ratio implies that an increase in house prices requires householders to have more saving to be able to access to a sufficient amount of mortgage credit required to fund their purchases of houses and others real estate properties. This means that the influence of house prices changes on mortgage lending depends on its impact on the household's ability to access mortgage credit not only on its effect on the value of collaterals. Low house prices mean that people who want to buy houses need to save less and this may encourage them to increase their consumption by taking loans to finance their purchase of house although the cost of these loans is higher as these loans become easier to access. However, according to Mishkin (2007), the consumption effect derived from housing wealth could be smaller than that derived from other assets. The decrease in wealth that is derived from a decrease in houses prices due to an increase in the key policy rate is matched by the influence of this increase in the key policy rate on the implicit cost of living in these houses. Hence, housing wealth might have only small effects on consumption.

As mentioned previously, the key policy rate changes have an impact on the household's wealth and disposable income that varies depending on the household gap between households' debt and savings. The impact of disposable income changes on mortgage lending depends on its influence on savings and consumption that depends, in turn, on households' consumption propensity. Moreover, house prices may affect the households' consumption propensity. People who need to buy houses may change their consumption propensity to increase their savings, as a response to house prices increase or disposable income reduction.

Chapter 3. Literature Review

Many empirical studies examine the interrelations between mortgages, house prices, and changes in key policy rate as monetary policy determinants. Bernanke and Gertler (1995) and Mishkin (2007) argue that there is a positive correlation between the key policy rate and mortgage burden raised from the influence of monetary policy rate changes on both nominal interest rate and household income. Aoki, Proudman, and Vlieghe (2004) use a general equilibrium model to investigate the macroeconomic effects of imperfections in credit markets. According to Aoki (2004), an endogenous development in credit markets works to amplify and propagate shocks to the macroeconomy. Moreover, a positive shock to economic activity causes a rise in housing demand, which leads to a rise in house prices. Empirical finding of Aoki (2004), using UK data, implies that shock in monetary that increases the interest rate by 1 % leads to 0.5% to 2 % fall in house prices. Calza (2007) conducts a VAR-based analysis of the effects of monetary policy shocks on consumption and house prices in a sample of euro area countries, in addition to Canada, the U.K. and the U.S and finds a significant heterogeneity in both the timing and strength of those effects across countries. Calza (2007, p 32) provides an empirical evidence in support of three facts: "first, there is significant divergence in the structure of mortgage markets across the main industrialized countries; second, at the business cycle frequency, the correlation between consumption and house prices increases with the degree of flexibility/development of mortgage markets; third, the transmission of monetary policy shocks on consumption and house prices is stronger in countries with more flexible/developed mortgage markets". Calza (2007) points out that the empirical evidence of the study implies that the sensitivity of consumption to monetary policy shocks increases with lower values of the down-payment rate and the mortgage repayment rate and is larger under a variable-rate mortgage structure. In light of Calza (2007) empirical findings, the influence of the tightening monetary policy shock is expected to be stronger under more flexible mortgage markets. Hence, Norges Bank movement toward higher key policy may have a strong influence on consumption and thus on the mortgage rate and volume since the Norwegian mortgage structure are characterized according to Assenmacher-Wesche and Gerlach (2008) as a flexible rate structure with variable interest rate adjustments. Goodhart and Hofmann (2008), uses a fixed-effects panel vector autoregression to assess the links between money, credit, house prices, and economic activity in 17 industrialized countries over the period from 1970-2006. The results of the analysis suggest a significant multidirectional link between house prices, monetary variables, and the macroeconomic variables. Moreover, the empirical findings imply that a 1% tightening shock in monetary policy leads to 2% to 4 % fall in house prices. Assenmacher-Wesche and Gerlach (2008) use single-country VARs and panel VARs models to study the responses of residential property and equity prices, inflation and economic activity to monetary policy shocks in 17 countries, using data span from 1986 to 2006. The results of the study include that the effect of monetary policy on property prices is only about three times as large as its impact on GDP.

Bjørnland and Jacobsen (2010) analyze the role of house prices in monetary policy transmission mechanism in Norway, Sweden, UK, as an example of small open economies, using a structural vector autoregressive analysis with quarterly data from 1983Q1 to 2006Q4. By imposing a combination of short-run and long-run restrictions that allow interdependence between the monetary policy stance and asset price movements, Bjørnland and Jacobsen (2010) find simultaneous responses between monetary policy and house prices. Hence, unexpected changes in interest rates have an immediate effect on house prices in most countries. According to Bjørnland and Jacobsen (2010), a shock in monetary policy that raises the interest rate by one present lead to 2% to 4 % fall in house prices. Moreover, Bjørnland and Jacobsen (2010) find that interest rate also responds systematically to house price shocks; however, the strength and timing of the response vary across countries. Musso, Neri, and Stracca (2011) analyse the effects of monetary policy, credit supply, and housing demand shocks on the housing market in the US and the euro area using a structural VAR model. The result of the analysis suggests a stronger role for housing in the transmission of monetary policy shocks in the US than Europe. The empirical results of Musso (2011) imply that a monetary policy shock that increases the interest rate by 1% percent leads to 1%-3% fall in house prices in the USA. Meanwhile, it leads to 0.5 % to 1.5% fall in house prices in the Euro area. Xu (2012) examines the U.S. monetary policy surprises impact on the mortgage rates in the nation and across five regions from 1990 to 2008 using a combination of even study analysis and two-factor regression analysis based on bootstrapping. The study finds that "surprises in the target federal funds rate (the target factor) have a significantly positive impact on the 1-year adjustable-rate mortgage (ARM) rate within the week of the Federal Open Market Committee announcements and the positive impact lasts up to 1 week after the announcements. Surprises in the future direction of the Federal Reserve monetary policy (the path factor) have significantly positive impacts on both the 1-year ARM rate and the 30-year fixed mortgage rates in the first week after the announcement. Furthermore, the responses of mortgage rates are asymmetric and affected by the size of monetary policy surprises, the stage of the business cycle, and whether the monetary policy is tightening or loosening. There also exists heterogeneity in the mortgage rate pass-through process across regions, and monetary policy surprises have differential impacts on the regional mortgage rates". Patrapanch, M. Doerner, and Asin (2014) examine the relationship between interest rates and mortgage rates and how the Federal Reserve affected them by large-scale asset purchases (LSAP) and its tapering using a combination of event study analysis and vector autoregressive analysis. The event study shows how the 10-year Treasury yield changed after each key LSAP event, including the event dates related to tapering. Meanwhile, the vector autoregressive time series analysis shows how the rates of the daily 30-year fixed- rate mortgages response to the changes in 10-year Treasury yields. Patrapanch, M. Doerner, and Asin (2014) conclude that the U.S. monetary policy after the financial crises could effectively, by using (LSAP), lower long-term interest rates, and mortgage rates. However, any surprises about monetary policy, including but not limited to tapering, may adjust mortgage rates upwards. Patrapanch (2014) focus on (LSAP) as a tool to affect the mortgage rate. Meanwhile, Xu (2012) examines generally the effect of monetary policy shock on the mortgage rate. Shi, Jou, and Tripe (2014) test the effect of bank policy and mortgage rates in New Zealand during the period 1999 – 2009 on real house pricing. Their study provides empirical evidence of house pricing bubble and suggests that the Central Bank could have limited the bubble if it had started to intervene in the housing market prior to 2003. Basten and Koch (2016) use the instrumental -variable methodology to examine the causal effect of house prices on mortgage demand and supply in Switzerland by exploiting exogenous shocks to immigration and thereby to house prices. The result of their research implies that within the same interest rate environment, 1% higher house prices imply 0.52% higher mortgage amounts. Moreover, with a full, partial correlation of 0.78%, the results suggest positive feedback from mortgage volumes to house prices. Alpanda and Zubiri (2017) investigate through a dynamic stochastic general-equilibrium model the effectiveness of monetary policy in reducing the household indebtedness. According to Alpand (2006), the monetary tightening can reduce the real mortgage debt but leads to an increase in the household debt-to-income ratio. Gerdrup (2018) uses the tax data from Statistics Norway for all Norwegian households in the period between 2004 and 2015 to shed light on developments in debt and bank deposits and the impact of higher interest rates on disposable income and consumption. Gerdrup (2018) argues that total consumption could fall by just under 0.4 percent as a result of the direct cash flow effect on the disposable income of 1% rise in interest rates. Gregor and Melecký (2018) assess how changes in the monetary policy rate affect the lending rates for the small and medium enterprise (SME), mortgage, and corporate loans in the Czech Republic using an Autoregressive Distributed Lag

Model (ADRL) with monthly data from January 2004 to November 2017 from the CNB's ARAD database. According to Gregor and Melecký (2018) findings, stable long-run interest rate pass-through for mortgages, SME, and corporate lending rates without considering model specification. Additionally, the findings of Gregor and Melecký (2018) confirm a stable pass-through from the monetary policy rate to consumer lending rates. Moreover, the result of the research indicates that the most important determinant of the mark-up across all considered lending rates is the spread between the government bond rate and the monetary policy rate. Noocera and Roma (2017) investigate the heterogeneous impact of housing demand shocks on the macro-economy and the role of house prices in the monetary policy transmission across Euro area countries (Belgium, France, Germany, Ireland, Italy, the Netherlands, and Spain) for the period 1980Q1-2014Q4, using Bayesian stochastic structural VAR model. The results confirm that the effects of housing demand and monetary policy shocks differ widely across countries. The researchers found modest housing wealth effect in the Euro area, except for Ireland and Spain, where a shock in house prices from 1% increase leads to 0.15% increase in the real private consumption. Moreover, the research results confirm a significant strong response of real loans to housing demand shocks. Additionally, the study provides empirical evidence of the strong role of house prices in the Euro area monetary policy transmission and document a high heterogeneity in the impact of monetary policy shocks on house prices fluctuating. D. Evans and L. Robertson (2018) examine the response of mortgage credit volumes to the Fed's planned monetary tightening campaign of continued policy rate increases and slowed future purchases of agency securitized mortgages, using Bayesian stochastic TVP -FAVAR model. The analysis focuses on several key dates before and after the recent financial crisis: 1995, 2000, 2006, 2009, and 2015; and confirms that following a monetary tightening, depository institutions experience declines in mortgages in contrast to nonbank finance companies and private pension funds. Finally, Robstad (2018) investigates the response of house prices and house credit to monetary policy shock in Norway by Bayesian structural VAR models. Robstad (2018) uses Cholesky model of zero short run restriction with two variables order, sign restriction model, and model with long and short-run restrictions with quarterly data span from 1994Q1 to 2013Q4. The results of the Robstad research show that the response of house prices is large, while the effect on household credit is muted. Moreover, empirical findings of Robstad (2018) imply that the response of house prices and household credits varies depending on the identification scheme and the order of the variables. According to Robstad (2018), a one percent shock in monetary policy leads to a maximum impact of 0-3 percent using Cholesky identification scheme with interest rate ordered last and 2-5 percent using Cholesky identification scheme with interest rate ordered last.

This research uses the structural VAR model with zero short run restriction as Robstad (2018) with quarterly data span from 2002Q1 to 2018Q4 to investigate the effects of key policy rate on house prices and mortgage lending in Norway. The household credit in Robstad (2018) is replaced by banks' mortgage lending in this research to capture the multidimensional relations among mortgage lending, house prices, and key policy rate. Moreover, the research examines whether the response of house prices to key policy rate shocks varies depending on the location and type of the houses by testing the response of house prices in two different locations and for two types of houses to the key policy rate shocks.

Chapter 4 Methodology

4.1 Vector autoregression:

Structural vector autoregression (SVAR) model is a dynamic multivariate time series procedure that is used to capture the interrelation between two or more variables. Structural VAR is considered according to Bjørnland and Jacobsen (2010), the most common approach for analyzing the effect of monetary policy on economic variables. As cited in Dougherty (2016), Sim (1980) states that the development of the vector autoregression model came as a response to the predictive failure of conventional multivariate models. The construction of conventional models had typically proceeded on an intuitive ad hoc basis. This means that these models incorporated implausible assumption concerning exogeneity and imposed a restriction of doubtful validity. According to Sim (1980) line of thinking as it is pointed out in Dougherty (2016), it would be better to assume that all variables are endogenous. Thus, the structural equitation for any variable would include the following regressors: the current values of all variables in the system; it is its own lagged values, and lagged values of all other variables.

If we have the following variable X_1, X_2, X_3. Hence, if we assume a two lags interrelation between those three variables, then the reduced form of the VAR model that represent this interrelation can be expressed using the following equation:

$$X_{1,t} = a_0 + a_1 X_{1,t-1} + a_2 X_{2,t-1} + a_3 X_{3,t-1} + a_4 X_{1,t-2} + a_5 X_{2,t-2} + a_6 X_{3,t-2} + \varepsilon_1$$

$$X_{2,t} = \beta_0 + \beta_1 X_{1,t-1} + \beta_2 X_{2,t-1} + \beta_3 X_{3,t-1} + \beta_4 X_{1,t-2} + \beta_5 X_{2,t-2} + \beta_6 X_{3,t-2} + \varepsilon_2$$

$$X_{3,t} = \mho_0 + \mho_1 X_{1,t-1} + \mho_2 X_{2,t-1} + \mho_3 X_{3,t-1} + \mho_4 X_{1,t-2} + \mho_5 X_{2,t-2} + \mho_6 X_{3,t-2} + \varepsilon_3$$

And the structural representation:

$$X_{1,t} = a_0 + a_1 X_{2,t} + a_2 X_{3,t} + a_3 X_{1,t-1} + a_4 X_{2,t-1} + a_5 X_{3,t-1} + a_6 X_{1,t-2} + a_7 X_{2,t-2} + a_8 X_{3,t-2} + \varepsilon_1$$

$$X_{2,t} = \beta_0 + \beta_1 X_{1,t} + a_2 X_{3,t} \beta_3 + X_{1,t-1} + \beta_4 X_{2,t-1} + \beta_5 X_{3,t-1} + \beta_6 X_{1,t-2} + \beta_7 X_{2,t-2} + \beta_8 X_{3,t-2} + \varepsilon_2$$

$$X_{3,t} = \mho_0 + \mho_1 X_{1,t} + \mho_2 X_{2,t} \beta_3 + \mho_3 X_{1,t-1} + \mho_4 X_{2,t-1} + \mho_5 X_{3,t-1} + \mho_6 X_{1,t-2} + \mho_7 X_{2,t-2} + \mho_8 X_{3,t-2} + \varepsilon_3.$$

The main motivation for developing the VAR model, as abovementioned, was to obtain a better forecast than those provided by conventional models. However, Dougerty (2016) mentions several challenging issues that have to be considered when applying this model:

1. The fact that one has to decide which variable should appear in the VAR means that the subjective judgment is inescapable.
2. There is a need to find some method for determining the appropriate number of lags.
3. There will be an inevitable problem of multicollinearity in estimating the parameter.
4. One must be careful about the characterization of the disturbance term.

Even though the construction of the VAR model implies all these challenging issues, it is obvious from the previous related study review that VAR models are the most common approach for investigating the impact of monetary policy on the macroeconomic variables.

4.2. Data and construction:

A sample period of quarterly data span from 2002 to 2018 is chosen since it follows the introduction of inflation targeting by the Norwegian Central Bank in March 2001. The adaptation of inflation targeting is used as a data range determinant because it can be considered as an indicator of monetary policy regime stability. The monthly frequencies of key policy rate and exchange rate are aggregated to quarterly frequencies by averaging. Meanwhile, the monthly frequencies of the banks' mortgage lending and consumer price index are aggregate to quarterly frequencies by taking the end of the period values.

In order to arrive at the best alternative VAR model, the number of candidate VAR models are estimated and compared to each other regarding the satisfaction of the OLS inference criteria for reduced form estimation in addition to maximum log likelihood, BIC, AIC, and HQ criterion. Each VAR includes the main variables of interest, namely, key policy rate, house price (growth), and the banks' residential mortgage loan. The candidate VARs are then generated by adding all possible two, or three -variables from the broader set of potentially relevant variables that are chosen in light of the theoretical framework and literature review, and regarding the differences transformation to obtain stationarity.

The broader set of potentially relevant variables includes:

- House prices (growth) –log differences of house price index
- GDP (growth) –log differences of GDP- Mainland Norway
- Exchange rate (growth) – log differences of the TWI (trade-weighted geometrical average of the exchange rates between NOK and Norway's 25 most important trading partners).
- Bank's residential mortgage loan - The log of all sectors loans secured by dwelling
- Inflation – difference log of the consumer price index- as in Robstad (2018).

- Key policy rate
- Residential saving growth- log differences of residential saving

This leads to 10 individual VARs for each length of lags. All the models are estimated from 2002Q1 to 2018Q4. (See appendix 2)

4.3. Models specifications

Considering the time series characteristics, as shown in appendix 5, it can be concluded that all the time series in the VAR model does not contain an apparent time trend. However, the time-series are assumed to have a seasonal component. Hence, this research uses the following reduced var model:

$$y_t = c_0 + +\delta_1 S_1 + \delta_2 S_2 + \delta_3 S_3 + A_1 y_{t-1} + \cdots + A_l y_{t-l} + U_t$$

where y_t is a vector of endogenous variables, c_0 is a constant, l is the number of lags; A_l are the coefficient matrices on the lags, and U_t is a vector of error terms at time S_1, S_2, S_3 are seasonal dummy variables.

$\delta_1 S_1$ = 1 if quarter = 2 and 0 otherwise

$\delta_2 S_2$ = 1 if quarter = 3 and 0 otherwise

$\delta_3 S_3$ = 1 if quarter = 4 and 0 otherwise

After estimating the reduced form of the VAR model, the identification scheme of Cholesky factorization of the variance-covariance matrix scheme as in Sims (1980) is used to identify the model.

The identified model has the following form:

$$B_0 y_t = c_0 + +\delta_1 S_1 + \delta_2 S_2 + \delta_3 S_3 + B_1 y_{t-1} + \cdots + B_l y_{t-l} + +\varepsilon_t$$

Where B_0 is the matrix of contemporaneous restrictions $B_0^{-1} B_l = A_l$, and ε_t is a vector of structural shocks.

The monetary policy shocks are identified by placing direct restrictions on the B_0 matrix using a Cholesky recursive order as in Robstad (2018). The variable that orders first in this Cholesky identification scheme is considered the most exogenous variable. This means that it does not respond contemporaneously to any of the other variables and that it contemporaneously affects all of them. However, it could be affected by them with a delay. If we assume that B_{0ij} is the contemporaneous effect of variable J on variable I, then the B_0 matrix using Cholesky identification scheme will be:

$$\begin{bmatrix} B_{011} & 0 & 0 & 0 & 0 & 0 \\ B_{021} & B_{022} & 0 & 0 & 0 & 0 \\ B_{031} & B_{032} & B_{033} & 0 & 0 & 0 \\ B_{041} & B_{042} & B_{043} & B_{44} & 0 & 0 \\ B_{051} & B_{052} & B_{053} & B_{054} & B_{055} & 0 \\ B_{0161} & B_{062} & B_{063} & B_{06} & B_{065} & B_{066} \end{bmatrix}$$

Lag length selection

The lag order of the model is based on the number of lags that minimize BIC, HQ and AIC criteria taking into consideration that the number of parameters in a VAR increases exponentially with the number of variables, causing a dimensionality problem. Hence, it might be preferred under the chosen sample size to take a VAR model that contains no more than two lags. A VAR lag length test with constant and seasonal dummies is conducted to each VAR with a maximum lag length of 4. From the results of these tests, it can be concluded that BIC, HQ, and AIC criteria suggest two lags length for each VAR models.

Stationarity

Two lags augmented Dickey-Fuller tests with constant and seasonal dummies are applied for all variables to test the existence of unit root in time series (time series stationarity). From the results, it can be concluded that the null hypothesis of unit-root cannot be rejected for a= 0.05 for all variable except log loan secured on dwelling. This means that all variables are two lags stationary with constants and seasonal dummies, apart from log loan secured on dwelling. (See Appendix 4).

To deal with the presence of non-stationarity in log loan secured on dwelling, exponential moving average with 0.400 weight on the current observation is employed in order to remove low-frequency movements caused by business cycle fluctuations. (See Appendix 6 Figure 7). The result of an augmented Dickey-Fuller test applied on the adjusted time series concludes that the null hypothesis of unit-root cannot be rejected for a= 0.05. (See Appendix 3).

4.4 Model selection

Residuals analysis

After choosing the optimal lag length and estimating all potential models, the resulted residuals are tested for autocorrelation, normality, and heteroskedasticity. (See Appendix 5).

- Autocorrelation:

The Portmanteau multivariate test is used to test whether the autocorrelation coefficients are significantly different from zero. If the p-value for the test is larger than alpha, it can be concluded that the null hypothesis of no autocorrelation cannot be rejected for the chosen significance level. Accepting the null hypothesis means that the autocorrelation coefficients in the VAR model are not significantly different from zero.

Rao f test with two lags is also used to test the autocorrelation in the residuals across the time. If the p-value for the test is larger than the chosen significance level, it can be concluded that the null hypothesis of no autocorrelation cannot be rejected for the chosen significance level.

The absence of autocorrelation is one of the asymptotic properties of OLS estimators. The existence of autocorrelation in the residuals can give a biased model estimation.

- Heteroskedasticity

The Autoregressive Conditional Heteroskedasticity (ARCH) is used to test if there is conditional heteroskedasticity between the residuals in the VAR models. The existence of conditional heteroskedasticity means that conditional on the regressor; there is unequal variance between the residuals. The absence of conditional heteroskedasticity is one of the asymptotic properties of OLS estimators. The p-value that is equal or larger than the chosen significance level means that the null hypothesis of no ARCH (2) effect is failed to be rejected. The existence of conditional heteroskedasticity in the model means that although the coefficients remain unbiased, the standard errors and t-test are unreliable.

Normality

The Doornik-Hansen normality test is used to test whether the residuals from the vector autoregression model are normally distributed. P-Value that equals or larger than the chosen significance level means that the null hypothesis of the normal distribution cannot be rejected.

4.5 Model selection

From the results shown in appendixes 2, it can be concluded that for 0.05 significance level only model 7 can be accepted, regarding the absence of autocorrelation, heteroskedasticity, and the normal distribution of the residuals. However, for 0.01 significance level models 1,2, 3 are accepted regarding autocorrelation and heteroskedasticity, and for 0.05 significance level, the null hypothesis of normally distributed residuals cannot be rejected for the same models. Furthermore, model 1 has the maximum log likelihood and the smallest AIC, BIC, and HQ among all the other estimated models. Hence, this model is used for the impulse response estimation. Nevertheless, a heteroskedasticity- and autocorrelation-consistent standard error (HAC) is used to ensure more accurate and unbiased estimation.

Model 1: House prices (growth), Key policy rate, Banks' mortgage lending, GDP (growth), Exchange rate, and Inflation

Model 1 Summary:

Log-likelihood = 1066.3827

AIC = -29.8579 BIC = -26.6465 HQC = -28.5908

Portmanteau test: LB(16) = 568.569, df = 504 [0.0242] > 0.01

Test for autocorrelation of order up to 2

	Rao F	Approx dist.	P-value
lag 1	1.345	F(36, 182)	0.1075 > 0.05
lag 2	1.151	F(72, 196)	0.2237 > 0.05

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	495.610	441	0.0367 > 0.01
lag 2	930.784	882	0.1237 > 0.05

Doornik-Hansen test

Chi-square(12) = 16.1229 [0.1857] > 0.05

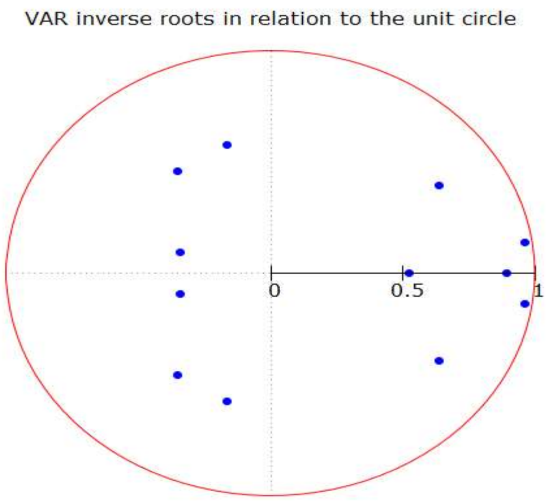


Figure.3

As shown in figure 5, all the roots have modulus less than lie inside the unit circle. This means According to Lutkepohl (1991) that the VAR model is stable. If the VAR model is not stable, one cannot undertake a valid impulse response analysis.

Chapter 5 Empirical results

5.1 Impulse responses:

The impulse response function from the two- orders of Cholesky identification scheme, as in Robstad (2018), are used in this research, one where the key policy rate is ordered last, and another one where house prices are ordered last as shown below:

Cholesky order 1 Cholesky order 2

$$\begin{bmatrix} \text{GDP} \\ \text{INFLATION} \\ \text{Bank's Mortgage lending} \\ \text{Exchange rate} \\ \text{House prices} \\ \text{Key policy rate} \end{bmatrix} \qquad \begin{bmatrix} GDP \\ INFLATION \\ Bank's\ Mortgage\ lending \\ Exchange\ rate \\ Key\ policy\ rate \\ House\ prices \end{bmatrix}$$

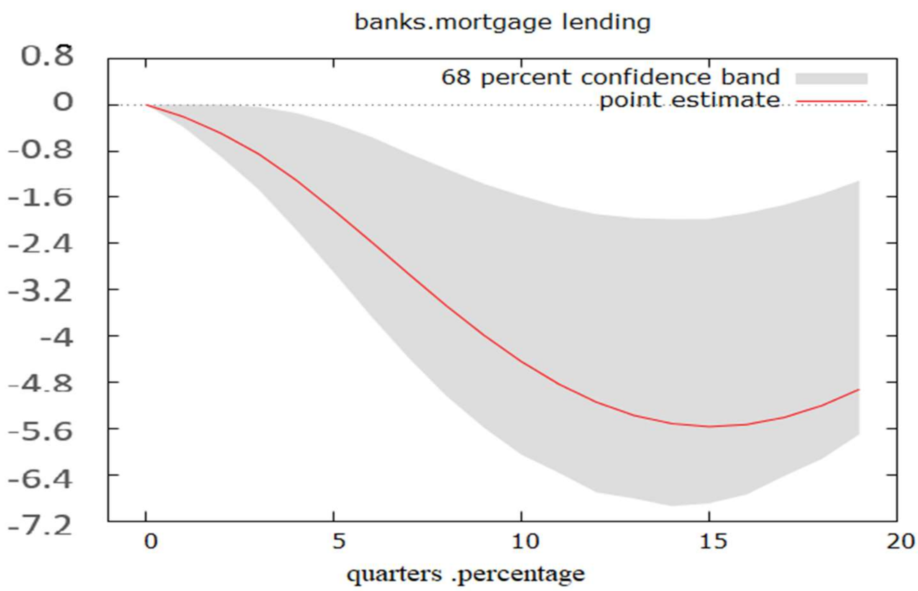
The impulse response from Cholesky identification scheme illustrates the effect of a one-time shock in the key policy rate structural errors on the current and future values of all the endogenous variables. Figures 11 and 12 in Appendices 6 and 7 shows the impulse responses of all variables to one standard error shock in the key policy rate using the two abovementioned Cholesky Identification orders. The most significant difference between the two orders is, as in, Robstad (2018), the effect of the key policy rate on house prices. The effect of the key policy rate is amplified when house prices are ordered last. This suggests, according to Robstad (2018), the important contemporaneous effects of the key policy rate on house prices.

As shown in figures 6 and 7, the tightening shock that comes from an unexpected increase in the key policy rate leads to a decrease in the banks' mortgage lending. Moreover, it leads to a decrease in inflation. This is described by Robstad (2018) as a prize puzzle that can be reduced by introducing a long-run restriction on the real exchange rate and GDP and relax the short-run restrictions on house prices and the real exchange rate as in Bjørnland (2010), or by the construction in a model with a significant restriction. However, this research does not deal with any of those models.

As the scope of interest in this research is to investigate the effect of the key policy rate on house prices and mortgage lending, the impulse responses of house prices and banks` mortgage lending to a shock in key policy rate, and the impulse response of mortgage lending to a shock in house prices are normalized to 1% as shown in figures 4, 5, and 6.

Figure 4 shows the impulse responses of 1% key policy rate shock on house prices growth and mortgage lending using the identification scheme of Cholesky factorization of the variance-covariance matrix with the key policy rate ordered last. Red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands.

Figure.4: Impulse responses of house prices and banks' mortgage lending to 1% shock in key policy rate (key policy rate ordered last).



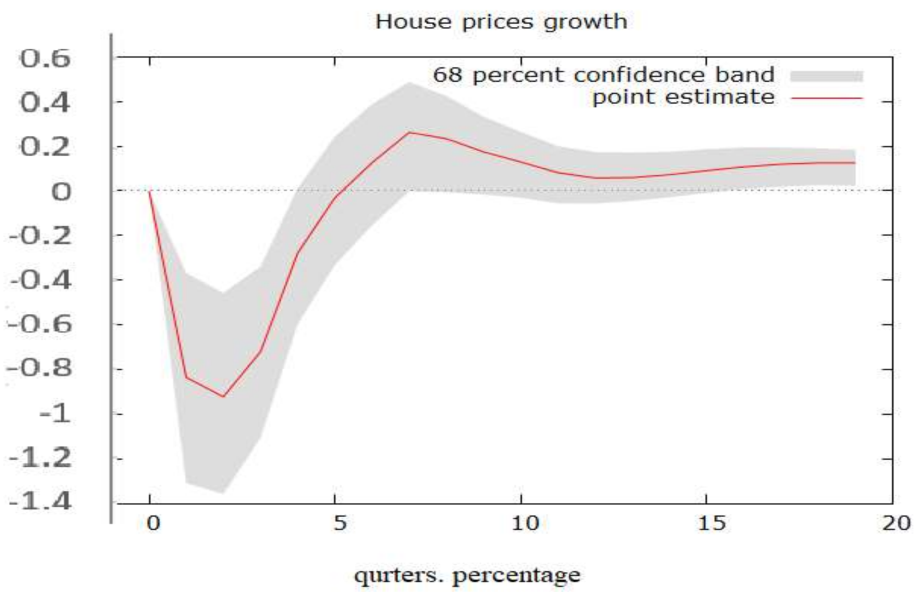


Figure 5 shows the impulse responses of to 1% shock in the key policy rate shock on house prices growth and mortgage lending using the identification scheme of Cholesky factorization of the variance-covariance matrix with house prices growth ordered last. Red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands.

Figure.5: Impulse responses of house prices and banks' mortgage lending to 1% shock in key policy rate (house prices ordered last).

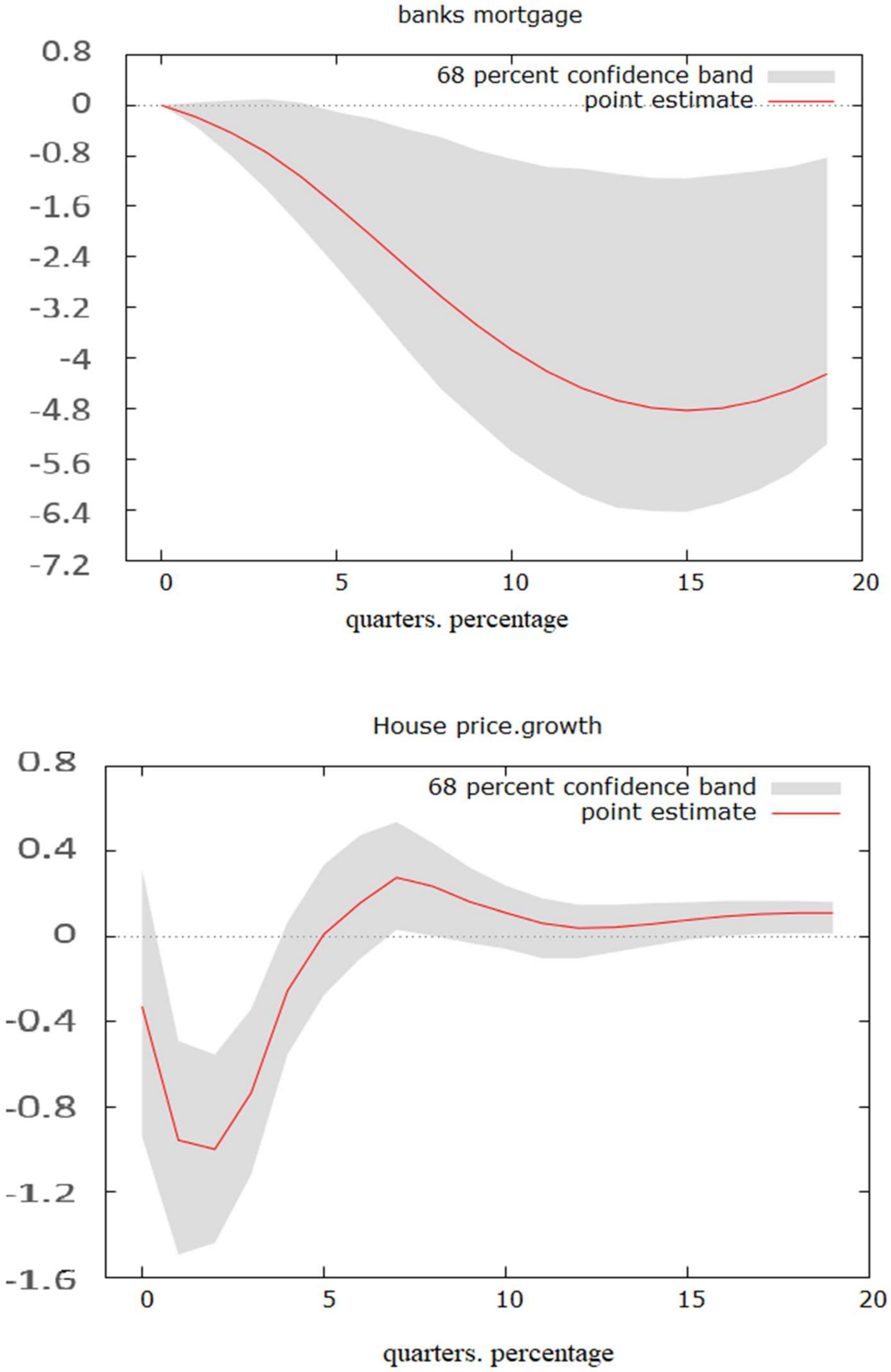
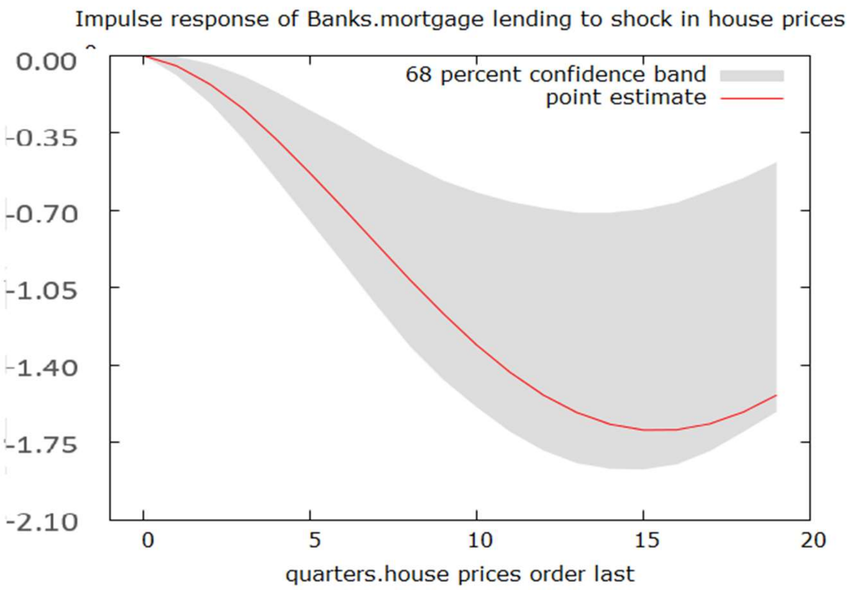
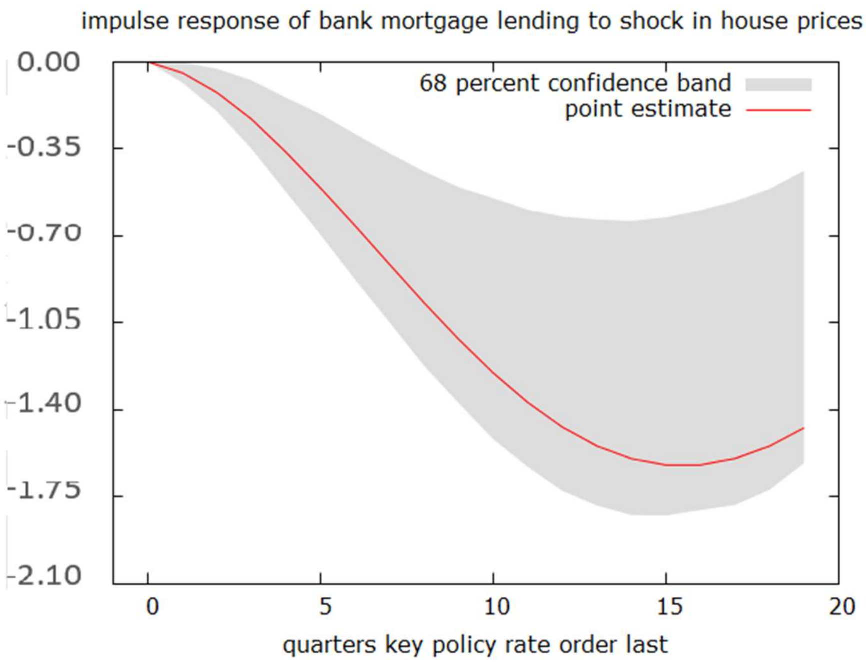


Figure 6 shows the Impulse responses of a 1% shock in house prices growth on mortgage lending and house prices using the identification scheme of Cholesky factorization of the variance-covariance matrix. Red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands.

Figure.6: Impulse responses of banks' mortgage lending to 1% shock in house price





From the impulse response analysis shown in figures 4, and 5, it can be concluded that house prices have a contemporaneous response to the key policy rate shocks. A 1% tightening shock in key policy rate leads to a median decrease of 0.87% in house prices growth in the first quarter and 0.96% median decrease in the second quarter. However, the absolute value of this response declines until it becomes mostly muted after the fourth quarter. The maximum response of house price growth to a 1% shock in key policy rate is 0.45%-1.45% using Cholesky decompensation with the key policy rate ordered last and 0.57%-1.57% using Cholesky decompensation with house prices ordered last. Additionally, a shock in the key policy rate does not have a noticeable initial impact on mortgage lending in the first quarters. However, mortgage lending responds negatively to the tightening shocks in the key policy rate in the long run up to 4 years. The maximum response of mortgage lending to a 1% shock in the key policy rate is 2%-7% using Cholesky decompensation with key policy rate ordered last, and 1.10%-6.85% using Cholesky decompensation with house prices ordered last. Hence, a tightening shock in the key policy rate has an asymmetric negative impact on mortgage lending in the short and long-run. However, a shock in house prices growth has a symmetric impact on mortgage lending in the short and long-run. Moreover, it can be concluded from figure 5 that a positive shock in house prices growth leads to a decrease in banks' mortgage lending. The maximum impact of 1% shock in house prices growth on mortgage lending is 0.65% -1.85% using Cholesky decompensation with key policy rate ordered last and 1%-1.81% Cholesky decompensation with house prices ordered last. The response begins weak in the first quarters and then its absolute value increases until it reaches its peak around the quarter 15.

In addition to investigating the response of house prices to the key policy rate, the research examines whether this response varies depending on the location and the type of the houses. In order to achieve this purpose, the whole country house price index used in the model 1 is replaced by Oslo house price index, Akershus house price index, the whole country detached house price index, and the whole country multi-dwelling price index. The residuals from the resulted VAR models are tested for autocorrelation, heteroskedasticity, and normality, and the impulse responses of the various house prices to a shock in key policy rate are identified using two Cholesky identification scheme as in model 1.

Figure 7 shows the impulse response of several house prices indices to a 1% shock in key policy rate using Cholesky identification scheme of factorization of the variance-covariance matrix with key policy rate ordered last. Red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands.

Figure.7: The impulse response of the different house price indices to 1% shock in key policy rate (key policy rate ordered last)

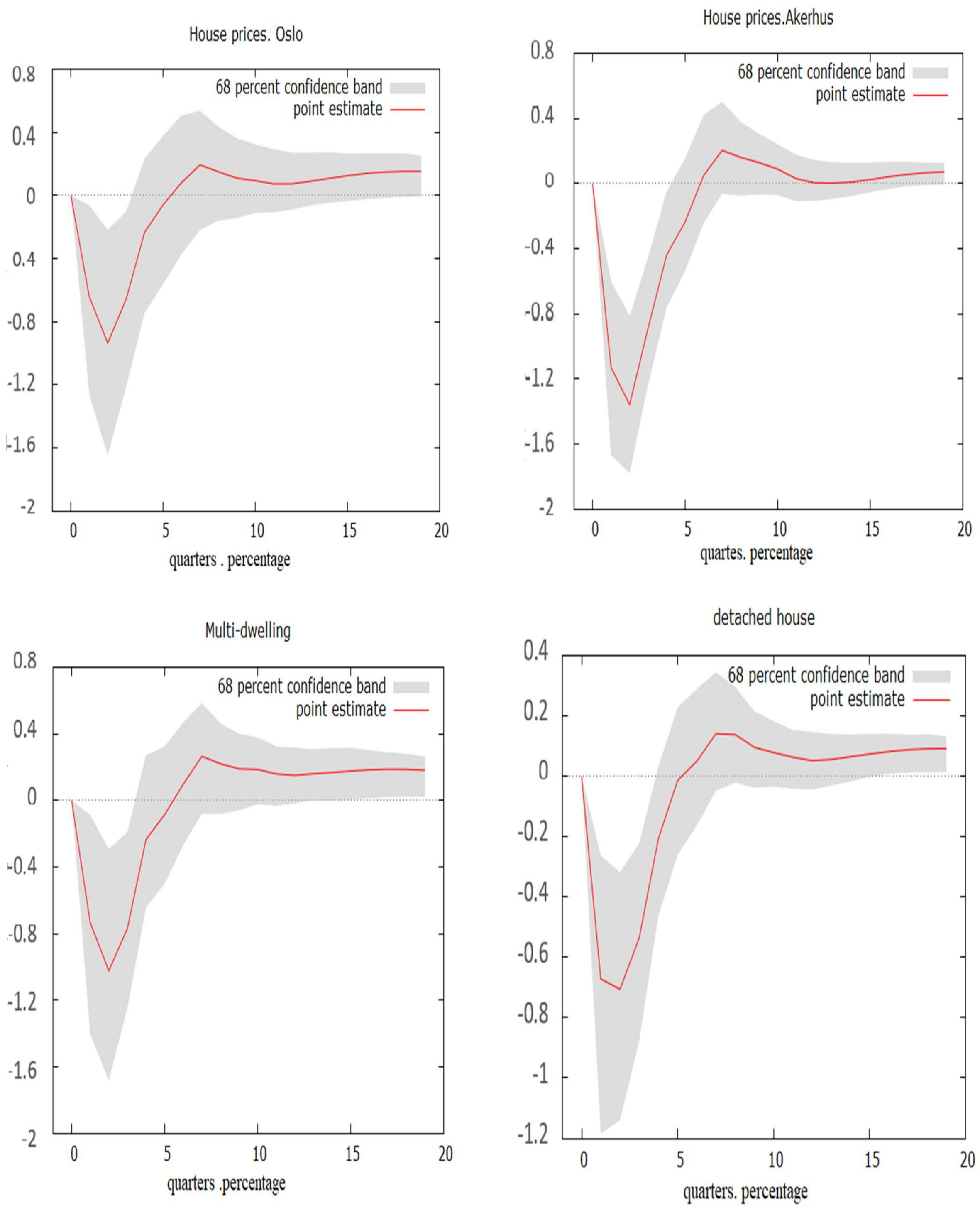
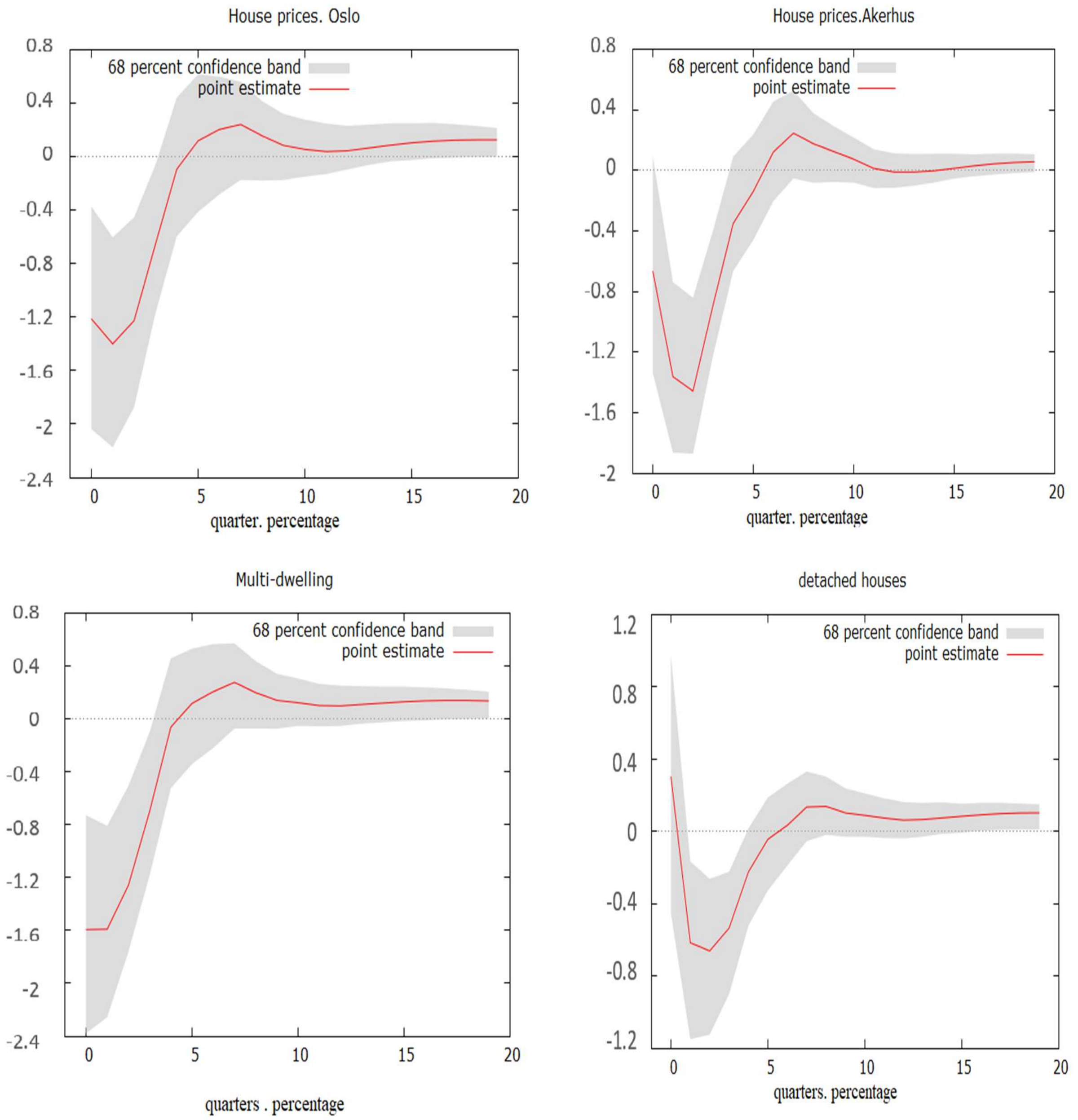


Figure 8 shows the impulse response of several house prices indices to a 1% shock in key policy rate using Cholesky identification scheme of factorization of the variance-covariance matrix with house prices ordered last. Red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands.

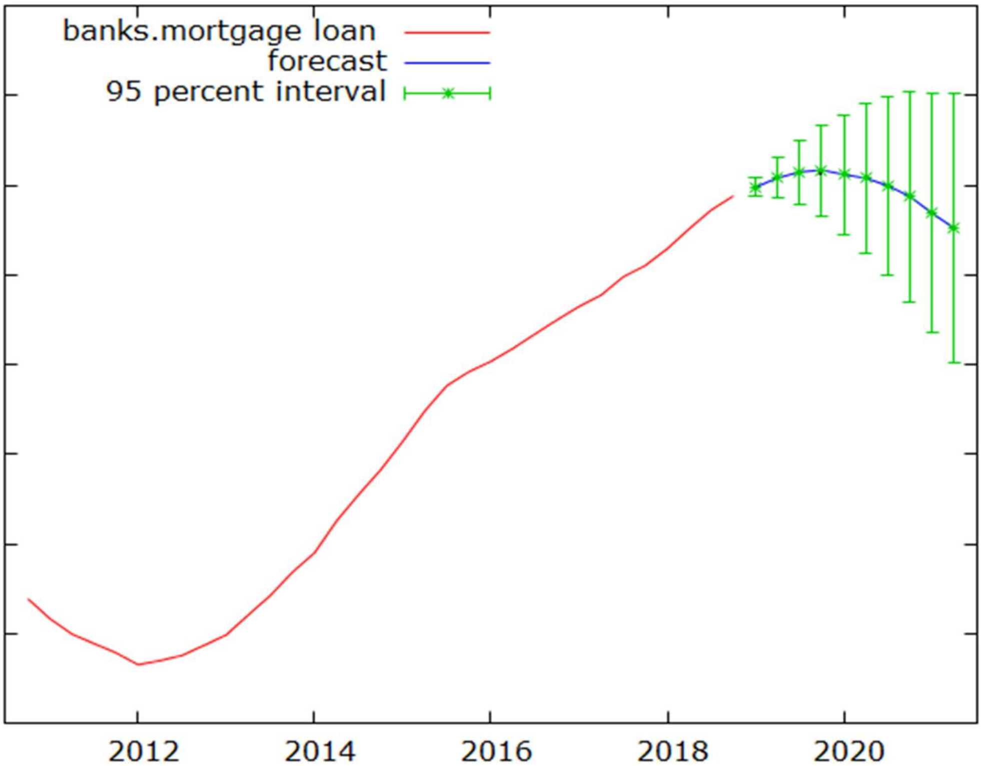
Figure.8: The impulse response of the different house price indices to 1% shock in key policy rate (key policy rate ordered last)



From the impulse responses to the abovementioned house prices indices, shown in figures 7 and 8, it can be concluded that the response of house prices in Oslo and Akershus to a shock in the key policy rate is stronger than the whole country average. Moreover, the response of multi-dwelling prices to a shock in the key policy rate is stronger than the response of detached house prices.

Finally, based on the empirical results, the study suggests that the banks` mortgage lending is anticipated, as shown in figure .9, to keep increasing during 2019 and begins to decline gradually thereafter as a result of the increase in the key policy rate.

Figure.9: dynamic out of the sample banks' mortgage lending forecast



5.2 Implications and discussion

This study supports the previous related studies that suggest a fall in house prices as a response to monetary policy shock. It suggests as Bjørnland and Jacobsen (2010) and Robstad (2018) that house prices in Norway respond very quickly to a monetary policy shock. However, the response is not so strong compared to those two previous studies and compared to other similar SVAR studies using the US, and OECD data. Moreover, the different responses of the house prices to the key policy rate shocks in Oslo and Akershus compared to the country average implies that the housing market differs among the different part of the country. Additionally, the empirical results go in line with the prior expectations discussed in the theoretical framework. An increase in the key policy rate reduces the mortgage demand by influencing the mortgage rate and making the mortgage credit more expensive. Hence, it decreases banks' mortgage lending. Moreover, an increase in the key policy rate increases the cost of capital and leads to a decrease in house prices. This decrease leads to an increase in mortgage lending as it means that households need to save less, which, in turn, motivate them to increase their current consumption by taking mortgage loans as mortgage credit becomes more accessible. The research shows that the response of mortgage lending to a shock in the key policy rate is stronger than to a shock in house prices. This means, considering the prior theoretical framework, that the response of mortgage lending to house prices changes in Norway can be attributed mostly to its impact on households' current savings and consumption that affect somewhat the mortgage credit accessibility. Hence the loan to value ratio can be used by Norwegian Central Bank as an effective tool for controlling the mortgage market without increasing the key policy rate. Higher loan to value ratio assuming no changes in the key policy rate and house prices means a decrease in the households' ability to access mortgage credit and hence a decrease in banks' mortgage volume.

5.3 Robustness

The impulse response of both house prices and banks' mortgage lending to a shock in the key policy rate, and the impulse response of mortgage lending to a shock in house prices from models 2, 3 , and 7 are identified using Cholesky identification scheme with two different variables order as model 1 and compared to each other and to those derived from model 1. The comparison supports the result derived from model 1. However, there is a relatively small variation in the size of the responses depending on the chosen VAR model and the order of the variables in the used Cholesky identification scheme.

Conclusion:

This research provides an empirical analysis of the effect of the key policy shocks on house prices and mortgage lending using a structural vector autoregression model. The first chapter provides an introduction that summarizes the background, motivations, and the objective of the study. The second and third chapters provide a literature review that includes a theoretical framework and relevant related empirical studies. The data construction and the specification of the model used for data analysis are discussed in chapter four. The results of the research discussed in chapter five support the finding of Bjørnland and Jacobsen (2010) and Robstad (2018) that house prices respond quickly to a monetary policy shock in Norway. However, the response is not so strong compared to those two previous studies that used Norway data and compared to similar SVAR studies using the US, and OECD data. Meanwhile, it seems closer to the response in SVAR studies using the UK, and Euro data. The research finds that the maximum response of house price to a 1% shock in the key policy rate is 0.45%-1.45% using Cholesky decompensation with key policy rate ordered last and 0.57% -1.57% using Cholesky decompensation with house prices ordered last. The response begins weakly in the first quarter, and then its absolute value increases in the second quarter and declines in the third until it becomes almost muted after the fourth quarter. Moreover, this response varies depending on the location and type of the house. The stronger response of the house prices in Oslo to the key policy rate shock than that of the whole country prices implies that there is a significant difference in the housing market among the different part of the country. On the other hand, the maximum response of mortgage lending to 1% key policy rate shock is 2%- 7% using Cholesky decompensation with the key policy rate ordered last and 1.10%- 6.85% using Cholesky decompensation with house prices ordered last. This response is muted for the first quarters, and then it increases gradually until it reaches its highest value around the 15th quarter and begins to decline thereafter.

Furthermore, the research finds that maximum impact of 1% shock in house prices growth on mortgage lending is 0.65%-1.85 % using Cholesky decompensation with the key policy rate ordered last and 1%- 1.81% Cholesky decompensation with house prices ordered last. The response begins weak in the first quarter and then increases to reach its peak. Hence, it can be concluded that the impact of the increase in the key policy rate on mortgage lending through the direct influence on mortgage supply and demand is stronger than the indirect influence through the house prices. This implies that Norwegian banks pass- through the increase in the key policy rate to its mortgage lending, which increases the cost of the mortgage and hence reduce the mortgage demand. Moreover, the increase in Norwegian monetary policy rate leads to a decrease in house prices due to the increase in the user cost of capital. The impact of lower house prices motivates household in Norway to increase their consumption by taking loans, although it costs more as it becomes more accessible. However, the direct impact of the Norwegian key policy rate on the bank's mortgage demand due to the increased interest payment is higher than the impact of the lower house prices on mortgage demand.

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Statistic Norway

https://www.ssb.no

Appendices

Appendix 1: Data

- Key policy rate- monthly average of daily observations. Source: Norges Bank

- Consumer price index CPA. Source: Statistics Norway

- The trade-weighted exchange rate against Norge's 25 most important trading partners. Source: Norges bank

- GDP mainland Norway from national accounts. Source: Statistics Norway

- Price of existing dwellings by region and type of the building. Source: Statistics Norway

- Loans by type and sector. Source: Statistic Norway.

- Residential saving from the non-financial sector account. Source: Statistic Norway

Appendix 2: Models description

Model 1: House prices growth, Key policy rate, Bank's mortgage lending, GDP growth, Exchange rate, and Inflation

Model 2: House prices growth, Key policy rate, inflation, Bank's mortgage lending, Residential saving growth, and GDP growth.

Model 3: House prices growth, Key policy rate, Bank's mortgage lending, GDP growth, Exchange rate, and Residential saving growth.

Model 4: House prices growth, Key policy rate, Bank's mortgage lending, Residential saving growth, Exchange rate, and Inflation.

Model 5: House prices growth, Key policy rate, Bank's mortgage lending, GDP growth, and Inflation.

Mode 6: House prices growth, Key policy rate, Bank's mortgage lending, Residential saving growth, and Inflation

Model 7: House prices growth, Key policy rate, Bank's mortgage lending, Residential saving growth, Exchange rate.

Model 8: House prices growth, Key policy rate, Bank's mortgage lending, Exchange rate, and Inflation.

Model 9: House prices growth, Key policy rate, Bank's mortgage lending, residential saving growth, and GDP growth.

VAR 10: House prices growth, Key policy rate, Bank's mortgage lending, exchange rate, and GDP growth.

Appendix 3 VAR lag selection

VAR 1 system, Maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	898.57445		-26.621411	-24.580331	-25.818644
2	1045.04486	0.00000	-30.128408*	-26.862679*	-28.843981*
3	1068.85846	0.09304	-29.741539	-25.251161	-27.975451
4	1104.60879	0.00039	-29.733612	-24.018586	-27.485865

VAR 2 system, Maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	776.95985		-22.760630	-20.719549	-21.957863
2	923.55190	0.00000	-26.271489*	-23.005760*	-24.987062*
3	951.92909	0.01519	-26.029495	-21.539117	-24.263407
4	987.31443	0.00048	-26.009982	-20.294956	-23.762234

VAR 3 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	701.65883		-20.370122	-18.329041	-19.567355
2	835.33103	0.00000	-23.470826*	-20.205097*	-22.186399*
3	864.03664	0.01313	-23.239258	-18.748881	-21.473171
4	897.23731	0.00151	-23.150391	-17.435365	-20.902643

VAR 4 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	755.35647		-22.074809	-20.033728	-21.272042
2	897.44944	0.00000	-25.442840*	-22.177110*	-24.158412*
3	928.25312	0.00497	-25.277877	-20.787499	-23.511789
4	967.13838	0.00007	-25.369473	-19.654447	-23.121725

VAR 5 system, maximum lag order 4
The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	755.35647		-22.074809	-20.033728	-21.272042
2	897.44944	0.00000	-25.442840*	-22.177110*	-24.158412*
3	928.25312	0.00497	-25.277877	-20.787499	-23.511789
4	967.13838	0.00007	-25.369473	-19.654447	-23.121725

VAR 6 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	585.43374		-17.156627	-15.625816	-16.554551
2	721.00947	0.00000	-20.666967*	-18.285707*	-19.730406*
3	743.88183	0.00687	-20.599423	-17.367712	-19.328376
4	770.57774	0.00080	-20.653262	-16.571100	-19.047728

VAR 7 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	513.18274		-14.862944	-13.332134	-14.260869
2	637.82481	0.00000	-18.026184*	-15.644924*	-17.089623*
3	659.72951	0.01139	-17.927921	-14.696210	-16.656873
4	679.22775	0.03687	-17.753262	-13.671101	-16.147728

VAR 8 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	714.42062		-21.251448	-19.720638	-20.649373
2	850.72017	0.00000	-24.784767*	-22.403507*	-23.848206*
3	867.30223	0.12702	-24.517531	-21.285820	-23.246483
4	893.76521	0.00091	-24.563975	-20.481814	-22.958441

VAR 9 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	532.78168		-15.485133	-13.954322	-14.883058
2	662.43125	0.00000	-18.807341*	-16.426080*	-17.870780*
3	681.36669	0.04762	-18.614816	-15.383104	-17.343768
4	705.36538	0.00373	-18.583028	-14.500867	-16.977494

VAR 10 system, maximum lag order 4

The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	654.73308		-19.356606	-17.825795	-18.754530
2	784.69138	0.00000	-22.688615*	-20.307354*	-21.752054*
3	803.33975	0.05410	-22.486976	-19.255265	-21.215928
4	825.92838	0.00798	-22.410425	-18.328263	-20.804891

Appendix 4 Augmented Dickey-Fuller test

Augmented Dickey-Fuller test for the key policy rate
test with constant plus seasonal dummies
including 2 lags of (1-L) key policy rate
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.0847305
test statistic: tau_c(1) = -3.62884
asymptotic p-value 0.00526

Augmented Dickey-Fuller test for log diff GDP mainland Norway
test with constant plus seasonal dummies
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -1.27824
test statistic: tau_c(1) = -4.25253
asymptotic p-value 0.0005317

Augmented Dickey-Fuller test for log diff House price index
test with constant plus seasonal dummies
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.53771
test statistic: tau_c(1) = -3.61629
asymptotic p-value 0.005485

Augmented Dickey-Fuller test for log diff CPI
test with constant plus seasonal dummies
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -1.14308
test statistic: tau_c(1) = -4.34936
asymptotic p-value 0.0003593

Augmented Dickey-Fuller test for log diff exchange rate
test with constant plus seasonal dummies
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.911259
test statistic: tau_c(1) = -4.54678
asymptotic p-value 0.0001571

Augmented Dickey-Fuller test for log diff residential investment
test with constant plus seasonal dummies
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -1.69459
test statistic: tau_c(1) = -5.935
asymptotic p-value 1.715e-007

Augmented Dickey-Fuller test for LMA.log repayment loan secured on dwelling
test with constant plus seasonal dummies
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.0151964
test statistic: tau_c(1) = -3.18449
asymptotic p-value 0.02093

Appendix 5 Models summary

Model 1 lag order 2

Portmanteau test: LB(16) = 568.569, df = 504 [0.0242]

Test for autocorrelation of order up to 2

	Rao F	Approx dist.	P-value
lag 1	1.345	F(36, 182)	0.1075
lag 2	1.151	F(72, 196)	0.2237

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	495.610	441	0.0367
lag 2	930.784	882	0.1237

Doornik-Hansen test
Chi-square(12) = 16.1229 [0.1857]

Log-likelihood = 1066.3827
AIC = -29.8579
BIC = -26.6465
HQC = -28.5908

Model 2 lag order 2

Portmanteau test: LB(16) = 571.95, df = 504 [0.0191]

Test for autocorrelation of order up to 2

	Rao F	Approx dist.	P-value
lag 1	1.377	F(36, 182)	0.0903
lag 2	1.316	F(72, 196)	0.0713

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	472.609	441	0.1441
lag 2	920.136	882	0.1811

Doornik-Hansen test
Chi-square(12) = 19.2206 [0.0833]

Log-likelihood = 942.42556
AIC = -26.0439
BIC = -22.8325
HQC = -24.7768

Model 3 lag order 2

Portmanteau test: LB(16) = 568.569, df = 504 [0.0242]

Test for autocorrelation of order up to 2

	Rao F	Approx dist.	P-value
lag 1	1.272	F(36, 182)	0.1559
lag 2	1.193	F(72, 196)	0.1718

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	449.043	441	0.3853
lag 2	905.606	882	0.2833

Doornik-Hansen test
Chi-square(12) = 20.1841 [0.0637]

Log-likelihood = 857.51132
AIC = -23.4311
BIC = -20.2197
HQC = -22.1640

Model 4 lag order 2

Portmanteau test: LB(16) = 602.284, df = 504 [0.0017]
Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.168	F(36, 182)	0.2521
lag 2	1.163	F(72, 196)	0.2080

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	466.043	441	0.1976
lag 2	900.765	882	0.3229

Doornik-Hansen test
Chi-square(12) = 14.1001 [0.2944]

Log-likelihood = 916.74565
AIC = -25.2537
BIC = -22.0423
HQC = -23.9866

Model 5 lag order 2

Portmanteau test: LB(16) = 391.082, df = 350 [0.0642]
Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.605	F(25, 168)	0.0426
lag 2	1.431	F(50, 185)	0.0463

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	286.623	225	0.0034
lag 2	522.704	450	0.0100

Doornik-Hansen test
Chi-square(10) = 16.0878 [0.0971]

Log-likelihood = 886.84437
AIC = -25.1337
BIC = -22.7920
HQC = -24.2097

Model 6 lag order 2

Portmanteau test: LB(16) = 398.989, df = 350 [0.0362]
Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.297	F(25, 168)	0.1694
lag 2	1.142	F(50, 185)	0.2622

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	271.073	225	0.0192
lag 2	526.681	450	0.0072

Doornik-Hansen test
Chi-square(10) = 15.3029 [0.1214]

Log-likelihood = 735.19387
AIC = -20.4675
BIC = -18.1259
HQC = -19.5436

Model 7 lag order 2

Portmanteau test: LB(16) = 385.337, df = 350 [0.0937]

Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.494	F(25, 168)	0.0721
lag 2	1.224	F(50, 185)	0.1695

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	259.842	225	0.0553
lag 2	485.989	450	0.1168

Doornik-Hansen test
Chi-square(10) = 17.1466 [0.0712]

Log-likelihood = 655.17003
AIC = -18.0052
BIC = -15.6636
HQC = -17.0813

Model 8 lag order 2

Portmanteau test: LB(16) = 417.788, df = 350 [0.0074]
Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.100	F(25, 168)	0.3479
lag 2	1.249	F(50, 185)	0.1473

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	273.570	225	0.0149
lag 2	503.116	450	0.0421

Doornik-Hansen test
Chi-square(10) = 13.3724 [0.2036]

Log-likelihood = 871.65385
AIC = -24.6663
BIC = -22.3246
HQC = -23.7423

Model 9 lag order 2
Portmanteau test: LB(16) = 407.886, df = 350 [0.0178]
Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.344	F(25, 168)	0.1394
lag 2	1.070	F(50, 185)	0.3652

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	251.535	225	0.1082
lag 2	477.950	450	0.1749

Doornik-Hansen test
Chi-square(10) = 24.6791 [0.0060]

Log-likelihood = 679.54621
AIC = -18.7553
BIC = -16.4136
HQC = -17.8313

Model 10 lag order 2

Portmanteau test: LB(16) = 386.414, df = 350 [0.0875]
Test for autocorrelation of order up to 2

	Rao F	Approx dist.	p-value
lag 1	1.344	F(25, 168)	0.1394
lag 2	1.070	F(50, 185)	0.3652

Test for ARCH of order up to 2

	LM	df	p-value
lag 1	251.535	225	0.1082
lag 2	477.950	450	0.1749

Doornik-Hansen test
Chi-square(10) = 24.6791 [0.0060]

Log-likelihood = 679.54621
AIC = -18.7553
BIC = -16.4136
HQC = -17.8313

Appendix 6 Figures

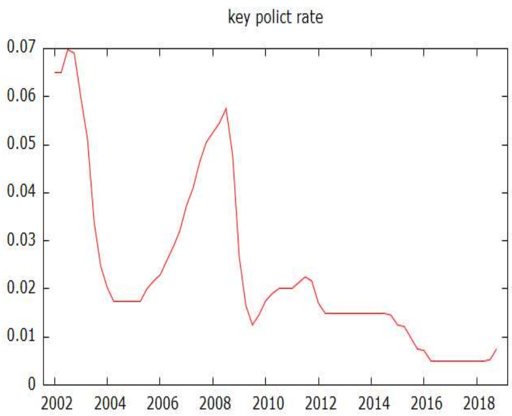


Figure .1

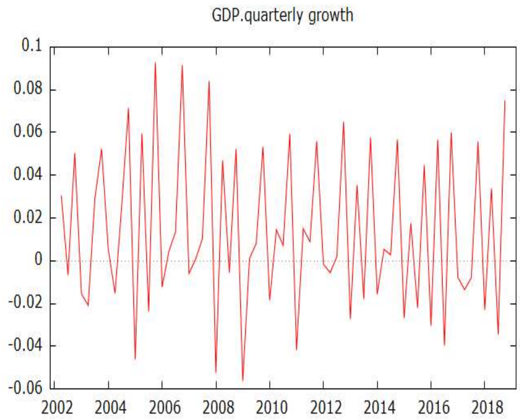


Figure .2

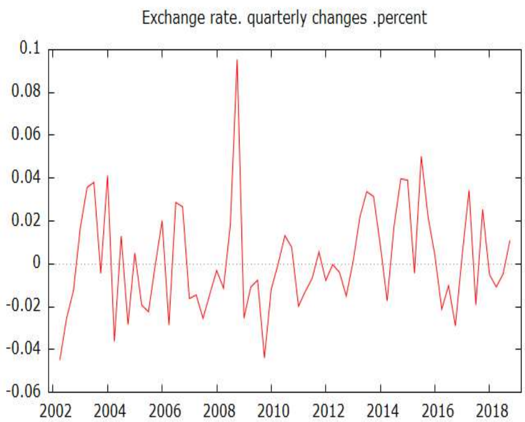


Figure .3

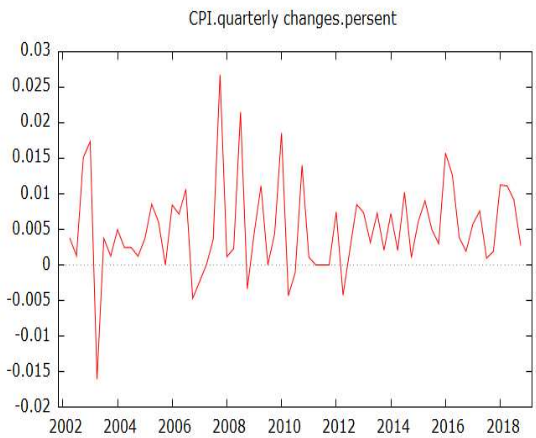


Figure .4

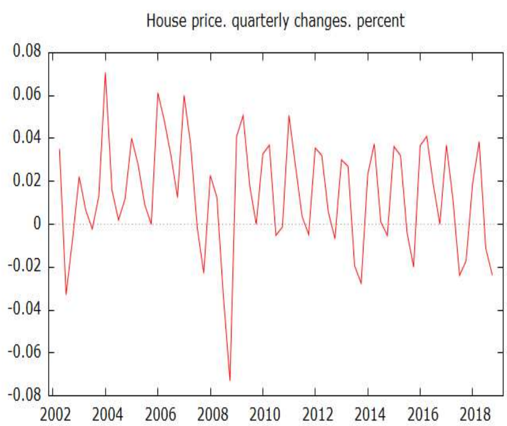


Figure .5

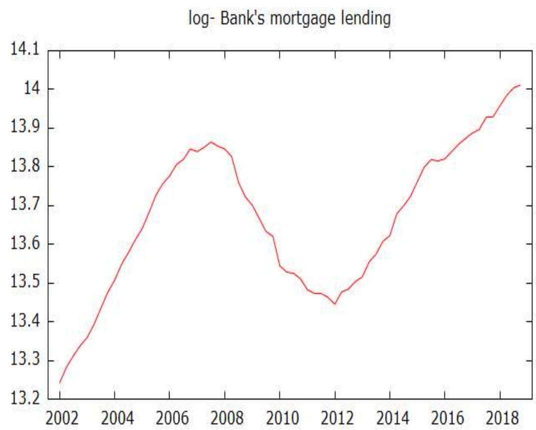


Figure .6

Exponential moving average of bank`s mortgage loan with
0.4000 weight on current observation

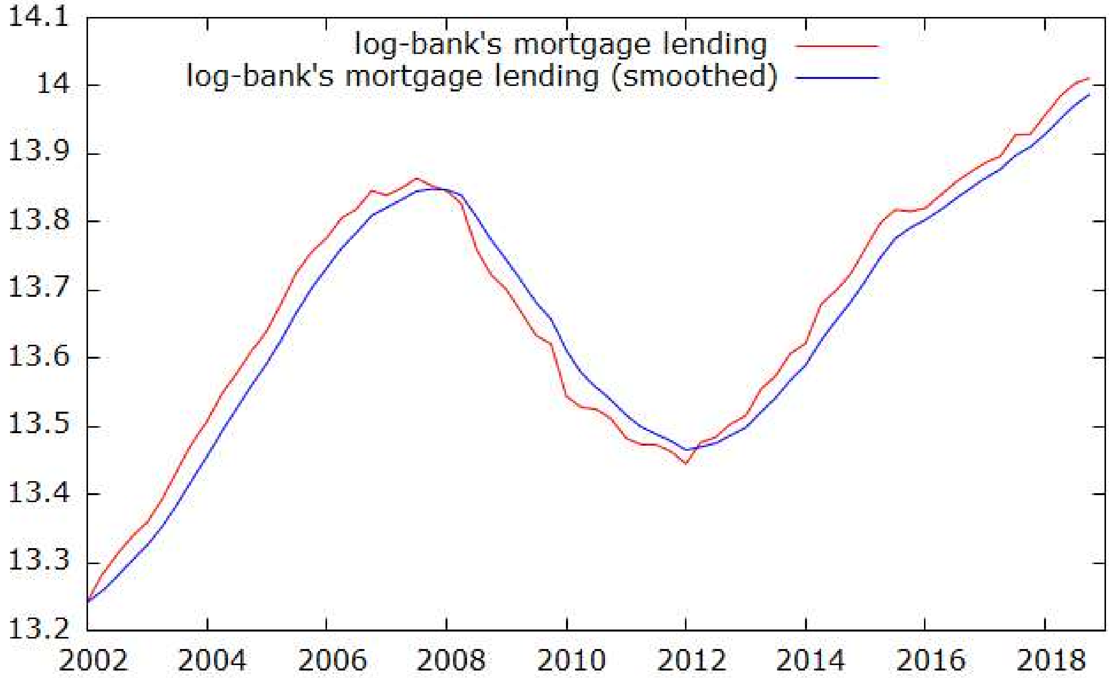
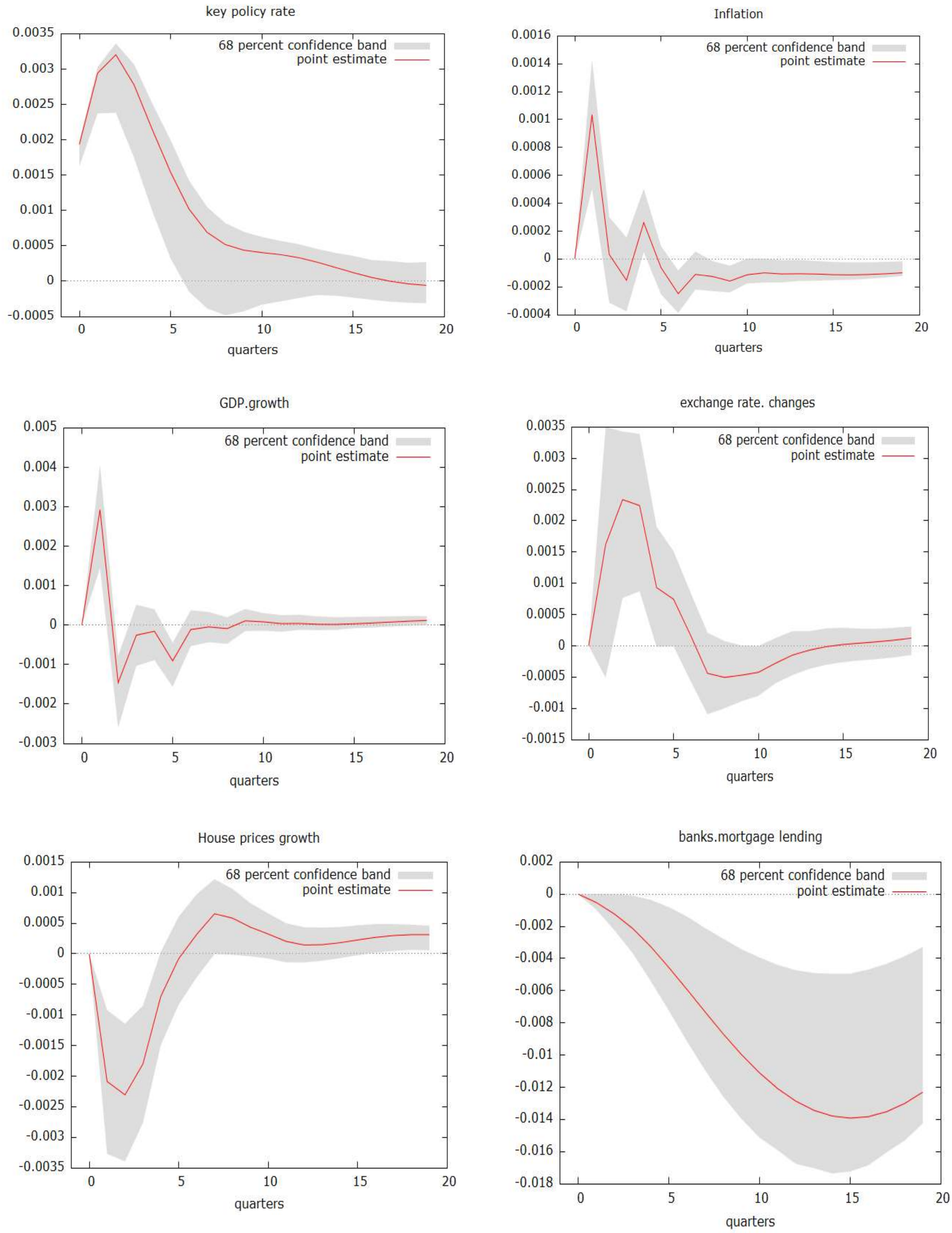


Figure .7

Appendix 7: Impulse response to a shock in the key policy rate

Impulse responses from 1 standard error key policy rate shock. Identification is achieved through a Cholesky factorization of the variance-covariance matrix with key policy rate ordered last. red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands



Impulse responses from a one standard error key policy rate shock. Identification is achieved through a Cholesky factorization of the variance-covariance matrix with house prices ordered last. red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands

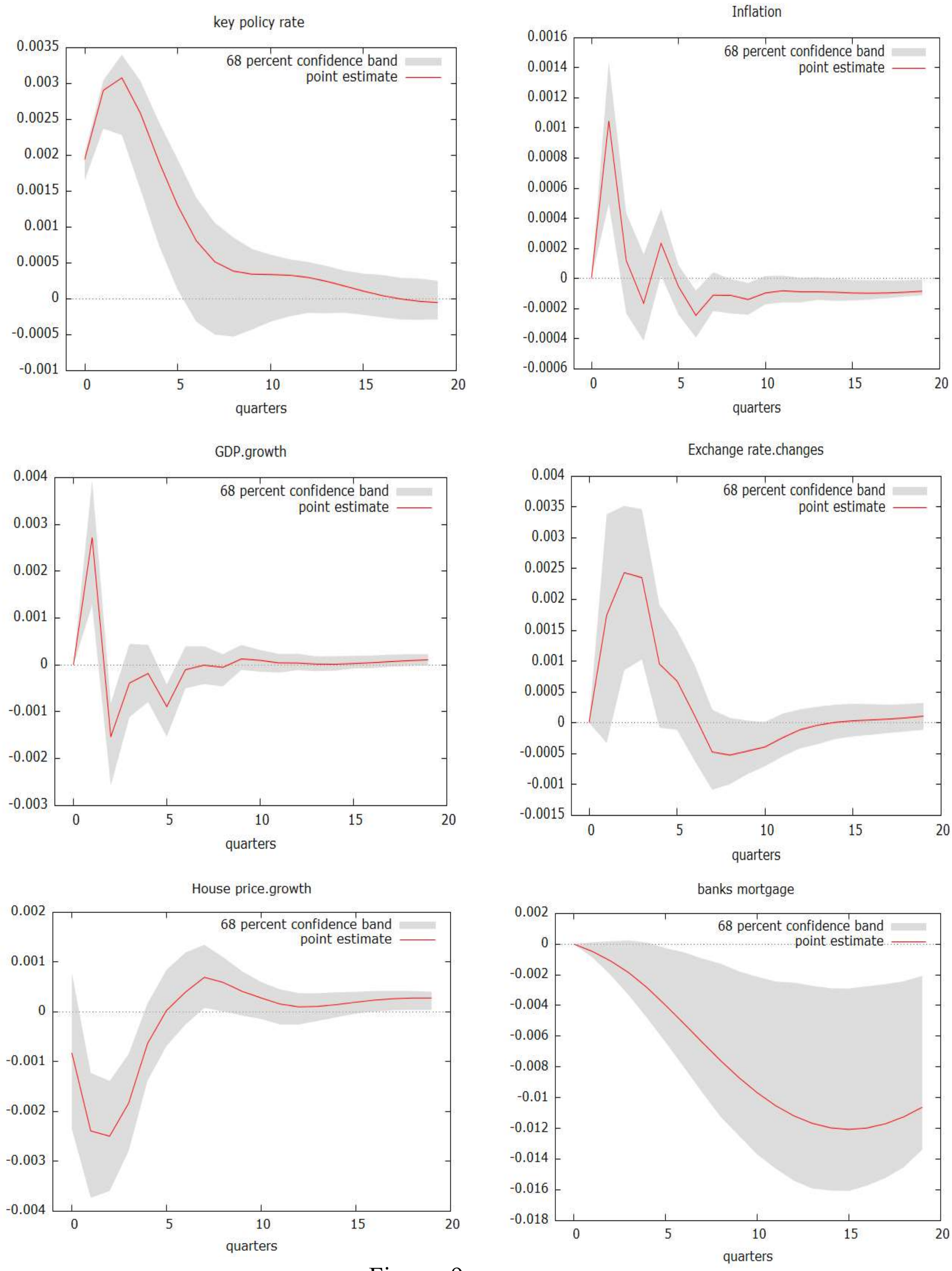
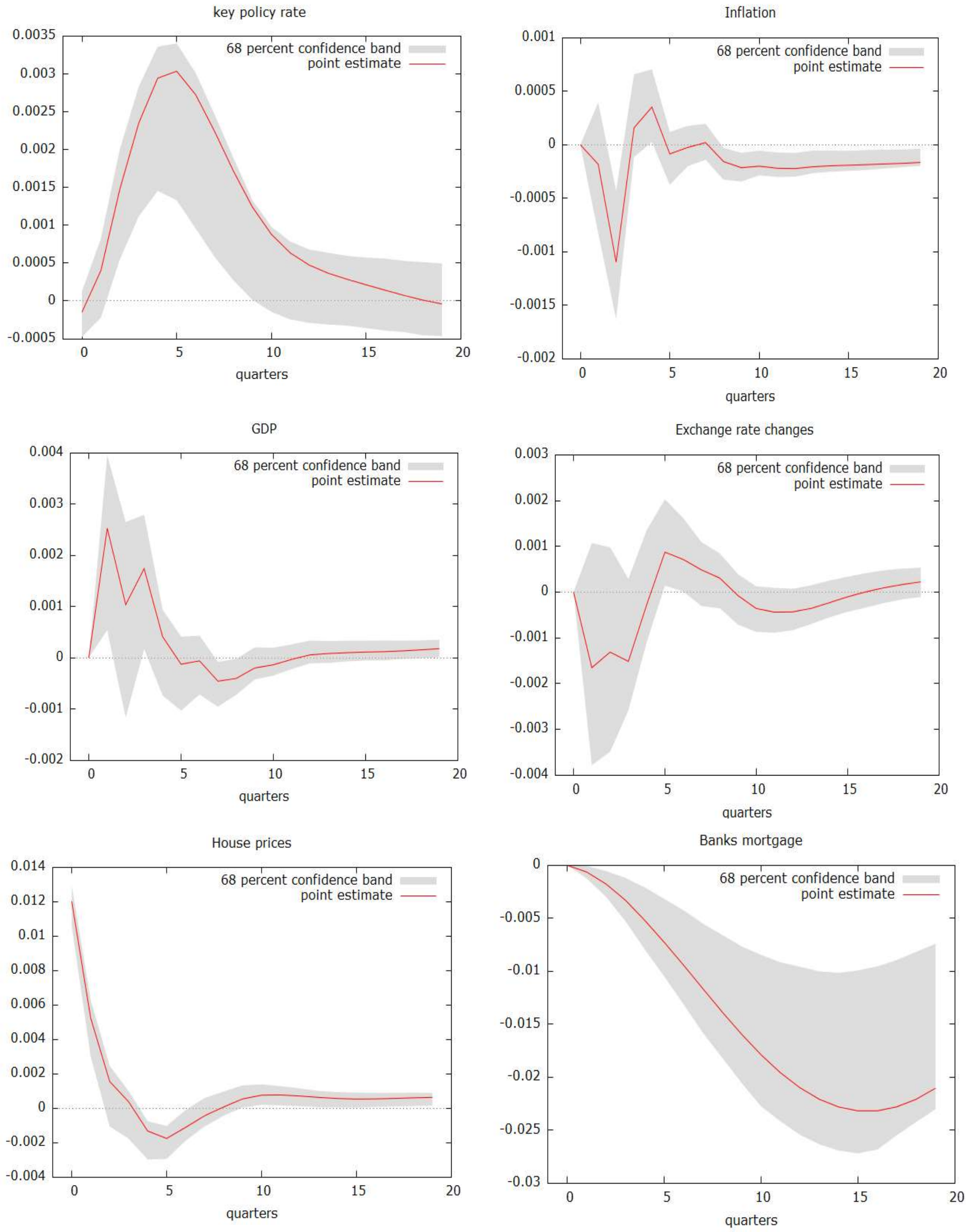


Figure .9

Appendix 8 impulse response to a shock in house prices

Impulse responses from a one standard error shock in house prices growth. Identification is achieved through a Cholesky factorization of the variance-covariance matrix with Key policy rate ordered last. red lines are median estimates, while shadow area represents the area between 16^{th} and 84^{th} percentile probability bands



Impulse responses from a one standard error shock in house prices growth. Identification is achieved through a Cholesky factorization of the variance-covariance matrix with house prices ordered last. red lines are median estimates, while shadow area represents the area between 16th and 84th percentile probability bands