Unconventional Monetary Policy in Scandinavia

A Local Projection Analysis of House Prices

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Abstract

This paper investigates the spillover effects of unconventional and conventional monetary policy measures on house prices in Denmark, Norway, and Sweden. Two notable results were found using the local projections method and data, including the years of the Covid Pandemic and the Invasion of Ukraine. The first result revealed that policy rate and total asset shocks had spillover effects on house prices in the initial and intermediate periods. Nevertheless, only the unconventional policy shock affected house prices through its corresponding transmission mechanism. The impact of unconventional monetary policy measures on mortgage interest rates was significant in Norway, while Sweden and Denmark exhibited insignificant results. The second result implied a delayed effect on house prices, where the unconventional policy shock positively affected house prices at the end of the period. In contrast, the conventional policy shock had a negative effect. However, these results were insignificant and had to be carefully interpreted. The findings of this paper highlight the effect of unconventional measures on house prices and emphasize the need for policymakers to consider the effects on the housing market when implementing monetary policies.

Keywords: Unconventional Monetary Policy, House Prices, Mortgage Interest Rates Transmission Mechanisms, Local Projections, Scandinavia

Contents:

List of Tables

List of Figures

1. Introduction

This paper investigates the effects of different monetary policies on house prices in Scandinavia. Specifically, this paper will seek to answer the primary question of whether unconventional monetary policies have a spillover effect on house prices through the asset price channel. The second question this paper aims to answer is whether conventional monetary policy has a spillover effect on house prices through the interest rate channel and how it compares to unconventional monetary policy spillover effects. This paper will contribute to the existing literature by comparing house prices in Denmark, Norway, and Sweden while employing a local projection (LP) method. The Scandinavian countries share aspects of a similar economic structure as small, open, and advanced economies, while having different levels of economic autonomy. The similarities enable them to be compared, increasing our results' validity.

Conventional monetary policy was found to be less effective than desired in the aftermath of the Great Financial Crisis in 2008 (Federal Reserve Bank of St. Louis, 2015). The crisis arose from the burst of the US housing market bubble and the bankruptcy of the US investment bank Lehman Brothers. This led to a global financial crisis that induced severe contractionary monetary policy measures in Scandinavia (Sveriges Riksbank, 2023). As illustrated in Figure 1 the Scandinavian central banks lowered their policy interest rates following the Great Financial Crisis. Due to the constraint of not being able to change the policy interest rate further, other policy measures were required, spurring the use of unconventional measures (Federal Reserve Bank of St. Louis, 2015).

The importance of investigating unconventional monetary policies' spillover effects on real economic variables, specifically house prices, is threefold. The first is that house prices affect the wealth formation of households, when house prices and mortgage rates change, households' wealth also changes (OECD, 2023). The second reason is that house prices affect the gross domestic product (GDP) growth rate in countries and their overall economic development in the long term (Mian & Sufi, 2018). The third reason is that a spillover effect of monetary policies on house prices may lead to the burst of a housing market bubble (Rosenberg, 2019).

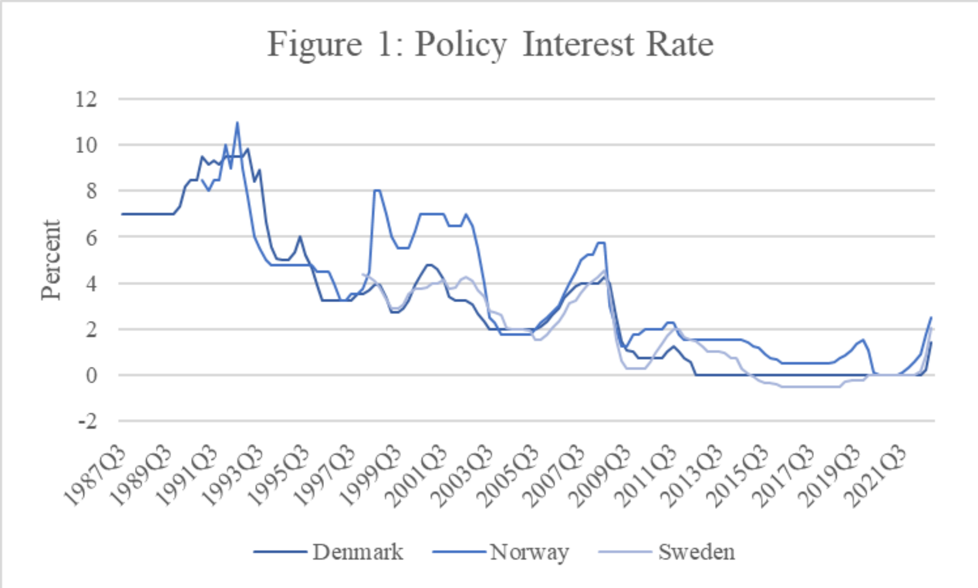


Figure 1: Policy interest rate in Denmark, Norway, and Sweden from 1987Q3 to 2022Q4

The two categories of monetary policies investigated in this paper are conventional and unconventional. Conventional monetary policy entails changing the policy interest rate and is the primary monetary measure central banks use to reach their inflation target (Sveriges Riksbank, 2023a). Unconventional monetary policy is used when conventional monetary policy is either ineffective or constrained (Reserve Bank of Australia, 2023). Sweden has officially used unconventional monetary policies, and while Denmark and Norway have not officially used unconventional monetary policies, their balance sheets have indicated otherwise (Grahn & Mammos, 2021; Rosenberg, 2019).

This paper's expansionary conventional monetary policy is modeled as a decrease in the policy interest rate. There are several types of unconventional monetary policies. However, this paper will only model one: quantitative easing. Quantitative easing consists of central banks setting a numeric target for buying or selling assets to private banks (Reserve Bank of Australia, 2023). It can both devalue or increase the value of money in the financial system, affecting the economy's price development. Quantitative easing acts through the asset price channel, a transmission mechanism affecting the inflation rate.

The research field investigating unconventional monetary policies' effects on house prices and other real economic variables has been sparse. Some previous research, including Hülsewig & Rottmann (2021), investigated the effect of different unconventional monetary policies on house prices in the euro area using a local projections method. Rosenberg (2019; 2020) investigated the effect of unconventional monetary policies using a vector autoregressive (VAR) model in Denmark, Norway, Sweden, and Finland. Renzhi (2022) investigated the effects of unconventional monetary policy on house prices and other economic variables using a structural VAR (SVAR) in Japan.

This paper aims to contribute to the existing literature concerning the impact of monetary policies on housing prices in Scandinavia by employing local projections. It has not been done before, meaning that this paper is an essential contribution to an unexplored research area with a new method. The method simulates predictions and differs from the frequently used VAR method by estimating an equation for each period in the simulation. In doing so, the external validity of previous research on the relationship between unconventional monetary policies on house prices, specifically in Scandinavia, will be examined. The model will consist of two policy shocks. The model was based on quarterly time series data from 1986 to 2022[1]. The impulse responses on the endogenous variables will be simulated in the short term over three years consisting of 12 quarters.

The rest of the paper proceeds as follows. The second section will present previous literature on monetary policies and house prices. The third section describes the economic structures of Sweden, Norway, and Denmark, their monetary policy objectives, exchange rate regimes, and the respective mortgage industries. Transmission mechanisms and the two categories of monetary policy measures will also be described. In addition, the potential impact on the effectiveness of monetary policies of the impending Basel III regime will be discussed. The fourth section will present the data used. The fifth section will present the local projections method and its theoretical framework, and the sixth section will consist of the results. The seventh section will discuss the results compared to previous research, the possible implications, and the limitations and suggestions for future research. The eighth section will conclude.

[1] For an overview of the size of dataset see Table 4.1.

2. Previous Research

Previous research[2] concerning the relationship between monetary policies and house prices is intricate and touches upon tangent variables. The previous research will be exemplified by the proceeding chapter, reviewing it in four parts. The first part will consist of a literature review by Leung, highlighting the importance of investigating the housing-macroeconomic nexus. The second part will include research investigating the relationship between monetary policies and wealth distribution. The third part will present studies investigating different factors that affect house prices. Different factors include currency unions and monetary policies. Finally, the chapter will conclude with a summary of articles investigating the relationship between unconventional monetary policies on the housing market variables such as house prices and foreclosures.

A vital perspective for understanding the importance of house prices is presented in "Macroeconomics and Housing: A Review of the Literature" by Leung (2004). In Leung's literature review, housing is described as an integral part of the economy in three ways. First, most of a household's expenditures are diverted to housing. The second reason is that the residential capital stock is larger than the capital or business stock. The third reason is that residential investments are higher than business capital investments. Since Leung's paper, more studies have been conducted on the role of house prices.

The first relevant area of research involves studies investigating the interrelationship between monetary policies and households' wealth. In Hohberger, Priftis & Vogel (2020), conventional and unconventional monetary policies were found to affect wealth and income distribution. At the same time, Barba and Pivetti (2009) showed that income distribution and income inequality increase household debt, which means that monetary policies affect household wealth which is mediated through household debt. This is due to households' wealth consisting of assets that are divided into financial and non-financial assets, where income is a financial asset and residential property is a non-financial asset. Liabilities include household debt.

Additionally, as shown by Mian and Sufi (2018), high levels of household indebtedness depreciate long-term the economic growth rate of advanced economies. Household

[2] A summary of the previous research can be found in Table 1.

indebtedness is substantial since economic growth increases the possibility of an increase in the overall level of wealth in an economy. A decline in economic growth could decrease the growth of households' wealth. Mian and Sufi investigated the connection between household debt and financial risk. They found that an expansion in credit supply was affected by household demand and that credit supply drove the business cycle. The authors described a correlation in the relationship between household debt and the GDP growth rate. Credit supply expansions increased the household debt-to-GDP ratio, which drove a boom-bust cycle. Credit demand shocks are made up by changes in households' permanent income, beliefs, and demographic. The credit supply shock consisted of an increased willingness to lend to households independent from the income of households and borrowers.

The second area of research is investigating factors that affect house prices. Goodhart and Hofmann (2008) assessed the link between house prices, credit, money, and economic activity in industrialized countries. They found a multidirectional link between these variables, and the link between monetary variables and house prices was more robust in recent years. Lastly, they found that the effects on money and credit are stronger when house prices are booming. Musso, Neri, and Stracca (2011) showed, using a SVAR model, that the housing market in the US and euro area propagates monetary policy shocks. Rabanal and Aspachs-Bracons (2011) used a VAR model to investigate the effects of a housing demand shock in a counterfactual context if Spain had not become a European Monetary Union (EMU) member compared to when they were. They found that the loss of monetary autonomy did not increase the sensitivity of house prices to the boom-and-bust cycle. Thus, membership in currency unions does not change the susceptibility to house demand shocks.

The third area of research is studies investigating the effects of unconventional monetary policies on the housing market. Two studies investigated unconventional monetary policies and their effects on the transmission mechanisms through the housing market on other real economic variables are Renzhi (2022) and Huber and Punzi (2020). Renzhi investigated the effects of unconventional monetary policies on house prices in Japan. He found that house prices provide a vital transmission channel for unconventional monetary policy on other macroeconomic variables such as GDP, residential investment, inflation rate, and mortgage loans. The transmission mechanisms worked directly through the cost of housing and the indirect transmission mechanisms work through both wealth and collateral effects. The study by Huber and Punzi focused on investigating two types of unconventional monetary policies, quantitative easing and forward guidance, and if they changed the transmission mechanisms to the housing market. They found that unconventional monetary policies did not change the transmission mechanisms. These studies highlight the importance of the housing market and its role in providing transmission mechanisms for unconventional monetary policies.

Similar to this paper, five other studies have investigated the direct effects of unconventional monetary policies. Grahn & Mammos (2021) investigated the effects of unconventional monetary policy, specifically quantitative easing, and its potential spillover effects on real economic variables, such as housing prices in Scandinavia, with the help of Bayesian SVAR (BSVAR). They found that quantitative easing had a positive effect on house prices. Similarly, a study by Rahal (2016) also investigated the effects of different unconventional measures on house prices in Sweden, Norway, and the euro area. He used VAR and found that house prices were positively affected by an expansionary policy shock. The results illustrate that despite the different exchange rate regimes of the Scandinavian countries and the euro area, the effect was in the same direction. In contrast, Chiang, Sa-Aadu & Shilling (2015) found that a constrained market such as the US exhibited minor sensitivity in housing prices with fluctuations induced by quantitative easing. They also found that in the occurrence of a build-up in the number of single-family homes-for-rent, the housing rate started decreasing.

Rosenberg (2019) investigated the effects of conventional and unconventional monetary policies on house prices in Scandinavian countries with a SVAR. The conventional monetary policy shock was modeled as a policy rate shock, while the unconventional monetary policy shock was modeled as a balance sheet shock. The results showed that an expansionary shock in both exogenous variables positively affected house prices in all countries. The effect of a balance sheet shock in Norway was slow-moving compared to Sweden and Denmark. Another observation was that a balance sheet shock had a larger and more persistent effect than a policy rate shock in all countries. The unexpected finding was that the effects were similar in all countries despite having different monetary policy regimes and levels of monetary autonomy. The author suggested that the results could be generalized to other small open welfare economies. Rosenberg (2020) also investigated the effects of expansionary conventional and unconventional monetary policy on house prices in Finland using a BSVAR. Where the conventional monetary policy and unconventional monetary policy shock both positively affected house prices, these studies imply that house prices increase due to expansionary unconventional monetary policies in the euro area and the northern European countries.

Hülsewig and Rottmann (2021) found that ECB's expansionary unconventional monetary policies stimulated the economy and increased house prices. The authors calculated real house prices by deflating the index of nominal house prices with the GDP deflator. The nominal house price ratio consisted of the index of nominal house prices to the nominal output per capita index. The size of the shock was equal to one standard deviation. According to Hülsewig and Rottman, the ECB's use of unconventional expansionary measures decreased the risk of deflation and removed risk premia on government bonds. In addition, nominal house prices increased relative to nominal output per capita, which increased household debt and financial stress. Hülsewig and Rottman's study supports Mian and Sufi's findings that household debt and financial stress are procyclical and deepen the analysis by presenting house prices as a determinant of households' indebtedness.

Finally, other studies have investigated the effect of unconventional monetary policies on other parts of the housing market, excluding house prices. For example, Gabriel and Lutz (2017) found that expansionary unconventional monetary policy shocks reduce foreclosures in the US. However, the underlying economic mechanisms indicated that increasing employment has a vital role in the monetary-induced decreased foreclosures. They also found that the Fed policy areas were hit hard during the housing crisis.

Author	Location & date	Model, estimation	Key results
Chiang, Sa-Aadu & Shilling	USA, 2015	Structural Econometric Model	Constrained markets exhibit small sensitivity in housing prices with fluctuations induced by quantitative easing. If there is a build-up in single-family homes for rent, the shadow liquidity risk exerts a negative pressure

			on investments for single-family housing.
Gabriel & Lutz	USA, 2017	SVAR, Factor-Augmented VAR,	Foreclosures are reduced by expansionary unconventional monetary policy shocks. However, the underlying economic mechanisms indicate that employment increases have a vital role in the monetary-induced decreased foreclosures.
Huber & Punzi	USA, 2020	Time-Varying Parameter VAR	Quantitative easing and forward guidance did not change the monetary policy transmission mechanism to the housing market.
Hülsewig & Rottmann	European countries, 2021	Local projections	Expansionary monetary policy shocks related to unconventional policy measures increased real house prices. Relative to the nominal output, house purchases increase, leading to household debt.
Mian & Sufi	Comparative, USA, and other countries, 2018	Literature review	An expansion in credit supply through household demand is a vital business cycle driver.
Rahal	OECD countries, 2016	PVAR	Mortgage rates initially decreased by 5-6 basis points following a 3 percent balance sheet shock. However, residential investments responded more strongly than house prices.

Renzhi	Japan, 2022	SVAR	UMP shocks significantly affect house prices, affecting other macroeconomic variables. They concluded that house prices provide important transmission channels for unconventional monetary policy.
Rosenberg	Scandinavia 2019	BSVAR	Balance sheet shocks give house prices higher peaks and are more persistent than policy rate shocks.
Rosenberg	Finland, 2020	BSVAR	Both policy interest rate and balance sheet shocks have a temporary positive effect on house prices. This effect's peak arrives faster than the euro area; however, the peak is smaller.

Table 1: Summary on previous research of the housing-macroeconomic nexus

3. Background

This chapter presented the economic structure of the three sample countries: Sweden, Norway, and Denmark. In addition, this chapter presented conventional and unconventional monetary policy measures and the transmission mechanisms through which they affect the inflation rate. Finally, this chapter discussed how the pending implementation of the Basel III regime might mitigate the effect of expansionary monetary policies.

3.1. Economic Structure of the Scandinavian Countries

3.1.1. Monetary Policy Objectives in Scandinavia

The three Scandinavian countries investigated in this paper include Sweden, Denmark, and Norway. All three countries' central banks aim at ensuring financial stability and economic growth by achieving specific monetary policy objectives. The main objective of the Swedish Central Bank (Sveriges Riksbank) is to ensure an inflation target of around two percent (Sveriges Riksbank, 2023b). Secondary goals include maintaining sustainable development of output and employment rate (Sveriges Riksbank, 2022). The main objective of the Danish Central Bank (Danmarks Nationalbank) is to ensure price stability. Similarly to Sweden, Danmarks Nationalbank ensures price stability through an inflation target of two percent. Both central banks are also in charge of physical money and the government's transactions, including borrowing and debt (Danmarks Nationalbank, 2023a).

Similarly to its Scandinavian neighbors, the Norwegian central bank (Norges Bank) has an inflation target of two percent and aims to stabilize output and employment (Norges Bank, 2023a). For all three countries, the central banks' main objective is to ensure financial stability through an inflation target and ensure sustainable output and employment rate development. The similarities in monetary policy objectives between the three sample countries likely affect what type of measures they implement.

3.1.2. The European System of Central Banks and the Exchange-rate Regimes

Two factors that affect the monetary autonomy of the Scandinavian central banks: membership in the European System of Central Banks (ESCB) and their type of exchange-rate regime. The first difference between the Scandinavian countries is that Sweden and Denmark are members of the European Union (EU) and part of the European System of Central Banks (ESCB). The ESCB comprises all the EU member's central banks and the European Central Bank (ECB). All members are tasked with implementing the single monetary policy to eventually become part of the euro area monetary union (Danmarks Nationalbank, 2023b). Unlike Sweden and Denmark, Norway does not belong to the EU and is not a part of the ESCB.

The second difference is that Sweden and Norway have a floating exchange rate regime, unlike Denmark. Sweden and Norway abandoned their fixed exchange rates in 1993 and adopted floating exchange rates to have a larger influence over the inflation rate and ensure financial stability (Norges Bank, 2023b; Sveriges Riksbank, 2019). The change to the floating exchange rates was an outcome of the disintegration of the Bretton Woods system. The Bretton Woods system consisted of rules for managing exchange rates between countries (Zarei, Ariff & Bhatti, 2019). The disintegration of the Bretton Woods system and the failed attempt at early economic coordination among European countries, the "Snake in the Smithsonian tunnel" eventually resulted in previously fixed currencies becoming floating (De Groot, 2019). Despite this, Denmark kept its fixed exchange-rate regime which consists of keeping the Danish krone stable against the euro (Danmarks Nationalbank, 2023c).

As mentioned previously, the main monetary policy objective of the Scandinavian central banks is financial stability. However, the available monetary policy tools and the autonomy in choosing them for a central bank differ depending on the country's exchange-rate regime. In this regard, Norway out of the three Scandinavian countries could be speculated as having the most monetary autonomy due its floating exchange rate regime, remaining outside of the EU and not being a member of the ESCB (Eitrheim & Qvigstad, 2020; Norges Bank, 2021). Sweden has a floating exchange rate regime yet belongs to the ESCB, making it, in theory, the second-to-least in monetary autonomy. The least independent country is Denmark due to having a fixed exchange rate regime and belonging to the ESCB. The differences in monetary autonomy between the Scandinavian countries could affect the transmission mechanisms of monetary policy on housing prices.

3.1.3. Mortgage Industry in Scandinavia

The housing market variables in this paper consist of house prices and mortgage interest rates. The mortgage industries in Sweden, Norway, and Denmark differ in some aspects. Thus, the effectiveness of transmitting the effect of policy measures and house prices depends on the central banks' ability to affect market rates with its policy rate and, by doing so, affect mortgage rates. In Denmark, the only financial institutions allowed to lend loans on real property are mortgage banks. According to *Finans Danmark,* the Association of Danish Bankers & Mortgage Bankers (2023), the Danish mortgage model is one of the most effective models for mortgage lending in the world. They state that the loan rates are low and transparent with specific repayment terms, and the model stabilizes Denmark's economy and helps sustain financial stability. Mortgage banks employ a balance principle that restricts the market risk that mortgage banks can acquire. Thus, it balances the lender's tidal lending and the bonds that fund the lending. The housing ownership rate in 2021 was 59.2 (European Mortgage Federation, 2022).

Norway and Sweden have the same average maturities for mortgage loans as Denmark. They also have a mix of fixed and floating interest-rate mortgages. In Sweden, many different financial institutions can issue mortgage loans. Banks and credit market institutions issue most (99 percent) mortgages. The latter has about 70 percent of the market share, while the former has around 25 percent. The ownership rate was 59.2 percent in 2021. For Norway, the entities that issue mortgage loans are banks, credit institutions, and state lending institutions where the first two have most of the market shares. Norway has a subsidy so that vulnerable households can take loans with more advantageous interest rates. The Norwegian mortgage market is also determined by the high ownership rate, where around 76 percent of households own their homes. (European Mortgage Federation, 2022)

The differences between the Scandinavian countries' mortgage industries can be summarized in the following. Due to the separate mortgage banks in Denmark, Danish mortgage loans are much more in favor of the credit-taker. The second difference is that Norway has an exceptionally high ownership rate of 76 percent compared to both Sweden's rate of 64.9 percent and Denmark's rate of 59.2 percent. The differences in mortgage structure will likely cause differences in the responses to shocks in monetary policies.

3.2. Monetary Policy Measures

Monetary policy tools can be divided into two categories: conventional and unconventional. Different policy tools affect the inflation rate and economic variables through different transmission mechanisms. There are several transmission mechanisms, but the two transmission channels relevant to this paper are the interest rate and asset price channels (Cecioni, Ferrero & Secchi, 2017; Sveriges Riksbank, 2023d). This paper assumes that the conventional monetary policy primarily acts through the interest rate channel while the unconventional monetary policy acts primarily through the asset price channel. In line with economic intuition the transmission mechanisms are assumed to affect house prices through mortgage rates.

3.2.1. Conventional Monetary Policy

Conventional monetary policy consists of changing the central banks' policy interest rate. When central banks change the policy interest rate, it affects the interest rates of other financial institutions, such as private and mortgage banks, through the interest rate channel. The interest rate channel transmits the effects of a monetary policy on the inflation rate in the following way. An expansionary monetary policy entails a decrease in the policy interest rate affecting the overnight lending rate between the central bank, private banks, and other financial institutions (Romer, 2019). The market interest rates will, as a result, decrease. Since the market interest rates decrease, households and firms will begin to consume and invest more, effectively increasing their borrowing rate. The mortgage interest rates will also decrease, and households will increase their mortgage loans since they are profitable. As a result, the aggregate consumption will increase, increasing aggregate demand. Since consumption and demand increase, the inflation rate will begin to increase. This will raise the overall price level in the economy, and house prices will begin to increase as well (Reserve Bank of Australia, 2023; Sveriges Riksbank, 2023a).

This study assumes that an expansionary conventional monetary policy acting through the interest rate channel will also affect the mortgage interest rate.

3.2.2. Unconventional Monetary Policy

The other category of monetary policy tools is called unconventional. The policy tools that are considered unconventional are forward guidance, quantitative easing, negative policy rates, adjustments to market operations, and term funding facilities (Reserve Bank of Australia, 2023). This paper focuses solely on quantitative easing.

The Scandinavian countries' use of these unconventional measures differs officially. Sweden is the only country to state that they have used unconventional measures such as asset purchasing (Sveriges Riksbank, 2021). Norway and Denmark have not outright stated that they have used unconventional monetary policies. However, as mentioned in previous research by Grahn and Mammos (2021) and Rosenberg (2019), inspecting the central banks' balance sheets of both Denmark and Norway shows that both countries have used asset purchasing.

Quantitative easing consists of asset purchasing and sales, where government bonds are often the type of traded asset when using this type of unconventional measure. In practice, quantitative easing entails that the central bank sets a target for the number of assets which should be purchased to affect market interest rates. Empirical evidence from Weale and Wieladek (2016) shows that quantitative easing significantly affected real economic variables such as the consumer price index (CPI) and GDP per capita. Additionally, empirical evidence shows that the effect of quantitative easing does not differ in magnitude compared to conventional measures. Based on this previous research, conventional and unconventional measures might have an effect of equal magnitude on target variables. Their effect on the inflation rate is equal. The advantage of one category of policy measure over the other depends on their potential spillover effects on the rest of the economy.

The unconventional measure of quantitative easing acts primarily through the asset price channel. Through this transmission mechanism, the policy measure affects the inflation rate and the real economy (Reserve Bank of Australia, 2023). The economic intuition is that through the asset price channel, Central banks can change the relative supply of the assets being purchased by purchasing a large number of assets held by the private sector which induces changes in the relative yields of the assets. The sellers of these assets might rebalance their portfolios by buying other assets with similar components to those they sold. Thus, the prices of the purchased assets and their close substitutes increase, making the associated term premiums and yields decrease (Thornton, 2014). This decrease in yield affects other market interest rates, making loans more advantageous for borrowers. As a reaction, households and firms will borrow more, increasing aggregate consumption and aggregate demand, eventually increasing overall prices and the inflation rate.

3.2.3. The Basel Regime and the Expectations Channel

Basel II is an international framework for bank regulation; however, Basel III is pending implementation, and the process differs for the countries (Hull, 2023). Basel III differs from its predecessor by setting higher standard capital requirements for banks to minimize the risk of bank runs. Its implementation is driven by the lack of financial regulations in Basel II and how this partly led to the Great Financial Crisis in 2008. At the time of writing this paper Basel III regime had yet to be implemented (FSB, 2022).

Basel III will demand that private banks adhere to stricter capital requirements (FSB, 2022). The effect could be that private banks will have less capacity to buy or own government bonds than before. The economic intuition is that the price of bonds will decrease, and their yield will increase. The increase in yield will increase other interest rates and spread to other financial markets, which as a result, will lead households and firms to borrow less. Since households and firms will borrow less than before, consumption will decrease, and aggregate demand will follow. A decrease in aggregate demand decreases the inflation rate. While Basel III has not been implemented yet, the financial sector might experience an anticipation effect before the implementation. An anticipation effect acts through the expectation channel. The expectation channel is a transmission mechanism where signals from the central bank and other financial actors about their expectations of the future inflation rate affect today's investments (Sveriges Riksbank, 2023a). A potential anticipation effect of the Basel III regime constitutes a problem if the central bank implements an expansionary monetary policy simultaneously (Hull, 2023).

From economic intuition, it follows that if the central bank implements expansionary quantitative easing to increase the market rates, the anticipatory effect of the Basel III Regime will mitigate it and effectively decrease the effect of unconventional monetary policy on the inflation rate. Similarly, suppose the central bank instead implements an expansionary conventional monetary policy, decreasing the policy rate and affecting the market rates. In that case, the Basel III anticipation effect will also dampen the effect. This means that while Basel III has been pending implementation since 2015 (Hull, 2023), it could be speculated that the private financial sector has been anticipating it and as previously illustrated, dampened the effect of quantitative easing by central banks.

4. Data

The data used in this essay consists of the house price index (here on denoted HP), real GDP per capita (rGDP), mortgage interest rate (M), total assets (T), consumer price index (CPI), and the policy rate (P). All variables were treated with the natural logarithm and first differences, except for interest rates, for we only took the first differences. In addition, M and P have not been treated with the natural logarithm but were treated with first differences. All the variables were treated with natural logarithms in accordance with previous literature.

Country	HP	Type of HP	rGDP	M	CPI	P	T
Denmark	2002Q4-2022Q4	Purchases of dwellings, SA 2017 = 100	1991Q1-2022Q4	2003Q1-2022Q4	1981Q4-2022Q4	1987Q3-2022Q4	1987Q1-2022Q4
Norway	2005Q1-2022Q4	Existing dwellings, SA 2015 = 100	1980Q1-2022Q4	2008Q4-2022Q4	1980Q1-2022Q4	1991Q1-2022Q4	1992Q1-2022Q4
Sweden	1986Q1-2022Q4	Existing single-family houses 1981=100	1981Q1-2022Q4	2005Q4-2022Q4	1987Q1-2022Q4	1998Q1-2022Q4	1987Q1-2022Q4

Table 2: Size of dataset. The variables include the house price index (HP), real GDP per capita (rGDP), mortgage interest rate (M), total assets (T), consumer price index (CPI) and the policy rate (P)

The data for the countries have primarily been collected from the respective countries' governmental statistical databases. For Denmark, most of the data was collected from Danmarks Statistik (DST), for Norway from Statistisk sentralbyrå (SSB), and for Sweden from Statistics Sweden (SCB). A description of the statistics can be found in Data Sources. The length of time for the data is displayed in Table 2, and the descriptive statistics are displayed in Table 3.

Variables:	Real GDP	HP	M	CPI	T	P	POP
Denmark							
Max	570 417	133	6,50	117	725	10,83	5 928 364
Min	325 162	76	1,52	33	92	-0,60	5 129 049
Mean	442 752	98	3,46	77	350	3,15	5 457 246
Standard deviation	63 067	15	1,53	21	171	3,23	231 491
Number of Observations	128	72	80	172	144	141	140
Norway							
Max	936 312	143	6,88	160	13 373	11,00	5 488 984
Min	341 706	53	1,85	22	162	0,00	4 078 900
Mean	634 857	95	3,21	65	3 828	3,40	4 628 025
Standard deviation	177 649	25	0,90	29	4 006	2,63	436 461
Number of Observations	172	72	57	172	124	128	172
Sweden							
Max	1 403 754	1054	5,24	251	1 584	4,54	10 518 935
Min	563 883	111	1,48	98	179	-0,50	8 317 937
Mean	927 751	423	2,74	175	558	1,61	9 098 600
Standard deviation	250 549	253	1,10	35	406	1,67	638 334
Number of Observations	168	148	69	144	93	100	172

Table 3: Descriptive statistics, unedited. the real GDP in millions of the local currency (real GDP), house price index (HP), mortgage rate (M), consumer price index (CPI) with different indexed years, central banks' total assets in millions of local currencies (T), policy rate (P), and population (POP).

4.1. Data Sources

4.1.1. Denmark

For Denmark, the Real GDP data was taken as the quarterly seasonally adjusted, 2010-prices chained values, gross domestic product in millions of DKK from the *1-2.1.1 Production, GDP and generation of income (summary table) by seasonal adjustment, transaction, price unit and time* by Statistics Denmark (2023). It was calculated as real GDP per capita by dividing each period by the respective population at that same period. The data for the population was also taken from Statistics Denmark. From 2008Q1 (quarter 1) to 2022Q4 the *Population on the first day of the quarter by marital status, age, sex, region, and time* was used, from; 1990Q1 to 2007Q4, the *Average population, by quarter, by account, and time* (NATK10) was used and from; 1980Q1 to 1989Q4 *Average population, by quarter, by account and time* (NATK10X).

The data for the house price index was collected from Statistics Denmark (2023). It is purchases of dwellings that are *Seasonally adjusted sales of property by unit, region, property category, and time* with an index of 2017=100. The data consisted of one-family houses, weekend cottages, and owner-occupied flats separately, which we took the average of to obtain an overall house price index. This data ranged from 2005Q1 to 2022Q4.

The mortgage interest rate was also collected from Statistics Denmark (2023). The annualized agreed rate for households included the administration rate from the *Outstanding domestic mortgage loans from mortgage banks by currency, domestic sector, data type, and time* category. This data ranged from 2003M01 (month 1 = January) to 2023M03 (month 3 = March). The monthly data was altered by taking the average of 3 months to make a quarter. For example (2003M01+2003M02+2003M03)/3 = 2003Q1.

The consumer price index is indexed at 2015=100 and is monthly. The CPI data was collected from Statistics Denmark (2023), and it was converted to quarterly data by the same method as the mortgage interest rate. The monthly data ranged from 1980M01 to 2023M03.

The data for Denmark's policy rate was also collected from Statistics Denmark (2023). We used the *End-month, The Nationalbanks official rates - Current-account deposits (Aug 1987-)*

from the category *Interest rates by methodology, country, item, and time*. The monthly data was converted to quarterly data by the same method as the mortgage interest rate and the CPI.

Denmark's Central Banks total assets data was collected from (Danmarks Nationalbank, 2023e), specifically, the *Specification on Danmarks Nationalbank's balance sheet by specification and item - Stock (1987M01-2023M04)*. As evidenced by the name, the monthly data ranged from 1987M01-2023M04, and was expressed in billions of DKK. The monthly data was converted to quarterly data as it was for the other monthly data.

4.1.2. Norway

The quarterly data for Norway's real GDP was obtained from Statistics Norway (2023). We used the *Constant 2020 prices, seasonally adjusted (NOK million), Gross domestic product, and market values* from *09190: Final expenditure and gross domestic product, by macroeconomic indicator, quarter, and contents*. The data ranged from 1978Q1 to 2022Q4. As we did for Denmark, the real GDP per capita was calculated by dividing the real GDP by the population. The data for the population was also obtained from Statistics Norway and ranged from 1997Q4 to 2022Q4. It was called *Population at the end of the quarter* and was found in *01222: Population and changes during the quarter, by region, quarter, and contents*. No further changes were made to the data.

The house price index for Norway was also collected from Statistics Norway (2023). The seasonally adjusted quarterly price index for existing dwellings was found in *07221: Price for existing dwellings, by region, type of building, quarter, and contents*. It ranged from 2005 Q1 to 2023Q1.

The data for the mortgage interest rate was gathered from the category *07200: Interest rates on outstanding loans (percent), by the financial corporation, type of loans, sector, quarter, and contents* (Statistics Norway, 2023), and ranged from 2008Q4 to 2022Q4. The under category used were *Total (excl. The Norwegian Public Service Pension Fund)), Loans secured on dwellings in total, and Interest rate on outstanding loans*.

Norway's consumer price index data was gathered from Statistics Norway (2023). It was gathered from the same category as the real GDP data, *09190: Final expenditure and gross* *domestic product, by macroeconomic indicator, quarter, and contents*. The data was seasonally adjusted and ranged from 1978Q1 to 2022Q4 with an index of 2020=100.

The data for the exogenous variable, total assets, was gathered from Norges Bank (2023c). It was monthly data ranging from 1992M01 to 2023M02 and expressed in millions of NOK. It was calculated into quarterly data as previously.

The data for the second exogenous variable, policy rate, was gathered from Statistics Norway (2023). Two datasets constructed this variable. The first was quarterly (*09381: Money market rate (NIBOR), key policy rate, the interest rate on bank's overnight loans (D-loans) and interest rate margins (percent), quarterly (closed series) 1979K4 - 2014K2*) and ranged from 1991Q1 to 2014Q2. The second data set was monthly (*10701: NIBOR og Norges Banks' folio interest rate (percent) 2013M12 - 2023M03*) and ranged from 2013M12 to 2023M03. In both datasets, the variable used was *Sight deposit rate (key policy rate)*. The first data set was kept as is, and the second was calculated into quarterly data from 2014Q3 to 2022Q4. The recalculation of the monthly data to quarterly data was done as previously.

4.1.3. Sweden

The data for Sweden's real gross domestic product was gathered from Statistics Sweden (2023). It consisted of seasonally adjusted quarterly data from 1981Q1 to 2022Q4 with an index of 2021=100. It was found under the category *GDP: expenditure approach (ESA2010) by type of use, seasonally adjusted. Quarter 1980K1 - 2022K4*. Data for the population was gathered from SCB and was used to create real GDP per capita. The population data was created from two different datasets. We used a monthly dataset, *Population per month by region, age and sex. Year 2000M01 - 2023M02*, and an annual dataset ,*Population by age and sex. Year 1860 - 2022*, to create a quarterly dataset. The monthly dataset ranged from 2000M01 to 2023M02, and it was calculated into quarterly data by taking the average of 3 months to make a quarter, giving us data for 2000Q1 to 2022Q4. The annual data ranged from 1860 to 2022, and we used the moving average to obtain data for 1980Q1 to 1999Q4. These two datasets then made up the data for the population. The real GDP was then divided by the population giving us Sweden's real GDP per capita.

The house price index for single-family houses by Statistics Sweden (2023) was used in this paper. *Real estate price index for one- and two-dwelling buildings for permanent living (1981=100) by region and quarter* ranged from 1986Q1 to 2022Q4 and was indexed as 1981=100.

Sweden's mortgage rate was obtained from Statistics Sweden (2023). The monthly data from 2005M09 to 2023M03 was called *Lending rates to households for housing loans, breakdown by fixation periods* pertaining to outstanding agreements from monetary financial institutions, mortgage credit companies, and alternative investment funds to households. This monthly data was calculated quarterly as the other monthly data has been.

The data for the consumer price index was indexed as 1987=100 and was registered monthly by Statistics Sweden (2023). The name of the dataset was: *Consumer Price Index with fixed interest rate (CPIF), 1987=100. Month 1987M01 - 2023M04.* It ranged from 1987M01 to 2023M03 and was edited into quarterly data as all previous monthly data were.

The data for the exogenous variables policy rate and total assets were found at Sveriges Riksbank (2023c). The policy rate data ranged from 1998M01- 2023M03 and was recalculated into quarterly data. The total assets gathered from Sveriges Riksbank were weekly data and ranged from 1999-09-30 to 2023-03-23. This was calculated into quarterly data by taking the average of the monthly data, for example (2023-02-07 + 2023-02-15 + 2023-02-23 + 2023-02-28)/4, and then taking the average of the monthly data to create quarterly data. The final data for total assets ranged from 1999Q4 to 2023Q1.

5. Method

This chapter consists of two parts, the first is a description of the local projection method, and its merits and limitations are discussed in light of previous research. In the second part, the model specification and application are presented. The chapter concludes with a short discussion of the risk of omitted variable bias.

5.1. Local Projection Method

The local projection method has been extensively used to analyze the effects of conventional and unconventional monetary policy shocks on house prices[3]. The assumptions of the data are weak in the LP method making the impulse response functions (IRF) flexible. The LP method has an advantage over the standard VAR model, which rests on more strict assumptions (Barnichon & Brownlees, 2019). Additionally, the IRFs from a VAR model create only one equation for all horizons, which increases the risk of compounded misspecification. The LP method circumvents the same problem by creating an individual IRF for each horizon (Teulings & Zubanov, 2014). The local projections in this paper were made in R with the package named *lpirfs* made by Adämmer in 2019. The package is based on Jordá's 2005 paper.

Jordà (2005) introduced the local projection method to estimate the effects of technology shocks on macroeconomic variables. The idea behind the local projection method is to estimate a set of regression models of the variable of interest on a set of lagged variables and then use these estimated models to construct IRFs. The model estimates a set of regressions of the variable of interest on a set of lagged variables, where each regression has a different horizon. Once these regressions are estimated, the impulse response functions are constructed by plotting the estimated coefficients from each regression against the horizon. Thus, providing an estimate of the dynamic effects of the shock on the variable of interest over time. The LP method is a non-parametric approach and, in this case, preferable as we do not need to make any assumptions about the distribution of the sample. Another advantage is that it can simultaneously estimate a shock's effect on multiple variables, which helps analyze the dynamic interactions between variables. Overall, the local projection method is valuable for

[3] See for example Hülsewig & Rottmann, 2021; Jordà, Schularick & Taylor, 2015; Puy, Ari & Shi, 2020; Xie, 2019

analyzing the dynamic effects of shocks in economic systems. (See for example, Jordà (2005) or Brugnolini (2018)).

The statistical objective of identifying and calculating the impulse response function in the local projection method is to access mean-squared multi-step predictions. The maximum lag length is suggested to be determined by some information criteria, and the maximum lag length does not have to be the same for each horizon. The number of horizons to be used is determined by the lag length and dimension of the vector y (see Equations 1 and 2). The lag length and dimension of the vector y restricts the degrees of freedom, constricting the horizons to a practical number. (Jordà, 2005)

The lags are used in the model, t in Equations 1 and 2, while horizons are used for the simulation, h in Equations 1 and 2. The lag length of two quarters was selected based on the Akaike information criterion (AIC) (Akaike, 1974). Two lags were the optimal lag length for the variables, and countries and two lags were used for all variables to simplify the method. The lag length also aligns with some previous research, such as Hülsewig & Rottmann (2021). Their LP method used two lags (quarterly data) when looking at house prices and unconventional monetary policy surprises in the euro area.

5.1.1. Merits and Limitations of the Local Projection Method

The local projection method has been criticized by Kilian and Kim (2011). They investigated the performance of confidence intervals for impulse responses based on LP and VAR models in linear stationary settings. They found that the bias-adjusted bootstrap VAR interval in small samples is often more accurate than the asymptotic LP interval, despite the LPs having a longer average length. While the asymptotic LP interval achieves sufficient coverage in larger samples, its average length remains longer than the comparable bias-adjusted bootstrap VAR intervals. Kilian and Kim concluded that bootstrap LP intervals, with or without the bias correction, and asymptotic VAR intervals tend to be shorter on average. However, they may not achieve the necessary coverage accuracy in limited data scenarios.

Brugnolini (2018) proposes methods for making the LP method more reliable and even a competitive estimator of VAR. Brugnolini compared the performance of the LP estimator with the VAR IRF estimator and found that when using AIC to select lag length order, the LP is a better estimator than was shown in the paper by Kilian and Kim (2011). Brugnolini stated that when a well-specified VAR is used, the resulting IRFs are accurately specified, with any distortion only stemming from small-sample bias. However, LP is subject to an augmented form of small-sample bias and bias resulting from model misspecification.

In addition, Brugnolini (2018) performed a Monte Carlo test with a controlled form of misspecification. The results favored the LP method when testing both VAR and LP IRFs that were misspecified. Brugnolini also performed a test with fixed lag lengths for each equation of the LP. The results demonstrated that, in the case of a misspecified model, the VAR impulse responses return a vector of points with narrow confidence bands that are far from the true values. In contrast, the LP estimator returns points closer to the true values, albeit with larger confidence bands. Brugnolini concluded that the simulations indicated that the performance of local projection IRFs improved when the lag length was selected once for all projections.

To summarize, the LP method has three advantages over the SVAR model that many researchers often use when investigating the relationship between unconventional monetary policies and house prices. The first is that LPs are simpler to estimate because they solely rely on simple linear regressions; the second is that conducting point or joint-wise inference is relatively easy; and third, the IRFs are more robust compared to when a linear VAR model is misspecified. (Adämmer, 2019)

5.2. Model Specification and Application

All variables are transformed using natural logarithms except the interest rates, similar to Grahn & Mammos (2021) and Rosenberg (2019; 2020). The endogenous and exogenous variables included in this model were selected according to previous literature. The LP method has the advantage of having lower bias than VAR estimators, as described by Li, Plagborg-Møller & Wolf (2022).

An OLS regression is made for each forecast horizon (h), as is shown in Equation 1

$$y_{t+h} = \alpha^h + B_1^h y_{t-1} + ... + B_p^h y_{t-p} + u_{t+h}^h, \quad h = 0, 1, ..., H - 1 \qquad \text{Equation 1}$$

α^h is a vector of constants, B_i^h is parameter matrices for lag p and forecast horizon h in Equation 1. The vector elements u_{t+h}^h are autocorrelated disturbances. B_1^h can be interpreted as the response of y_{t+h} to the shock of reduced form. The collection of the OLS regressions for each horizon constitutes the local projections.

Since there is an identified shock, the following equation was used:

$$y_{t+h} = \alpha^h + B_h shock_t + \phi x_t + u_{t+h}^h, \qquad h = 0, 1, ..., H - 1 \qquad \text{Equation 2}$$

α^h denotes the regression constant, x_t is a vector of control variables and $shock_t$ is the shock variable in Equation 2. B_h is the coefficient corresponding to the response of y, at time *t+h,* to the shock variable at time *t*. The impulse responses are the sequence of all the estimated coefficients, B_p^h. The equations are derived from Adämmer (2019). This paper's endogenous (y) variables are house prices, real GDP per capita, mortgage interest rate, and consumer price index. The exogenous (x) variables are total assets and policy rate, and the $shock$ variable is the policy rate and total assets separately.

This paper primarily uses the same variables as in Rosenberg (2019). However, some variables have been replaced to fit our hypothesis. Rosenberg used a BSVAR model where the central banks' GDP per capita, house price index, building permits, nominal mortgage interest rate, nominal overnight/repo interest rate, and real total assets functioned as endogenous variables. We have, however opted for using seasonally adjusted (SA) real GDP per capita (rGDP), SA house price index (HP), mortgage interest rate (M), SA consumer price index (CPI), the CBs total assets (T), and the policy rate (P), where T and P were the shocks and exogenous variables. In line with Rosenberg (2020), the real total assets are calculated as real total assets per capita. Hülsewig & Rottmann (2021) and Rosenberg (2020) modeled the policy interest rate shock and balance sheet shock as exogenous innovation; therefore, the shocks in this paper will also be modeled as such. The shock variables policy interest rate (P) and total assets (T) affect each other. This interdependent relationship is not examined in this paper since the focus lies on their separate effects on house prices and other real economic variables. However, it is crucial to be aware of the possible endogeneity. In this study, the LP estimated the impact of policy shocks primarily on house prices with a 95 percent confidence interval. The confidence interval is visible in the results, Figure 2 and 3, as the gray area surrounding the IRF.

Hülsewig and Rottmann (2021) used the LP method to estimate the effects of several unconventional monetary policy measures on house prices in the euro area. Some variables that they used included the house price index, GDP, volume and interest rate for domestic mortgage loans, shadow short rate, and monetary policy shock series. They used a model similar to Equation 2, where they had a variable of interest, monetary policy shocks, control variables, and a polynomial in the lag operator. Similarly to Hülsewig and Rottmann, we chose a lag length of 2 for quarterly data (also backed up by AIC). They did, however, use standardized monetary policy shocks, and some variables differed from the ones used in this study.

5.2.1. Omitted Variable Bias

The exchange rate is a commonly used economic variable in monetary policy research. However, it was not used in previous research investigating the effect of monetary policy on house prices of Rosenberg (2019; 2020), Hülsewig and Rottmann (2021), Iacoviello (2000), or Iacoviello and Minetti (2003). Therefore, the exchange rate has not been included in this study either. Nevertheless, it could have some impact on some of the variables that were included in this study. In other words, there is a possibility of omitted variable bias. For example, the exchange rate could potentially influence the real GDP per capita or the inflation rate, which are variables assumed by economic intuition to influence house prices.

The exchange rate is also assumed to affect capital flows from foreign direct investments, which could affect the central banks' balance sheets (Hale & Juvenal, 2023). Since the exchange rate may affect variables such as real GDP per capita and inflation, some multicollinearity between the variables may occur. However, including the exchange rate as a variable could lead to an issue where the model could become overfitted due to redundant data, leading to an under- or overestimation of the model.

6. Results

The chapter consists of the results for the conventional monetary policy modeled as a policy rate shock and for the unconventional monetary policy modeled as a balance sheet shock, and their effect on the percentage change in real house price index (HP), mortgage interest rate (M), real consumer price index (CPI) and real gross domestic product per capita (rGDP). Significant results are at a 95 percent confidence level, and the significant results are explicitly stated as significant in the following sections. If a result is not said to be significant, assume insignificance.

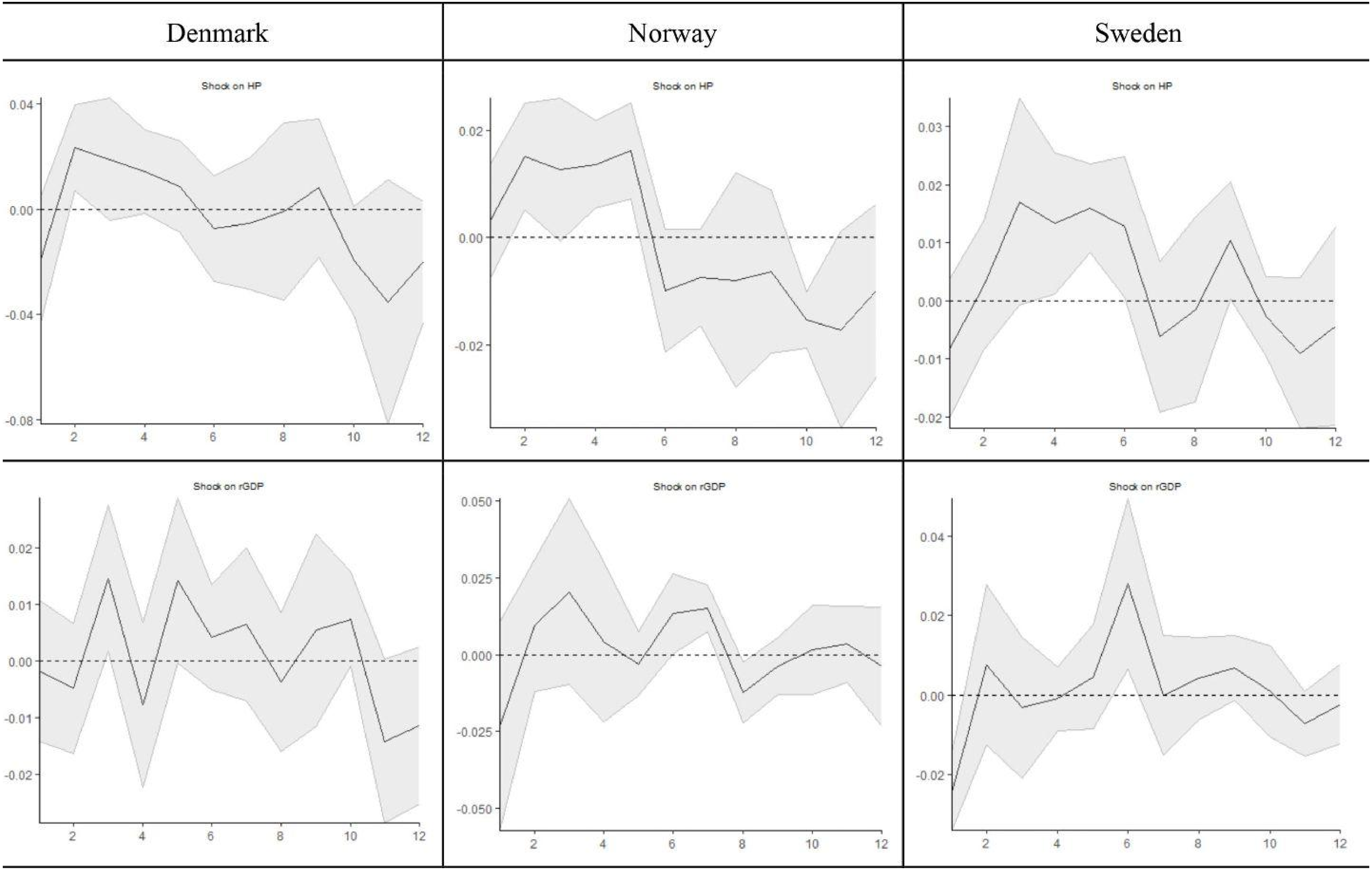
6.1. Conventional Monetary Policy Shock

Figure 2 illustrates an expansionary policy rate shock of one percentage point in Sweden, Norway, and Denmark. In Denmark, initially, HP reacted negatively but peaked in the second quarter. The peak at 0.02 percent was significant. After the peak, HP declined, and the change remained negative until the end of the time horizon. The rGDP was initially negatively affected, and afterward, it fluctuated. In the third quarter, there was a small positive statistically significant change. The rGDP was negative at the end of the horizon. The Danish M initially decreased. The decrease was only significant in the fifth quarter. The rate, however, changed and began increasing in the sixth quarter, with a significant peak in the seventh quarter. It remained positive until the end of the time horizon. Initially, CPI increased and remained positive until the 10th quarter, whereas afterward, they became negative until the 12th quarter. At the end of the time horizon, the change in CPI was zero.

An increase followed the expansionary policy rate shock in Norway in HP. The peak of about 0.0175 percent was significant in the second, fourth, and fifth quarters. The price development turned in the fifth quarter and began to decrease and became negative in the sixth quarter. After the sixth quarter, HP remained negative, significantly so in the 10th quarter, until the end of the time horizon. Initially, rGDP decreased and then increased, becoming significantly positive in the seventh quarter; however, the variable experienced fluctuations during the whole horizon. At the end of the time horizon, it was slightly negative. Initially, M had a significant decrease. Afterward, it steadily increased and became positive in the third quarter. The increase had a prolonged effect and remained positive after the fourth quarter, with two significant increases in the seventh and 11th quarters. At the end of the time horizon, M remained positive. CPI initially decreased in the first quarter and then sharply increased. They remained positive between the second and ninth quarters. Following the ninth quarter, they became negative, followed by a sharp, significant decrease in the 11th quarter. They were negative at the end of the time horizon.

The policy rate shock in Sweden resulted in HP initially becoming negative in the first quarter. However, it increased sharply to around 0.0165 percent and stayed positive between the second and sixth quarter and significantly between the fourth and sixth quarter. Afterward, they fell and began fluctuating. They ended negatively at the end of the time horizon. rGDP was initially significantly negative and then quickly became positive in the second quarter, with a significant peak in the sixth quarter. After this peak, rGDP began to decrease and became negative at the end of the time horizon. M became significantly negative initially and remained significantly negative until the fourth quarter. M increased steadily after the second quarter and became positive between the fifth quarter and 10th quarter, and it was positively significant between the eighth and 10th quarters. Nevertheless, M ended slightly negative at the end of the time horizon. CPI was initially negative and began fluctuating between negative and positive until the end of the quarter without any significant effect. They ended negatively.

A comparison of the countries exemplifies that an expansionary policy rate shock would initially decrease HP in Sweden and Denmark. All three countries experienced peaks in HP in the first six quarters. At most, Sweden changed with a significant peak at 0.016 percent, Denmark with a significant peak at 0.020 percent, and Norway with a significant peak at 0.0175 percent. The duration of these peaks differed, whereas Sweden and Denmark had a lower duration time for their peaks than Norway. Additionally, Sweden and Denmark had similar movements in HP, where both countries had the same number of peaks and had a negative house price effect at the end of the time horizon. Meanwhile, the conventional monetary policy shock in Norway initially increased HP for six quarters. The variation of HP had a higher periodicity in Denmark and Sweden compared to Norway.


Denmark
Norway
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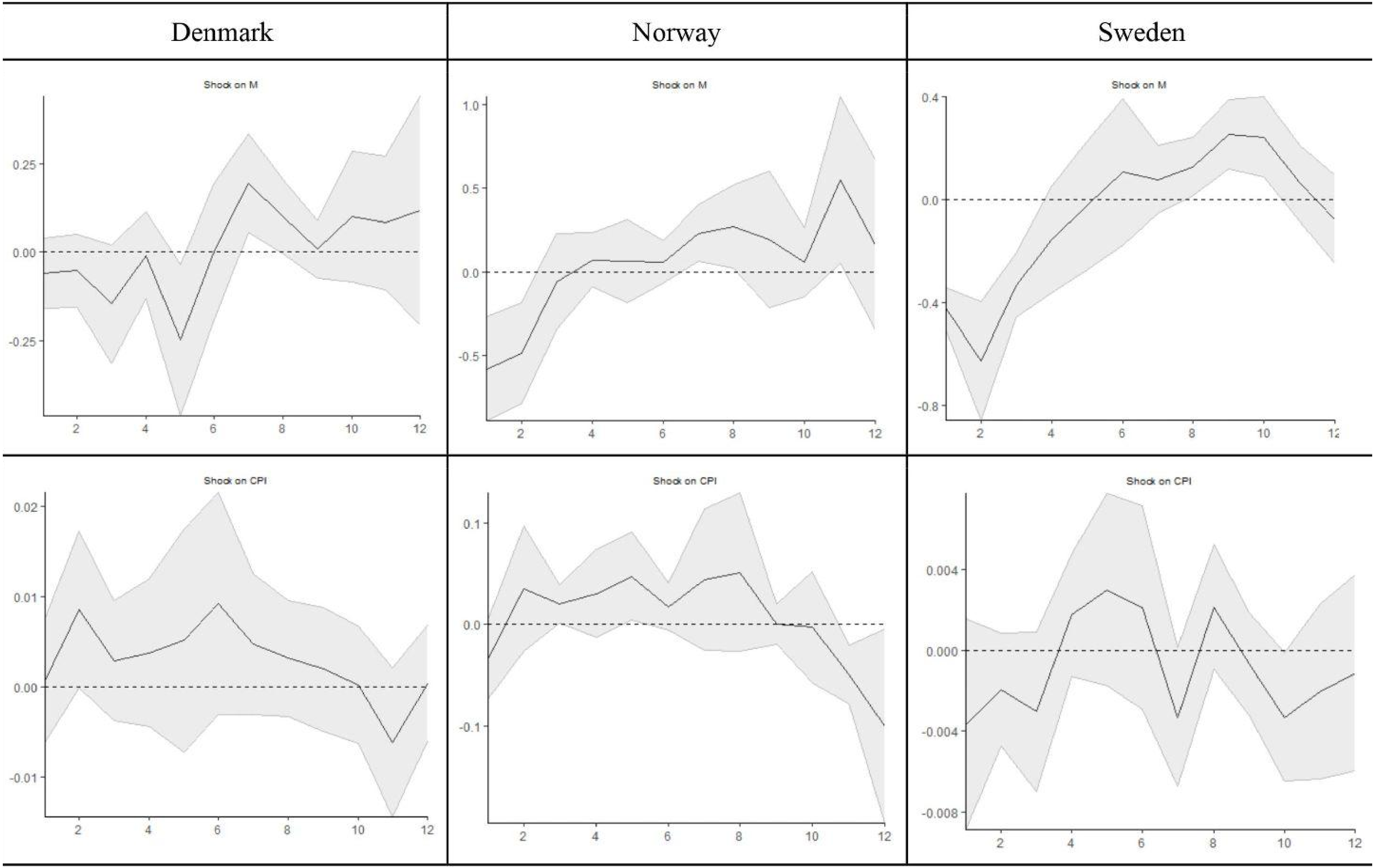


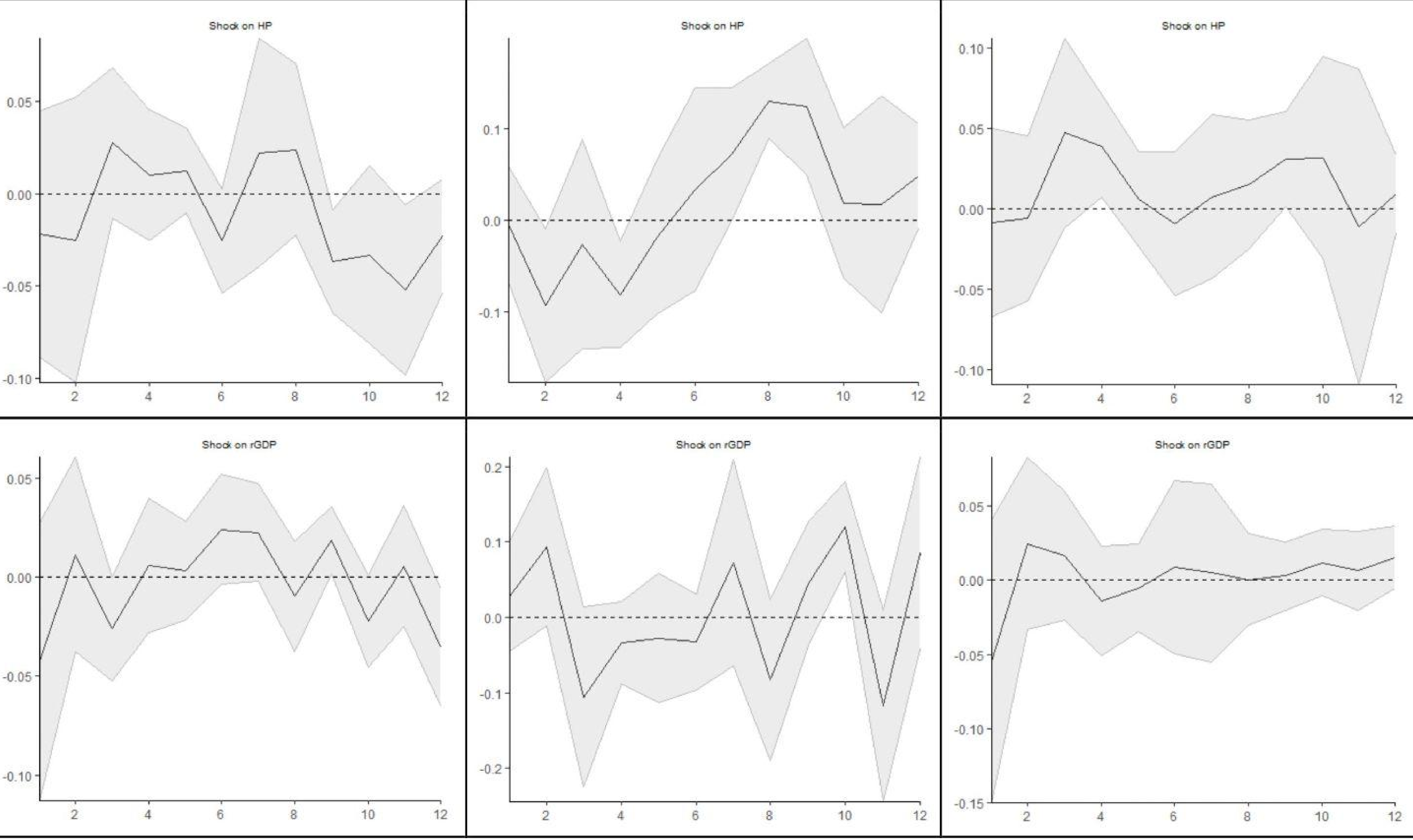
Figure 2: Impulse responses for a shock to the policy interest rate (P) on the endogenous variables House Price Index (HP), real GDP per capita (rGDP), Mortgage Interest rate (M), and Consumer price index (CPI) in Denmark, Norway, and Sweden. The shaded areas correspond to the 95 percent confidence intervals. The vertical axis displays the percentage change in the variable, and the horizontal axis displays the horizons.

6.2. Unconventional Monetary Policy Shock

Figure 3 shows the impulse responses of the positive balance sheet shock of one percent in Denmark, Norway, and Sweden. In Denmark, HP initially declined until a peak at 0.025 percent in the third quarter. After this peak, they steadily decreased and were significantly negative in the ninth and 11th quarters. After that, they remained negative until the end of the time horizon. Initially, in the first quarter, rGDP decreased. Afterward, starting from the second quarter, rGDP fluctuated, reaching a peak between the sixth and seventh quarters. It ended negatively at the end of the horizon. M initially increased and had two pronounced drops in the fourth and sixth quarters. Afterward, it increased again and stayed positive until the horizon's end. The positive balance sheet shock decreased CPI initially. After the first quarter, it increased periodically with three significant peaks in the second, sixth and between the ninth and tenth quarters. After the 11th quarter, CPI decreased.

In Figure 3, the impulse response functions of the balance sheet shock are shown for Norway. Initially, HP did not react significantly in the first quarter, but they then declined and became negative, and in the second and fourth quarters, they were significantly negative. HP remained negative but increased in the fourth quarter and became positive in the fifth quarter. Following the fifth quarter, they became positive and were significant between the seventh and the ninth quarter at around 0.12 percent. They remained positive until the end of the time horizon. Initially, rGDP became positive. It fluctuated and became significantly positive during one peak in the 10th quarter. It ended positively. Initially, M became negative, however, it experienced a sharp increase in the second quarter and showed a trend downwards. The negative trend exhibited a significant decrease in the 11th quarter. M was slightly negative at the end of the horizon. Initially, CPI was negative but peaked and became positive in the third quarter. Afterward, they quickly returned to being negative with a small negative significance in the 11th quarter. After the 11th quarter, they sharply increased and were positive at the end of the time horizon.

Denmark	Norway	Sweden



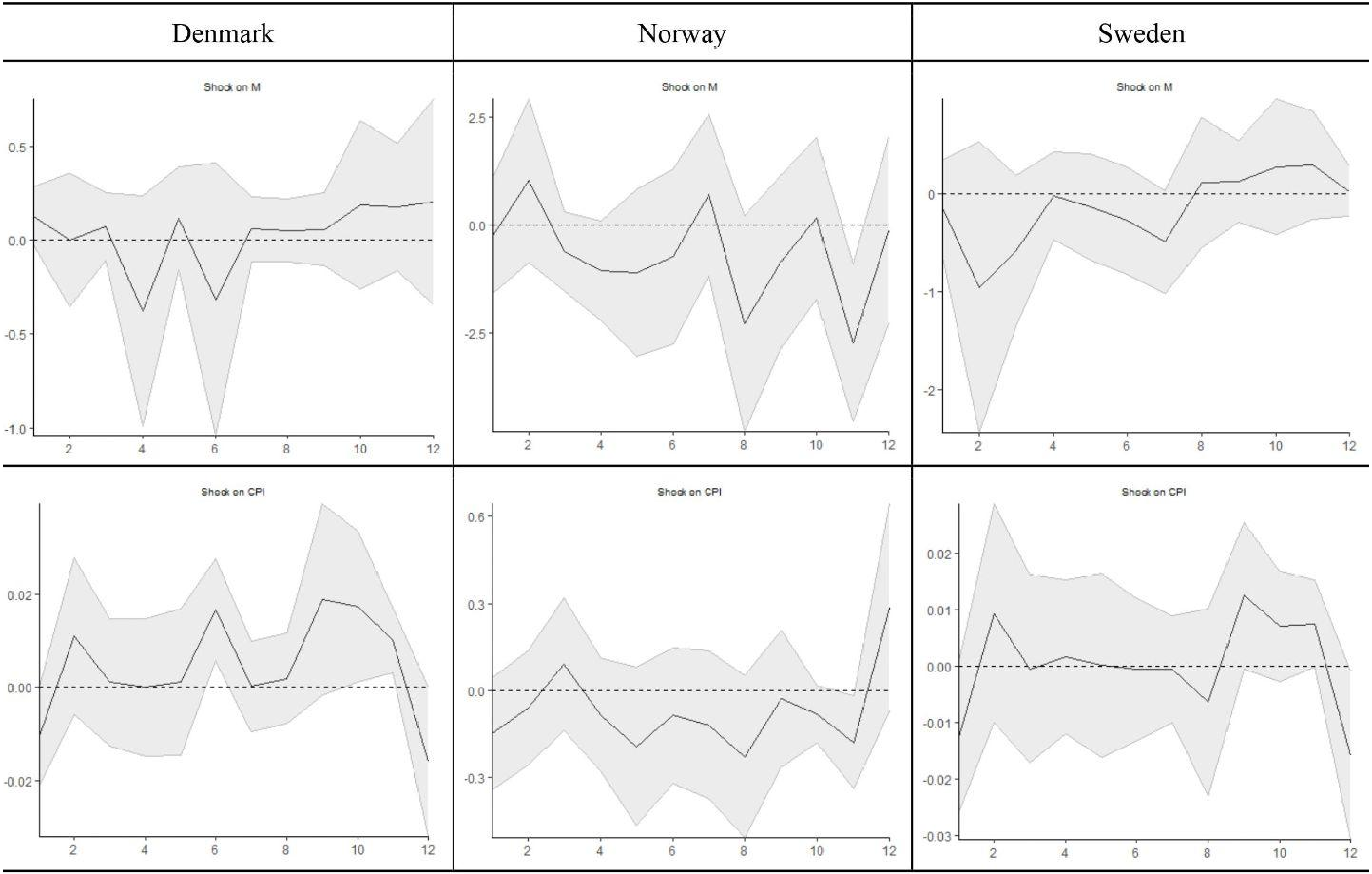


Figure 3: Impulse responses for a shock to the total assets of the central bank balance sheet (T) on the endogenous variables House Price Index (HP), real GDP per capita (rGDP), Mortgage Interest rate (M), and Consumer price index (CPI) in Denmark, Norway, and Sweden. The shaded areas correspond to the 95 percent confidence intervals. The vertical axis displays the percentage change in the variable, and the horizontal axis displays the horizons.

The effect of the balance sheet shock in Sweden shows that initially, HP decreased in the first quarter. However, they changed and peaked afterward with a significant positive effect in the fourth quarter at about 0.048 percent. Afterward, they had one additional peak in the ninth quarter and remained positive at the end of the time horizon. Initially, rGDP had a sharp decline in the first quarter and a positive price development in the second quarter. The rGDP was positive at the end of the time horizon, however, there were no significant effects. M was negative initially and became positive in the eighth quarter. The rate was still slightly positive at the end of the time horizon, although there were no significant effects. The CPI was initially negative and ended negatively but without significant effects.

Comparing the effects on HP by an expansionary balance sheet shock in the Scandinavian countries, the unconventional monetary policy shock negatively affected all three Scandinavian countries. Denmark initially experienced a negative effect on HP. During the 12th quarter, Denmark experienced two peaks with positive HP, with the largest peak at 0.025 percent. Sweden initially had a negative effect on HP. However, during the time horizon of 12 quarters, it also experienced two positive peaks. The largest peak for Sweden reached 0.048 percent. At the end of the time horizon, Sweden fluctuated close to zero. On the other hand, Norway experienced a rapid increase around the fifth quarter after the initial decrease. At the end of the third year, Norway still experienced a positive development in HP.

6.3. Robustness Check

If the results would change depending on the time range of the data implies that the results are not robust. Two robustness checks were performed to inspect whether the data was biased. The robustness check consisted of reducing the dataset's time into two reduced datasets. The first reduced dataset aimed to exclude volatile price periods such as the Covid Pandemic, beginning in 2020 and ending with the invasion of Ukraine in 2022. The second reduced dataset was to check if there was an anticipation effect before implementing the Basel III regime. The observations excluded spanned from 2013 and onwards.

For the first reduced dataset, the last two years of the data were removed, and the same type of simulation as previously was performed for the period of 1986Q1 to 2019Q4, before the pandemic and the invasion of Ukraine. The result of the robustness check showed some differences. The most notable difference in the reduced dataset occurred in the last horizons, where the results showed more extreme behavior. For example, for Swedish HP of an unconventional monetary policy shock, the last horizons displayed positive change compared to the original dataset.

For Norway, however, the results of a conventional monetary policy shock differed significantly from the results of the original dataset. The initial increase and later decrease of the Norwegian HP started later at the reduced dataset. The conventional monetary policy shock on rGDP overall also behaved differently. M behaved similarly to the results of the original dataset, while the CPI behaved very differently. The unconventional monetary policy shock in Norway did not display significant differences between the datasets. For Denmark, the IRFs for a conventional monetary policy shock behaved very similarly for both datasets. The CPI did, however, display some differences. For the unconventional monetary policy shock, the IRFs of both datasets behaved very similarly.

The second reduced dataset aimed at evaluating the robustness of the results by excluding years assumed to have been affected by an anticipation effect of the Basel III regime. The reduced dataset consisted of data from 1980Q1 to 2012Q4. Additionally, the simulation was only performed on Denmark and Sweden as Norway lacked a sufficient amount of data for the shorter period and it was not feasible to conduct a local projection on the limited data. The results for the second reduced dataset of a conventional monetary policy shock were that HP for Denmark behaved similarly compared to the original dataset. However, the results were more significant. The rGDP was not noticeably significant for the second reduced dataset, and this was in line with the results from the original dataset. M also behaved similarly, yet the shorter sample exhibited more significant results. The CPI was insignificant in the original dataset but showed some significance in the reduced dataset. The CPI in the reduced dataset behaved significantly differently from the original dataset after a conventional monetary policy shock.

Denmark's HP, after an unconventional monetary policy shock, differed quite a lot in the reduced dataset compared to the original. The general shape of the IRF was similar between the two datasets. However, the reduced dataset exhibited more significant results. The rGDP behaved similarly, and the reduced dataset was significant. M for the reduced dataset had a remarkably similar shape to the original dataset. However, the reduced dataset was more significant. The CPI differ a lot, with the shorter dataset exhibiting more significant results.

For Sweden, the shock on the conventional monetary policy and the shock on the unconventional monetary policy behaved much more similarly than in the results with the original dataset. All variables except for CPI had the same shape and were primarily significant at the same peaks and valleys. M for the conventional monetary policy shock behaved almost the same for the reduced and the original dataset, with the first half of the horizons behaving the same and behaving differently in the second half. The HP also had the same general shape of the reduced compared to the original dataset. However, the reduced dataset had more significance. The CPI also had the same general shape for both datasets, while the shorter dataset had more significant results. The rGDP differed significantly between the datasets.

The unconventional monetary policy shock for Sweden showed almost no similarities between the two datasets. HP and M had no similarities in the general shape of the IRFs compared to the results of the original dataset. rGDP, on the other hand, showed some similarities in the general shape initially, and in the second half of the horizons, they had essentially no similarities. The CPI had some similarities in the general shape of the IRFs. Conversely, the shorter dataset exhibited significance, while the full dataset did not.

7. Discussion

This chapter discussed the effects of a policy rate shock and a balance sheet shock on the house market variables, house prices, and mortgage rates. These findings were compared to previous research, and it was found that the results mainly differed. The effect of conventional and unconventional monetary policy shocks on house prices has policy implications. This chapter concluded with a discussion of the potential limitations and suggestions for future research.

7.1. Discussion of House Prices Regarding Previous Research

Rosenberg (2019) investigated the effect of an expansionary conventional monetary policy shock on house prices in Scandinavia, including Sweden, Norway, and Denmark. For Denmark, house prices initially reacted positively, followed by a rise that peaked in the 14th quarter. Rosenberg used a longer test period at around 18 quarters compared to our 12 quarters. Looking at the first 12 quarters of Rosenberg's results, the house prices in Denmark were the highest in the 12th quarter. In this paper, Denmark initially had a decrease in house prices and ended the last horizon with a negative house price development, which differs compared to Rosenberg. Our results were only significant in the second quarter.

In the same study, Rosenberg (2019) investigated the effect of an expansionary conventional monetary policy shock on house prices in Sweden, where house prices initially increased and peaked in the 14th quarter. Our results differ from Rosenberg's, as Sweden had an insignificant negative initial reaction to house prices. The reaction at the last horizon also differs. Rosenberg found in the case of an expansionary conventional monetary policy shock that house prices in Norway were initially positive, followed by a rise and a peak in the 14th quarter, after which the effect began to diminish. Our results are initially in line with Rosenberg's results for Norway, which were significant between the second and fifth quarters. In contrast, the price development deviates at the end of the time horizon, and our findings show a negative price development. In comparison, Rosenberg's findings showed a positive price development during the same quarter.

Denmark has a fixed exchange rate against the euro. Considering this, the effects of unconventional monetary policy shocks in Denmark could be comparable with the euro area.

Hülsewig and Rottman (2021) investigated the effects of unconventional monetary policy shocks in the euro area. Their paper found that unconventional monetary policy shocks positively affected house prices. However, in this paper, an unconventional monetary policy shock initially negatively affected house prices, but not significantly. Additionally, in this paper, the results showed that despite two positive price quarters in the intermediate time of the simulation, Denmark experienced a negative price change at the end of the time horizon. The change was only significant in the ninth and 11th quarters). Our results are not in line with Hülsewig and Rottman's results.

The inability to successfully simulate an unconventional monetary policy shock with significant results illustrates that the Danish fixed exchange regime makes it technically challenging to shock Danish house prices realistically. Another aspect could be due to the omitted variable bias since this paper does not include an exchange rate variable which potentially would have a large effect on house prices in Denmark due to the fixed exchange rate regime. A third reason for the overall insignificant results may be due to the method. As mentioned, the LP estimator returns points closer to the true values than the VAR model, albeit with larger confidence bands. The LP can capture more accurate point estimates with wider uncertainty intervals around those estimates. This paper may have benefitted from using lower confidence intervals, similar to Rosenberg (2019), who used 68 percent instead of our 95 percent confidence interval.

Another paper that aimed to investigate the effects of unconventional monetary policy on house prices was by Rosenberg (2019). Their results showed that Denmark's house prices initially reacted positively, followed by a peak in the 20th quarter. This differs from the results of our paper, where the initial reaction of house prices was insignificantly negative, compared to Rosenberg's positive results. In the 12th quarter, the price development was insignificantly negative, and this also differs from Rosenberg, which had a consistently positive price development.

Rahal (2016) found that in Sweden, house prices initially reacted slightly negatively and had a positive price development. The model with an average number of draws peaked in nine months, equivalent to three quarters. At the end of three years, the price was still positively affected. The initial reaction of Sweden in this paper is insignificant, and the subsequent positive price development is in line with Rahal's results. Rosenberg (2019) found in the case of an expansionary unconventional monetary policy shock that house prices in Sweden initially increased and kept growing until a peak in the 28th quarter. The reaction to unconventional monetary policy shock in Rosenberg's paper was more persistent and slower for house prices than for a conventional monetary policy shock. Our results are not in line with Rosenberg, neither for the initial reaction nor at the end of the time horizon.

Rahal (2016) investigated the effects of unconventional monetary policy shock. They investigated the results for Sweden and Norway. House prices initially reacted positively in Norway and peaked around 18 months or six quarters. They remained positive at the end of the three years. The results of our paper differ in the initial response to house prices from Rahal's results. However, the results became comparable in the intermediate quarters, where both papers had peaked significantly in house prices close in time, the eighth quarter in this paper and the sixth quarter in Rahal's. The direction of the percentage change of the house price index in our paper and Rahal's were positive after three years.

In this study, Norway's IRFs for house prices are periodically significant, with the other countries exhibiting fewer significant results. The potential reason for this is that the total assets in Norway's bank balance are, in absolute terms, much greater than the total assets of Sweden and Denmark. This is due to the unconventional monetary policy shock equaling one percentage point of total assets for all Scandinavian countries. The magnitude of Norway's results was, therefore, bigger. The importance of the magnitude of the effects on house prices and their significance should be interpreted carefully.

Rosenberg (2019) investigated an expansionary unconventional monetary policy shock on house prices in Norway. Initially, prices reacted positively and kept increasing until the 14th quarter, where after that, the effect started diminishing. The initial reaction to Norway’s house prices in our paper differs from Rosenberg's. However, at the end of the quarter, the price development in our paper was positive, which is in line with Rosenberg’s results.

7.2. Discussion of Mortgage Rates Regarding Previous Research

All countries were initially negatively affected by the conventional monetary policy shock regarding their mortgage rates. Norway had a negative change of 0.55 percent, and Sweden had at most a negative change of 0.60 percent. Compared to Rosenberg's (2019), the impact of a conventional monetary policy shock and an unconventional monetary policy shock on the Swedish mortgage rate, our results are relatively similar. For both papers, the rate initially insignificantly decreased with an expansionary monetary policy shock. The magnitudes differed, but this may result from different data management or shock magnitudes as Rosenberg uses a standard deviation while this paper used one percentage point. Our results for Norway compared to Rosenberg's results showed notable differences. Rosenberg's IRFs for Norway's mortgage rate were remarkably similar for an unconventional and a conventional monetary policy shock, while our results differed for the unconventional and conventional monetary policy shock.

The initial negative change in hour prices in Denmark after a conventional monetary policy shock was minor and insignificant compared to Norway and Sweden, with a significant negative change. One reason for this could be Denmark's mortgage industry, where the only financial institutions allowed to offer real property loans are mortgage banks and not private banks, as in Norway and Sweden. Comparing this to Rosenberg's (2019) results, there were essentially no similarities between their and our results, apart from around the sixth horizon IRFs increased in both papers regarding unconventional and conventional monetary policy shocks. The unconventional monetary policy shock also affected mortgage rates, where Denmark initially was insignificantly slightly positively affected, and Norway was notably insignificantly positively affected. Sweden's initial mortgage interest rate shock was insignificantly negative. Additionally, Denmark had an exceptionally low, insignificant change in mortgage rates with a negative change of approximately 0.375 percentage points.

On the other hand, Sweden had a negative, insignificant change after an unconventional monetary policy shock close to 1.0 percentage points. In contrast, Norway had the largest negative, insignificant change with approximately 3.12 percentage points. Sweden and Norway are close to zero at the end of the time horizon, while Denmark insignificantly remained positive. As previously mentioned, the seeming resilience of the Danish mortgage rates against conventional and unconventional monetary policy shocks could depend on Denmark's specific mortgage market structure. The Danish resilience is in line with Rahal's (2016) results that included, among others, Sweden and Norway showed that an increase in the central banks' total assets affected house prices and mortgage rates. The results were consistent across the countries that they evaluated despite the undertaking of policy measures and the countries' heterogeneous institutional mortgage market structures.

Rahal (2016) found that IRFs for the mortgage interest rate for both Sweden and Norway declined in the early horizons after an unconventional monetary policy shock, while for our results, this is true for Sweden, although not for Norway. Furthermore, Rahal found that the Norwegian mortgage interest rate initially declined and then started increasing towards zero percent change, staying at that level for later horizons. Our results were inconsistent with this. For Sweden, on the other hand, our results are more in line with Rahal, as the IRFs initially decreased and then started insignificantly increasing to a positive level and then started insignificantly decreasing towards zero. However, Rahal's IRFs ran for nearly twice the number of horizons compared to this paper. In conclusion, Rahal's results are more in line with our results for Sweden than for Norway.

When comparing, the effects on the Swedish mortgage rates in this paper with Rosenberg (2019) shows a difference in results. Rosenberg concluded that the shock initially decreases the mortgage rate and remains negative, which cannot be concluded from our results. This may, however, be due to the differences in the confidence bands.

7.3. Spillover Effects

The results showed that overall, both expansionary monetary policy shocks initially decreased house prices and increased them in the intermediate quarters. The difference in the effect on house prices between the conventional and unconventional policy shock was at the end of the three-year time horizon. Where in the end, the policy rate shock showed an overall decrease in house prices, while a balance sheet shock increased house prices. Since both types of shocks produced similar results, they can be analyzed in two different ways. The first approach examines whether house prices react due to increased mortgage rates. This can be done by examining the direction of mortgage rates and if they align with economic intuition in the initial and intermediate quarters. The second approach to analyzing these results is to examine the direction of the price development at the end of the time horizon.

7.3.1. Effects of Transmission Mechanisms

The first way to interpret the results is to look at the transmission mechanism of the conventional and unconventional monetary policy through the mortgage rate. The economic intuition behind this is that both expansionary monetary policy measures should decrease the market rates, which should decrease the mortgage rates before an increase in house prices. Economic intuition states that the policy rate should be transmitted through the interest rate channel. This implies that when the policy rate is lowered, market interest rates will also decline through the overnight lending rate. Since the market interest rates decline, so will the mortgage rates. When mortgage rates are low, firms and households will increase their borrowing rate to consume more. Since overall consumption increases means that the aggregate demand also increases. As a reaction to increased demand, firms will increase their prices. This will lead to an overall price increase and an increase in house prices.

In the case of an unconventional monetary policy such as quantitative easing, the central bank affects house prices through the asset price channel. The economic intuition states that when the central bank implements quantitative easing, they buy government bonds from private banks. By buying the bonds, their price will increase, and this will decrease their yield. The decrease in their yield will decrease other interest rates, such as mortgage rates, and as a result, firms and households will be able to borrow more. Consumption and demand will increase, and prices, including house prices, will increase as a result.

As a result of the conventional monetary policy shock in Figure 2, the mortgage rate initially decreased and then became positive. While as a result of the unconventional monetary policy shock in Figure 3, Norway and Sweden reacted initially negatively and remained negative in the intermediate quarters. Denmark differs in its reaction, perhaps due to its unique mortgage industry structure where private banks are not lenders of mortgage loans but are offered by separate institutions. This could be explained as the unconventional monetary policy shock does not affect house prices through the asset price channel in Denmark.

In the results of the unconventional monetary policy shock in Figure 3, the behavior of house prices could be interpreted as having a delayed reaction to the low mortgage rates, which means that house prices react only after a while during the intermediate quarters, where they become positive. To summarize, unconventional monetary policy's transmission mechanism of spillover effects seems to act through the asset price channel. However, it is important to note that the effect on mortgage rates is insignificant, so future research would have to investigate the external validity of this conclusion. The transmission mechanism for conventional monetary policy could not be derived from the interest rate channel. This implies that the asset price channel is more susceptible to transmitting spillover effects of unconventional monetary policies on mortgage rates and house prices.

The previous discussion on the asset price channel's susceptibility to spillover effects leads to certain policy implications. Unconventional monetary policies have a traceable spillover effect on house prices through the asset price channel. However, the results of Denmark compared to Sweden and Norway differed in the effects on house prices transmitted through the asset price channel and mortgage rates. Denmark did not follow the same pattern in the reaction to the mortgage rate of unconventional monetary policy. This means there is an inherent weakening of any spillover effect through the asset price channel in Denmark. This is potentially due to Denmark's unique mortgage industry structure, where mortgage banks are separated from private banks. This division between institutions has resulted in a difference in their stated objectives. The implication is that policymakers have to consider that there will be a higher risk of spillover effect in countries with a mortgage industry, unlike Denmark's, which means that countries such as Sweden and Norway risk spillover effects when using quantitative easing.

7.3.2. Delayed Effects

The second approach to analyzing the results is to look at the different directions of house price development at the end of the time horizon of three years. The delayed effect of conventional monetary policy on house prices was negative. The delayed effect of unconventional monetary policy, including in Sweden and Norway, was that house prices were positively affected. This implies a delayed effect of monetary policies on house prices. Central banks should therefore consider this delayed effect when implementing monetary policies. This implies that policymakers have to consider the possibility that monetary policies might have a cumulative or canceling effect on each other when they are consecutively implemented. However, this delayed effect has to be interpreted carefully due to the results not being significant for both the conventional and unconventional policy shock. This implies that future research has to investigate a potential delayed effect further.

7.4. Limitations and Suggestions for Future Research

In this paper, there are six limitations. We suggest how to suggest a solution for each limitation for future research. The first limitation is in the background characteristics of the Scandinavian countries. The Scandinavian countries share some similarities in their economic and institutional frameworks. However, they also have unique histories, geographies, and political contexts that can affect their economic outcomes separately. For example, there are differences in the use of unconventional monetary policies. Sweden and Denmark's central banks have used negative interest rates for an extended period, and Norway has primarily used interest rate cuts as unconventional monetary policies. In addition, Denmark's currency follows the euro due to its fixed exchange rate regime. Factors such as these must be considered when comparing countries. A suggestion for future research is to perform joint tests.

The second limitation was that this paper only examined the effects of quantitative easing. A suggestion for future research would be to compare other types of unconventional monetary policy measures, such as forward guidance compared to quantitative easing, and try to disentangle their spillover effects from each other. The third limitation is that the mortgage industry and owner-occupancy rates differ among the Scandinavian countries. We suggest investigating if countries with similar mortgage industry structures have the same effect when house prices are shocked. The fourth limitation of this study was the lack of data to conduct a robustness check and control for the potential anticipation effect of the Basel III regime. The robustness check would have consisted of excluding data after 2013. The suggestion for future research would be to find more detailed data on mortgage rates in Norway. Another alternative would be to include dummy variables depending on the periods of the current Basel Regime.

The fifth notable limitation of this paper is in the setup of the model, where the available LP packages were limited. Rosenberg (2019) compared the conventional and unconventional monetary policy shocks since both were modeled with the size of one standard deviation. The same was not possible in this study due to the inherent limitations of the LP package. This limited the scope of the analysis since it was not possible to determine which type of policy rate shock had the greatest effect. A solution to this problem would be to make an LP package that could incorporate such shocks. The sixth limitation is that the results differ from previous research. A suggestion for future research would be to use smooth local projections to check the validity of this paper's results (Barnichon & Brownlees, 2019).

8. Conclusion

This study investigated whether unconventional monetary policy, specifically quantitative easing, had a spillover effect on house prices mediated by mortgage rates. The secondary question was to investigate if conventional monetary policy had a spillover effect on house prices through the effect on mortgage rates. The former monetary policy was assumed to be transmitted through the asset price channel and the latter through the interest rate channel. The sample consisted of Scandinavia, including Sweden, Norway, and Denmark, which were selected based on their similarities in economic structure. The paper contributed to the existing literature by investigating the effect of unconventional monetary policy on real economic variables, specifically house prices, using the local projections method. It has also contributed to the existing literature by using more recent data that contain events such as the Covid Pandemic and the invasion of Ukraine.

Our results showed that both unconventional and conventional monetary policy measures have a negative effect on house prices. These findings contradict previous research, including Rosenberg (2019) and Hülsewig & Rottman which this paper draws inspiration from. The results led to two conclusions with their respective policy implications. The first was that an unconventional monetary policy shock, such as quantitative easing, had a spillover effect on house prices in Sweden and Norway through the asset price channel. However, only Norway's house prices displayed significant effects. Denmark was not similarly affected, presumably due to their unique mortgage industry. Conventional monetary policy shocks also affected house prices. However, since the mortgage rates in the conventional monetary policy case were not in line with economic intuition, the price inflation could not be said to have stemmed from the interest rate channel. This means policymakers must consider the mortgage industry structure when implementing unconventional monetary policy. The second conclusion showed that both conventional and unconventional policy measures had a delayed effect on house prices. A conventional monetary policy shock negatively affected house prices after three years, while an unconventional monetary policy shock had a positive price effect. This means that policymakers have to consider how implementing monetary policies of a specific type might amplify spillover effects in the future.

These results offer valuable insights for policymakers, researchers, and market participants. Future research can build on the findings of this paper to further explore the implications of unconventional monetary policies on the housing market and how they interact with other macroeconomic variables. Future research could expand the analysis to include additional macroeconomic variables, such as the exchange rate and a Basel regime dummy. Additionally, future research could conduct joint tests across countries, examine other types of unconventional monetary policy measures, such as forward guidance and use a smooth local projection method.

9. References

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Appendix

R code

```
#Activate the required packages
library(readxl)
library(dplyr)
library(lpirfs)

#Insert the data
setwd("C:\\Users\\...\\Master Thesis\\Data\\Quarterly")
data_set <- read_excel("Sweden.xlsx", sheet = "Edited")

#Creating the endogenous, exogenous, and shock variables
#Endogenous data is HP, rGDP, M, and CPI
endog_data <- select(data_set, "HP", "rGDP","M", "CPI")
#MP is the expansionary conventional monetary policy shock (policy rate)
MP <- (-1)*(select(data_set,"P"))
#MP is the expansionary unconventional monetary policy shock (total assets)
UMP <- select(data_set,"T")
#Exogenous data is T and P
exog_data <- select(data_set,"T","P")

#Local projection method with an MP shock, two lags for the endogenous and
exogenous variables, and a 95% confidence interval
results_SweMP <- lp_lin_iv(endog_data,
                           shock = MP,
                           cumul_mult = FALSE,
                           instr = NULL,
                           use_twosls = FALSE,
                           instrum = NULL,
                           lags_endog_lin = 2,
                           exog_data,
                           lags_exog = 2,
                           contemp_data = NULL,
                           lags_criterion = NaN,
                           max_lags = NaN,
                           trend = 0,
                           confint = 1.96,
                           use_nw = TRUE,
```

```
                           nw_lag = NULL,
                           nw_prewhite = FALSE,
                           adjust_se = FALSE,
                           hor = 12,
                           num_cores = 1
)
#Summary of the results, this can be found in Summary results
summary(results_SweMP)

#Plotting the results
linear_plots <- plot_lin(results_SweMP)
#Plotting the results for HP
linear_plots[[1]]
#Plotting the results for rGDP
linear_plots[[2]]
#Plotting the results for M
linear_plots[[3]]
#Plotting the results for CPI
linear_plots[[4]]

#Local projection method with an UMP shock, two lags for the endogenous and
exogenous variables, and a 95% confidence interval
results_SweUMP<- lp_lin_iv(endog_data,
                           shock = UMP,
                           cumul_mult = FALSE,
                           instr = NULL,
                           use_twosls = FALSE,
                           instrum = NULL,
                           lags_endog_lin = 2,
                           exog_data,
                           lags_exog = 2,
                           contemp_data = NULL,
                           lags_criterion = NaN,
                           max_lags = NaN,
                           trend = 0,
                           confint = 1.96,
                           use_nw = TRUE,
                           nw_lag = NULL,
                           nw_prewhite = FALSE,
                           adjust_se = FALSE,
                           hor = 12,
```

```
                           num_cores = 1
)
#Summary of the results, this can be found in Summary results
summary(results_SweUMP)

#Plotting the results
linear_plots <- plot_lin(results_SweUMP)
#Plotting the results for HP
linear_plots[[1]]
#Plotting the results for rGDP
linear_plots[[2]]
#Plotting the results for M
linear_plots[[3]]
#Plotting the results for CPI
linear_plots[[4]]
```

Summary of Results

Denmark

```
> summary(results_DenMP)
$`Endog. Variable: HP`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1   0.7738300   0.720371666 14.4753796 2.400230e-13
h 2   0.6174733   0.525383600  6.7051258 2.072840e-07
h 3   0.5202167   0.402533972  4.4205024 5.161368e-05
h 4   0.3752427   0.219053338  2.4024859 1.287971e-02
h 5   0.1831554  -0.025059934  0.8796441 5.784424e-01
h 6   0.1112295  -0.119850856  0.4813455 9.250198e-01
h 7   0.1773400  -0.040916679  0.8125296 6.445446e-01
h 8   0.2066126  -0.008263184  0.9615444 5.009596e-01
h 9   0.2815038   0.082770849  1.4164928 1.875682e-01
h 10  0.3160197   0.122720874  1.6348766 1.099628e-01
h 11  0.3167781   0.119402911  1.6049539 1.194655e-01
h 12  0.3110984   0.107559311  1.5284454 1.453501e-01

$`Endog. Variable: rGDP`
       R-sqrd. Adj. R-sqrd.    F-stat    p-value
h 1   0.3041517   0.139678516 1.8492478 0.05793527
h 2   0.1743500  -0.024417568 0.8771552 0.58066514
h 3   0.1794242  -0.021849140 0.8914454 0.56674929
h 4   0.1825971  -0.021753650 0.8935475 0.56479841
h 5   0.1465153  -0.071039639 0.6734634 0.77893366
h 6   0.1460439  -0.075984726 0.6577705 0.79293885
h 7   0.1128765  -0.122482804 0.4795922 0.92579548
h 8   0.1381691  -0.095243375 0.5919526 0.84839076
h 9   0.0890866  -0.162868165 0.3535817 0.97769156
h 10  0.2054847  -0.019052279 0.9151486 0.54484040
h 11  0.2276354   0.004507811 1.0202028 0.44949427
h 12  0.1490533  -0.102362764 0.5928551 0.84650979

$`Endog. Variable: M`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1   0.6511926   0.568747252 7.8984734 1.457455e-08
h 2   0.6903928   0.615857677 9.2626556 1.223902e-09
h 3   0.7085604   0.637075168 9.9119877 4.632888e-10
h 4   0.6327329   0.540916073 6.8912547 1.779989e-07
```

```
h 5  0.5697117  0.460030316 5.1942441 8.869352e-06
h 6  0.4477267  0.304135702 3.1180687 1.879160e-03
h 7  0.4639430  0.321723842 3.2621689 1.324729e-03
h 8  0.3438156  0.166099032 1.9346287 4.939861e-02
h 9  0.3746666  0.201702102 2.1661471 2.695271e-02
h 10 0.3421020  0.156174353 1.8399736 6.489988e-02
h 11 0.2252855  0.001479057 1.0066086 4.613438e-01
h 12 0.1819839 -0.059702720 0.7529746 7.023558e-01

$`Endog. Variable: CPI`
       R-sqrd. Adj. R-sqrd.    F-stat     p-value
h 1  0.3879883   0.24333093 2.6821197 0.005483982
h 2  0.2131723   0.02375078 1.1253859 0.359168579
h 3  0.3393914   0.17735527 2.0945418 0.029988285
h 4  0.2714218   0.08927727 1.4901452 0.152863832
h 5  0.1902192  -0.01619556 0.9215387 0.537928689
h 6  0.1889296  -0.02194869 0.8959178 0.562711187
h 7  0.2972746   0.11083728 1.5945015 0.119266177
h 8  0.3566568   0.18241797 2.0469423 0.036563445
h 9  0.4024299   0.23714455 2.4347585 0.013073031
h 10 0.2326712   0.01581742 1.0729405 0.404685489
h 11 0.2034919  -0.02661043 0.8843539 0.574436856
h 12 0.1378525  -0.11687287 0.5411809 0.885391745
```

```
> summary(results_DenUMP)
$`Endog. Variable: HP`
       R-sqrd.  Adj. R-sqrd.     F-stat      p-value
h 1  0.7518079  6.931443e-01 12.8155784 2.656331e-12
h 2  0.5944415  4.968070e-01  6.0884388 8.262216e-07
h 3  0.5070640  3.861551e-01  4.1937710 9.282296e-05
h 4  0.3632989  2.041236e-01  2.2823829 1.801966e-02
h 5  0.1803541 -2.857527e-02  0.8632300 5.945282e-01
h 6  0.1153780 -1.146237e-01  0.5016398 9.130386e-01
h 7  0.1810669 -3.620111e-02  0.8333804 6.239701e-01
h 8  0.2131586  5.573249e-05  1.0002615 4.658675e-01
h 9  0.2929225  9.734788e-02  1.4977531 1.538796e-01
h 10 0.3066901  1.107547e-01  1.5652614 1.309671e-01
h 11 0.2809338  7.320356e-02  1.3523973 2.201990e-01
h 12 0.2944637  8.600986e-02  1.4126085 1.920410e-01

$`Endog. Variable: rGDP`
        R-sqrd. Adj. R-sqrd.    F-stat    p-value
h 1  0.34405055   0.18900796 2.2190711 0.02055565
h 2  0.17450761  -0.02422204 0.8781156 0.57972108
```

```
h 3  0.16791051  -0.03618692 0.8226978 0.63459094
h 4  0.17566985  -0.03041268 0.8524247 0.60513503
h 5  0.12063385  -0.10351831 0.5381784 0.88936124
h 6  0.15777158  -0.06120781 0.7204860 0.73463713
h 7  0.11958058  -0.11400009 0.5119455 0.90635776
h 8  0.13851843  -0.09479949 0.5936896 0.84700170
h 9  0.09354463  -0.15717707 0.3731015 0.97200711
h 10 0.21038220  -0.01277066 0.9427717 0.51885492
h 11 0.20665263  -0.02253662 0.9016681 0.55783633
h 12 0.16223438  -0.08528729 0.6554351 0.79350518

$`Endog. Variable: M`
       R-sqrd.   Adj. R-sqrd.    F-stat      p-value
h 1  0.6486253  0.5655731442 7.8098520 1.746954e-08
h 2  0.6872548  0.6119642983 9.1280404 1.569300e-09
h 3  0.6852121  0.6080000268 8.8744122 3.000150e-09
h 4  0.6618384  0.5772979730 7.8286634 2.624184e-08
h 5  0.5020908  0.3751727659 3.9560241 1.932347e-04
h 6  0.4686506  0.3304997678 3.3923109 8.979363e-04
h 7  0.4151602  0.2599986251 2.6756637 6.470565e-03
h 8  0.3313556  0.1502644626 1.8297724 6.524244e-02
h 9  0.3753707  0.2026008479 2.1726634 2.648505e-02
h 10 0.3384548  0.1514963279 1.8103209 7.010610e-02
h 11 0.2247003  0.0007247931 1.0032360 4.643096e-01
h 12 0.1755747 -0.0680055629 0.7208083 7.331973e-01

$`Endog. Variable: CPI`
       R-sqrd. Adj. R-sqrd.    F-stat     p-value
h 1  0.3981442   0.25588738 2.7987706 0.003931083
h 2  0.1854886  -0.01059743 0.9459552 0.514212796
h 3  0.3349193   0.17178628 2.0530443 0.033657898
h 4  0.2637593   0.07969915 1.4330060 0.176328143
h 5  0.1763747  -0.03356899 0.8401048 0.617325805
h 6  0.1706633  -0.04496426 0.7914726 0.665394620
h 7  0.2856324   0.09610629 1.5070874 0.148720771
h 8  0.3517882   0.17623088 2.0038365 0.041051210
h 9  0.4349826   0.27870122 2.7833294 0.005118935
h 10 0.2622053   0.05369813 1.2575361 0.272695737
h 11 0.1960079  -0.03625647 0.8439000 0.613685398
h 12 0.1624878  -0.08495893 0.6566578 0.792416682
```

Norway

```
> summary(results_NorMP)
$`Endog. Variable: HP`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.6054479   0.47721853 4.7215994 7.110212e-05
h 2  0.3878765   0.18383530 1.9009716 6.093841e-02
h 3  0.2789334   0.03225276 1.1307470 3.651239e-01
h 4  0.3391346   0.10693868 1.4605536 1.792070e-01
```

```
h 5  0.3190126   0.07310042 1.2972623 2.593608e-01
h 6  0.4243642   0.21055660 1.9847948 5.332278e-02
h 7  0.5525978   0.38153231 3.2303284 3.011539e-03
h 8  0.3505703   0.09473443 1.3702937 2.253702e-01
h 9  0.2103136  -0.11049647 0.6555705 7.889529e-01
h 10 0.3707549   0.10687799 1.4050296 2.123197e-01
h 11 0.3835810   0.11646610 1.4360150 2.004692e-01
h 12 0.3882494   0.11401637 1.4157646 2.112087e-01

$`Endog. Variable: rGDP`
        R-sqrd.  Adj. R-sqrd.    F-stat   p-value
h 1  0.37167589  0.1674705497 1.8201086 0.0734328
h 2  0.32376684  0.0983557932 1.4363397 0.1868857
h 3  0.25197985 -0.0039217755 0.9846747 0.4835813
h 4  0.08445612 -0.2372214612 0.2625490 0.9937211
h 5  0.31008323  0.0609466173 1.2446313 0.2902425
h 6  0.30843198  0.0515638631 1.2007406 0.3193015
h 7  0.29688219  0.0280430307 1.1043116 0.3884605
h 8  0.26045733 -0.0308776586 0.8940132 0.5673018
h 9  0.16551010 -0.1735014170 0.4882138 0.9152073
h 10 0.15799686 -0.1951012379 0.4474588 0.9373480
h 11 0.19730637 -0.1505275349 0.5672431 0.8602852
h 12 0.31000638  0.0006988937 1.0022595 0.4740467

$`Endog. Variable: M`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.7769026   0.70439593 10.714914 2.824626e-09
h 2  0.6729761   0.56396816  6.173642 4.420953e-06
h 3  0.6639788   0.54902414  5.776007 1.073478e-05
h 4  0.6175238   0.48314023  4.595234 1.250115e-04
h 5  0.3656643   0.13659857  1.596329 1.320661e-01
h 6  0.2850253   0.01946322  1.073291 4.115076e-01
h 7  0.3064309   0.04124278  1.155523 3.511625e-01
h 8  0.2585692  -0.03350963  0.885272 5.753891e-01
h 9  0.3560690   0.09447200  1.361136 2.314432e-01
h 10 0.4814682   0.26401939  2.214168 3.450290e-02
h 11 0.3812621   0.11314237  1.421984 2.065501e-01
h 12 0.3494063   0.05776088  1.198052 3.290750e-01

$`Endog. Variable: CPI`
       R-sqrd. Adj. R-sqrd.   F-stat    p-value
h 1  0.3517181   0.14102652 1.669350 0.10648011
h 2  0.2614627   0.01528360 1.062083 0.41755006
h 3  0.3907468   0.18231802 1.874726 0.06602877
h 4  0.3447650   0.11454728 1.497561 0.16459623
h 5  0.2885776   0.03167512 1.123296 0.37239923
h 6  0.4415872   0.23417677 2.129050 0.03773735
h 7  0.3569428   0.11106805 1.451726 0.18709259
h 8  0.4166678   0.18687033 1.813196 0.08293818
h 9  0.3752578   0.12145635 1.478549 0.17942765
h 10 0.3195492   0.03419880 1.119848 0.38009345
```

```
h 11 0.4159500   0.16286173 1.643498 0.12770545
h 12 0.4062810   0.14013107 1.526512 0.16693711


> summary(results_NorUMP)
$`Endog. Variable: HP`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.6027350  0.473623908 4.6683434 0.0000797263
h 2  0.3752639  0.167018514 1.8020275 0.0778173446
h 3  0.2424452 -0.016718307 0.9354913 0.5277428809
h 4  0.3321672  0.097523310 1.4156225 0.1984908532
h 5  0.2543211 -0.014951783 0.9444735 0.5202531317
h 6  0.4068531  0.186541337 1.8467154 0.0741253949
h 7  0.5692288  0.404522196 3.4560165 0.0018281730
h 8  0.4392415  0.218336642 1.9883741 0.0551413600
h 9  0.2948423  0.008372012 1.0292247 0.4493792668
h 10 0.3091392  0.019423350 1.0670428 0.4199834966
h 11 0.3123344  0.014346025 1.0481429 0.4358440094
h 12 0.3857925  0.110458167 1.4011783 0.2177682271

$`Endog. Variable: rGDP`
        R-sqrd. Adj. R-sqrd.    F-stat   p-value
h 1  0.28479657  0.052355462 1.2252418 0.2981570
h 2  0.33974279  0.119657050 1.5436838 0.1453916
h 3  0.23055211 -0.032680066 0.8758508 0.5834027
h 4  0.08587682 -0.235301597 0.2673804 0.9931583
h 5  0.31152826  0.062913461 1.2530560 0.2851089
h 6  0.28357173  0.017469798 1.0656508 0.4175594
h 7  0.27924440  0.003661376 1.0132859 0.4611773
h 8  0.26139287 -0.029573577 0.8983609 0.5632936
h 9  0.17120616 -0.165491341 0.5084866 0.9026101
h 10 0.21680041 -0.111638127 0.6600943 0.7844922
h 11 0.25193384 -0.072228165 0.7771850 0.6767462
h 12 0.33883883  0.042456243 1.1432481 0.3659154

$`Endog. Variable: M`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.5981450  0.467542173 4.5798769 9.654115e-05
h 2  0.5581761  0.410901484 3.7900358 6.107002e-04
h 3  0.6666825  0.552652788 5.8465696 9.398348e-06
h 4  0.6276859  0.496872898 4.7983436 8.242617e-05
h 5  0.3775276  0.152745925 1.6795301 1.086302e-01
h 6  0.2892249  0.025222724 1.0955398 3.942126e-01
h 7  0.2869970  0.014378210 1.0527411 4.286865e-01
h 8  0.2811874 -0.001981164 0.9930036 4.790222e-01
h 9  0.3461208  0.080482375 1.3029772 2.617557e-01
h 10 0.4800732  0.262039348 2.2018289 3.548520e-02
h 11 0.3347995  0.046545904 1.1614756 3.519280e-01
h 12 0.3415570  0.046392848 1.1571764 3.562702e-01

$`Endog. Variable: CPI`
```

```
        R-sqrd. Adj. R-sqrd.    F-stat    p-value
h 1   0.3294013   0.11145676 1.5113996 0.15572714
h 2   0.2251473  -0.03313696 0.8717035 0.58722506
h 3   0.3849170   0.17449383 1.8292521 0.07380733
h 4   0.3235409   0.08586602 1.3612752 0.22422302
h 5   0.2516543  -0.01858163 0.9312392 0.53226605
h 6   0.4380784   0.22936472 2.0989441 0.04056321
h 7   0.3125521   0.04970439 1.1890996 0.32817480
h 8   0.3774537   0.13220823 1.5390852 0.15529998
h 9   0.3757993   0.12221773 1.4819662 0.17808448
h 10  0.3235136   0.03982580 1.1403860 0.36532395
h 11  0.3762904   0.10601627 1.3922546 0.21998084
h 12  0.2806845  -0.04176735 0.8704695 0.58985176
```

Sweden

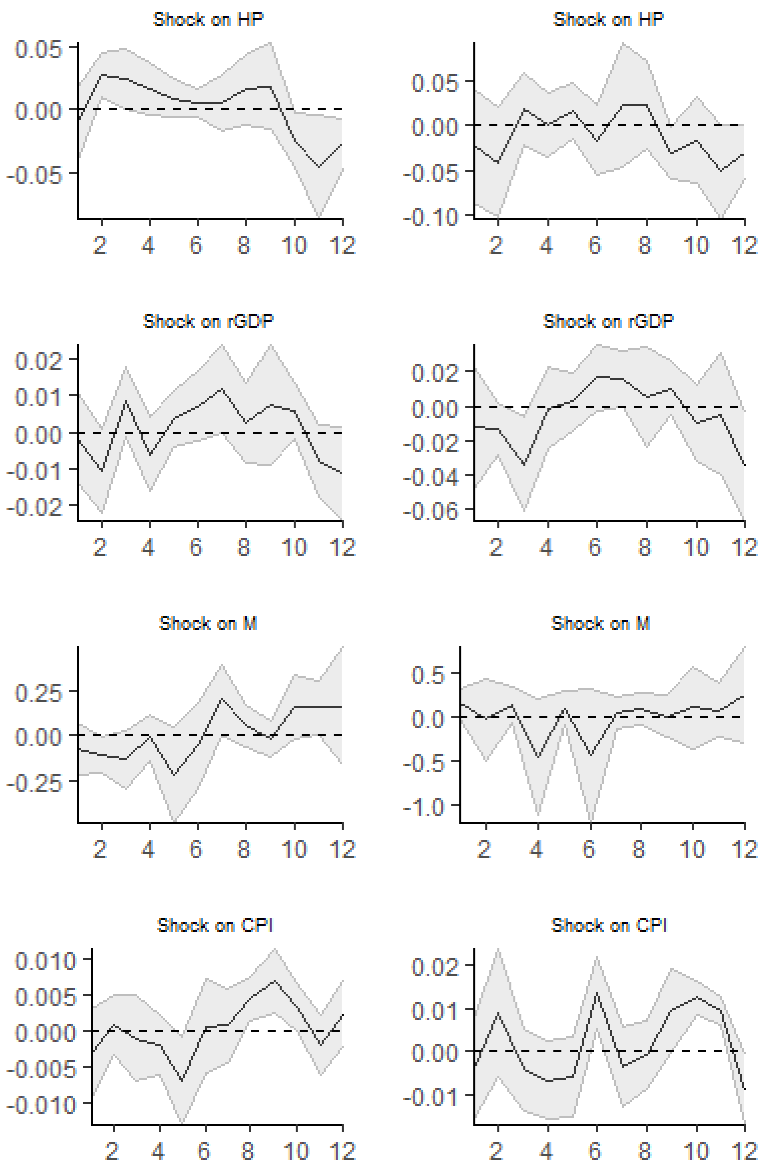
```
> summary(results_SweMP)
$`Endog. Variable: HP`
        R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1   0.5919356   0.48991945 5.8023734 1.954278e-06
h 2   0.5065497   0.38076819 4.0272203 1.606266e-04
h 3   0.4221461   0.27190412 2.8097743 4.359332e-03
h 4   0.4825249   0.34523554 3.5146568 6.787555e-04
h 5   0.4360251   0.28328184 2.8546280 4.097652e-03
h 6   0.3257913   0.13930805 1.7470271 8.180531e-02
h 7   0.1011577  -0.15286301 0.3982261 9.632575e-01
h 8   0.1450058  -0.10199255 0.5870719 8.514112e-01
h 9   0.5205904   0.37894661 3.6753500 5.841481e-04
h 10  0.4627308   0.30030056 2.8487972 4.922890e-03
h 11  0.2186371  -0.02321326 0.9040181 5.560942e-01
h 12  0.2661611   0.03348048 1.1438903 3.530354e-01

$`Endog. Variable: rGDP`
         R-sqrd. Adj. R-sqrd.    F-stat     p-value
h 1   0.38650622   0.23313277 2.5200335 0.009267402
h 2   0.18105692  -0.02769328 0.8673377 0.590493860
h 3   0.24473051   0.04836044 1.2462720 0.276788470
h 4   0.25670407   0.05950311 1.3017384 0.244293418
h 5   0.26083041   0.06063865 1.3029028 0.244388265
h 6   0.26293914   0.05907124 1.2897525 0.252697871
h 7   0.07873546  -0.18162191 0.3024130 0.988753751
h 8   0.16935987  -0.07060284 0.7057758 0.747620812
h 9   0.13923173  -0.11508617 0.5474712 0.880932094
h 10  0.07447465  -0.20533534 0.2661615 0.993657050
h 11  0.06981930  -0.21809378 0.2425013 0.995913519
h 12  0.05177626  -0.24888004 0.1722108 0.999280685

$`Endog. Variable: M`
```

```
       R-sqrd. Adj. R-sqrd.     F-stat      p-value
h 1  0.9358944   0.91986805 58.3970799 2.680295e-26
h 2  0.7317974   0.66343209 10.7042146 1.877037e-10
h 3  0.3967989   0.23996655  2.5300837 9.417239e-03
h 4  0.3468167   0.17352320  2.0013254 4.078995e-02
h 5  0.3164849   0.13136622  1.7096324 8.934261e-02
h 6  0.2529317   0.04629573  1.2240449 2.931131e-01
h 7  0.3212417   0.12941871  1.6746777 9.939754e-02
h 8  0.3363951   0.14468704  1.7547258 8.175976e-02
h 9  0.4393871   0.27375148  2.6527330 7.921172e-03
h 10 0.4122392   0.23454411  2.3199243 1.940622e-02
h 11 0.2553889   0.02491409  1.1080989 3.791636e-01
h 12 0.2182393  -0.02963605  0.8804397 5.786580e-01

$`Endog. Variable: CPI`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.4603749   0.32546868 3.4125542 7.823835e-04
h 2  0.4590723   0.32118874 3.3294205 1.020582e-03
h 3  0.5431129   0.42432227 4.5720176 4.326047e-05
h 4  0.5634794   0.44766777 4.8654831 2.295813e-05
h 5  0.2861010   0.09275338 1.4797234 1.600102e-01
h 6  0.2686816   0.06640208 1.3282689 2.311716e-01
h 7  0.4347329   0.27498357 2.7213435 6.225341e-03
h 8  0.3704732   0.18860988 2.0370970 3.922856e-02
h 9  0.4473404   0.28405466 2.7396166 6.312696e-03
h 10 0.3136906   0.10620172 1.5118429 1.523382e-01
h 11 0.3220126   0.11215939 1.5344659 1.452372e-01
h 12 0.2056360  -0.04623549 0.8164323 6.404064e-01


> summary(results_SweUMP)
$`Endog. Variable: HP`
        R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.58377814   0.47972267 5.6102593 3.045093e-06
h 2  0.50588919   0.37993938 4.0165934 1.651099e-04
h 3  0.40808733   0.25419003 2.6516862 6.733989e-03
h 4  0.47581148   0.33674105 3.4213707 8.679687e-04
h 5  0.40363587   0.24212058 2.4990568 1.073522e-02
h 6  0.30479331   0.11250209 1.5850610 1.237894e-01
h 7  0.09675775  -0.15850636 0.3790496 9.699629e-01
h 8  0.14729653  -0.09904002 0.5979483 8.427235e-01
h 9  0.51672785   0.37394289 3.6189236 6.715568e-04
h 10 0.47289135   0.31353292 2.9674700 3.631897e-03
h 11 0.21032252  -0.03410147 0.8604823 5.977209e-01
h 12 0.26486119   0.03176840 1.1362908 3.586147e-01

$`Endog. Variable: rGDP`
        R-sqrd. Adj. R-sqrd.    F-stat    p-value
h 1  0.31460050   0.14325062 1.8360124 0.06170284
h 2  0.17883056  -0.03048714 0.8543499 0.60326693
h 3  0.24696394   0.05117456 1.2613756 0.26740602
h 4  0.25934324   0.06284246 1.3198077 0.23420413
```

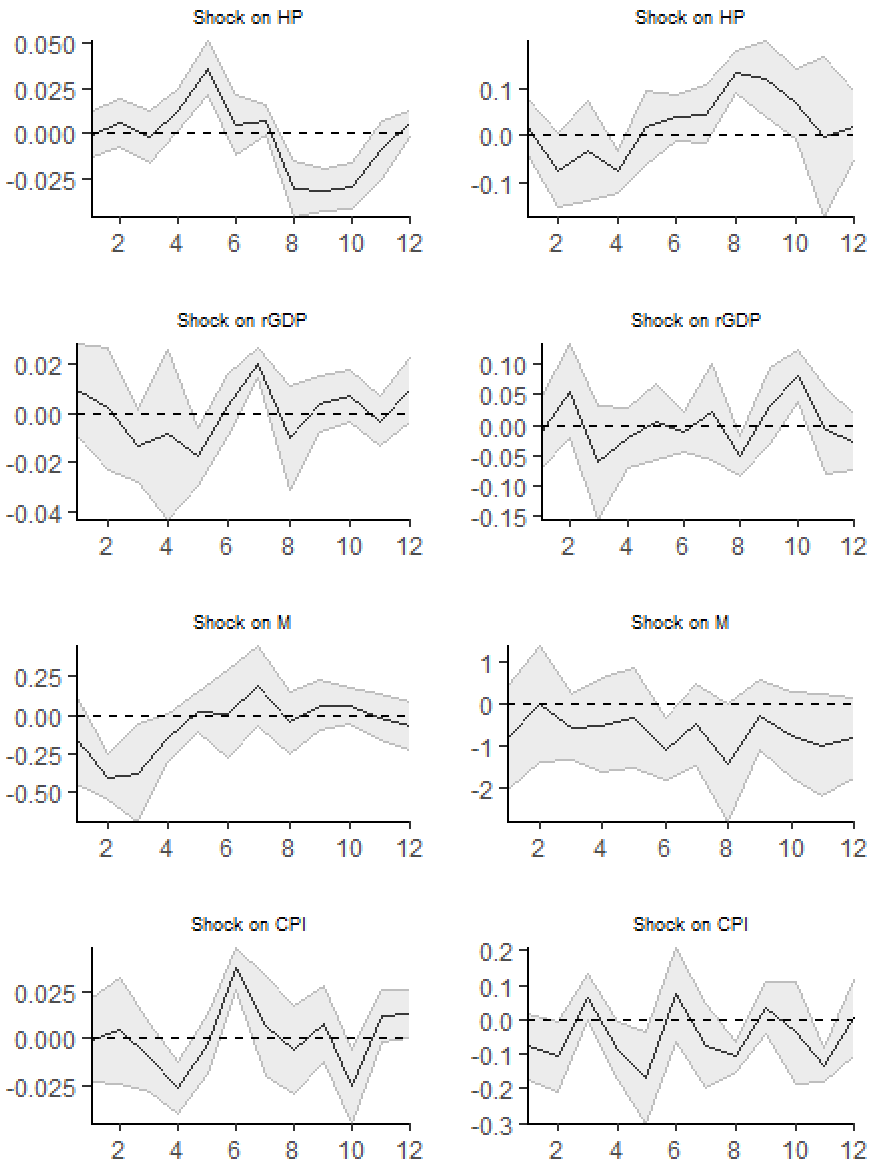
```
h 5  0.25726421   0.05610660 1.2789186 0.25827312
h 6  0.12260244  -0.12008199 0.5051929 0.91012301
h 7  0.07909761  -0.18115742 0.3039235 0.98849590
h 8  0.16616138  -0.07472534 0.6897905 0.76254458
h 9  0.13108515  -0.12563969 0.5106056 0.90589345
h 10 0.07638681  -0.20284509 0.2735605 0.99278001
h 11 0.06215117  -0.22813537 0.2141028 0.99779878
h 12 0.05467951  -0.24505626 0.1824257 0.99902501

$`Endog. Variable: M`
       R-sqrd. Adj. R-sqrd.     F-stat      p-value
h 1  0.7535347   0.69191837 12.2294648 1.381257e-11
h 2  0.4161556   0.26733256  2.7963112 4.398254e-03
h 3  0.3169656   0.13937663  1.7848271 7.207634e-02
h 4  0.3241979   0.14490347  1.8081872 6.838489e-02
h 5  0.3173743   0.13249647  1.7166705 8.772577e-02
h 6  0.2474524   0.03930099  1.1888096 3.167512e-01
h 7  0.3341108   0.14592473  1.7754279 7.674251e-02
h 8  0.3208094   0.12459884  1.6350260 1.107937e-01
h 9  0.3758938   0.19149884  2.0385251 3.969552e-02
h 10 0.3568054   0.16235118  1.8349071 6.809909e-02
h 11 0.2590512   0.02970992  1.1295446 3.628873e-01
h 12 0.2104974  -0.03983263  0.8408796 6.167067e-01

$`Endog. Variable: CPI`
       R-sqrd. Adj. R-sqrd.    F-stat      p-value
h 1  0.4581016   0.32262700 3.3814575 8.514325e-04
h 2  0.4624936   0.32548220 3.3755843 9.008668e-04
h 3  0.5327013   0.41120360 4.3844567 6.888912e-05
h 4  0.5602390   0.44356772 4.8018586 2.672437e-05
h 5  0.2759904   0.07990444 1.4074970 1.908301e-01
h 6  0.2635928   0.05990566 1.2941063 2.501857e-01
h 7  0.4219861   0.25863433 2.5832969 8.993444e-03
h 8  0.3690595   0.18678774 2.0247764 4.052006e-02
h 9  0.4620562   0.30311832 2.9071490 4.084036e-03
h 10 0.3053546   0.09534558 1.4540070 1.750105e-01
h 11 0.3233496   0.11391020 1.5438814 1.419699e-01
h 12 0.2276170  -0.01728491 0.9294211 5.324972e-01
```

Robustness Check

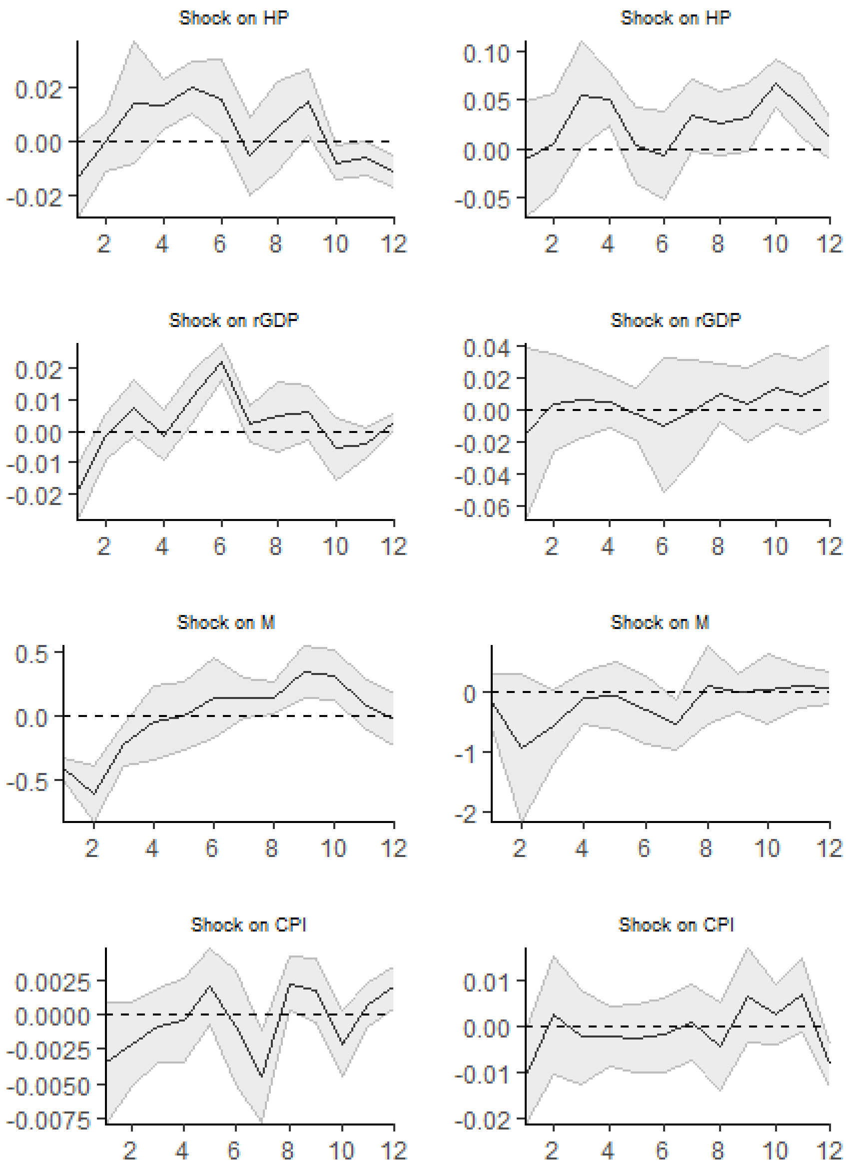
2020-2022 removed



Denmark: IRFs from 1980Q1-2019Q4 MP and UMP respectively

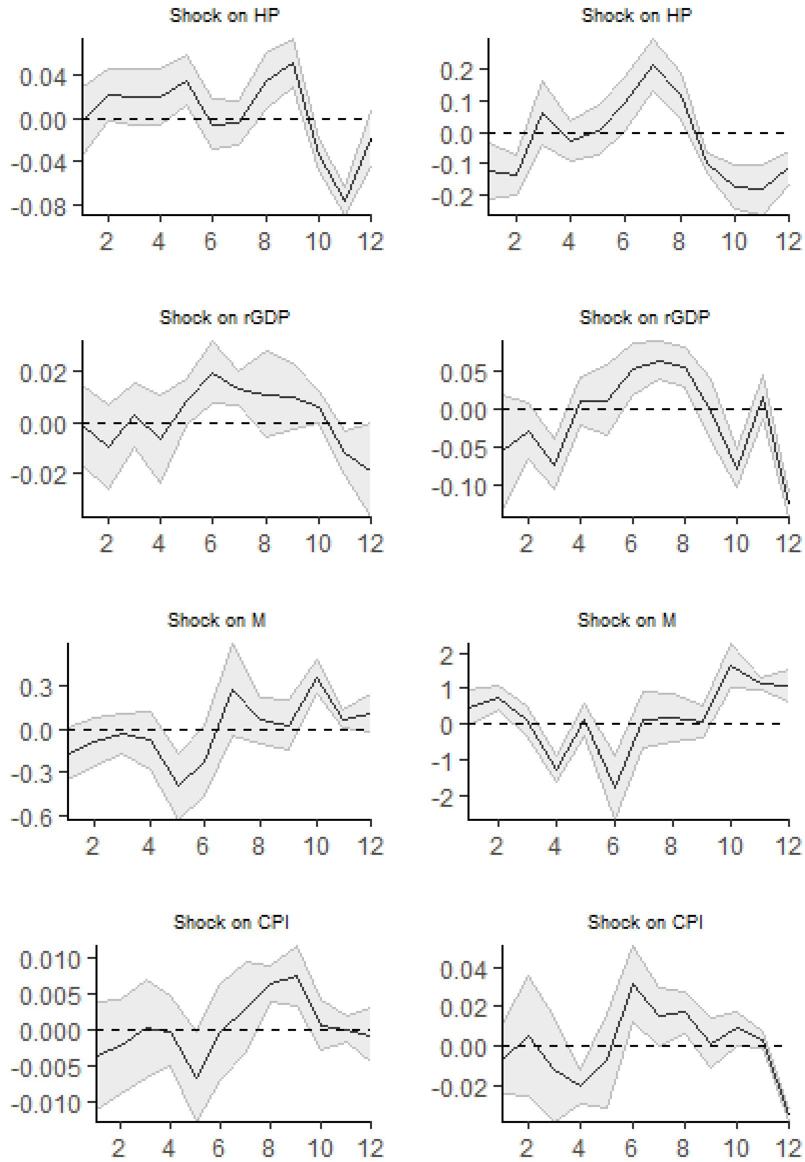


Norway: IRFs from 1980Q1-2019Q4 MP and UMP respectively

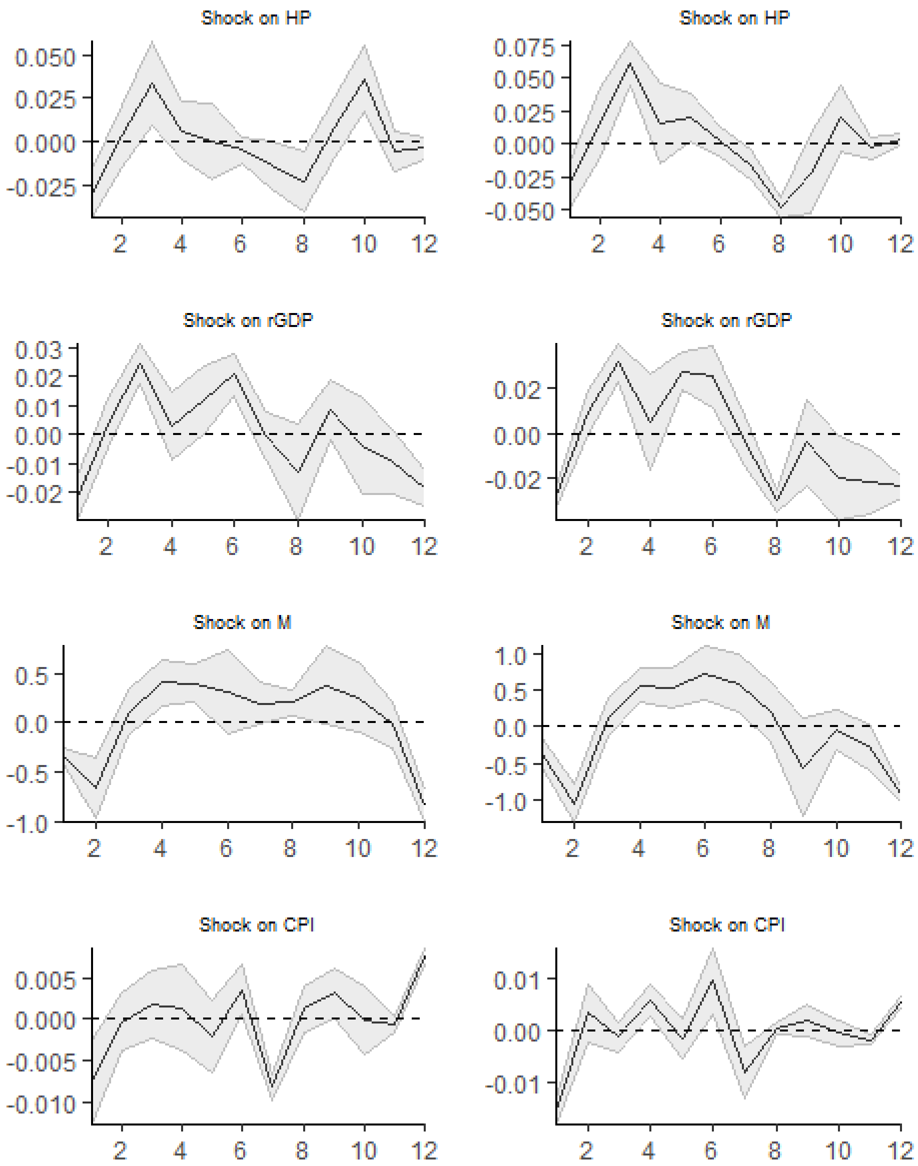


Sweden: IRFs from 1980Q1-2019Q4 MP and UMP respectively

2013-2022 removed



Denmark: IRFs from 1980Q1-2012Q4 MP and UMP respectively



Sweden: IRFs from 1980Q1-2012Q4 MP and UMP respectively