The Effects of Conventional and Unconventional Monetary Policy on House Prices in the Scandinavian Countries

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Abstract

This paper studies the impact of conventional and unconventional monetary policy on house prices in the Scandinavian countries, using sign and zero restrictions in a Bayesian structural vector autoregressive model, covering the central banks’ policy rate and balance sheet policies over a period of nearly 30 years. Expansionary shocks of the policy rate and the balance sheet both have a positive impact on house prices in the Scandinavian countries, but the effects vary greatly within each country. In all the three countries the effect of balance sheet shocks on house prices peaks higher and is more persistent than the response of policy rate shocks. In Sweden and Denmark the impact is more sluggish in case of balance sheet shocks while in Norway the speed of the reaction is similar in case of both types of monetary policy shocks.

JEL codes: C32, C51, E30, E42, E52, R30
Keywords: Unconventional monetary policy, house prices, SVAR, zero and sign restrictions.

1. Introduction

After the global financial crisis broke out in 2008, there has been a growing interest in the effects of monetary policy on macroeconomic variables. After the interest rates reached the zero lower bound (ZLB), unconventional monetary policy became the primary monetary policy tool. Theoretical and empirical studies suggest that unconventional monetary policy measures can be effective tools if changing the short-term interest rates is not possible (Paavola, 2016). There may also be effects of unconventional monetary policy on the prices of long-term assets (Gagnon et al., 2011). One of the fields where unconventional monetary policy may have effects would be house prices. Considering existing literature it would be expected that in case of conventional as well as unconventional expansionary monetary policy shocks the demand for the house purchases would increase and hence the house prices would start to rise, but the transmission mechanisms would be different. The rise in liquidity due to unconventional monetary policy measures would increase the credit supplied by the banks that would in turn reduce the lending rates and the interest rate spreads of banks (Peersman, 2011). In case of expansionary conventional monetary policy shocks, there would be a decline in the banks’ lending rates and a rise in the interest rate spreads.

Housing wealth comprises a large share of the wealth of households. Since the interest rates have been historically low since the beginning of the financial crisis and this could incur

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the risk of housing market bubbles with possible effects on economic and financial stability, it is relevant to study the role of monetary policy in house price dynamics. As there may be a need for unconventional monetary policy measures also in the future, it is important to study how unconventional monetary policy shocks affect house prices and to compare their effect with those of conventional monetary policy shocks. This will reveal whether within an environment in which the policy rate is constrained by the ZLB, unconventional monetary policy measures could influence house prices. It is also important to examine if there are differences in the impacts across countries that share many economic characteristics but have different monetary policy regimes (as, for instance, Scandinavian countries).

The increases and decreases in house prices were particularly large in many European countries, including the Scandinavian countries. In this paper I focus on the three Scandinavian countries (Sweden, Norway and Denmark), all three of which were severely affected by the crisis. In these countries there had been another cycle of real estate bubbles and busts in the early 1990s. Those three advanced economies with two house price booms and busts in the similar economic backgrounds but different monetary policy systems and differences in owner-occupancy rate2 constitute good cases for exploring the impact of different monetary policy measures on house prices. Sweden announced government bond purchases in 2015. Although there has been no official unconventional monetary policy in Norway and Denmark, the effects of balance sheet policies in Norway have been studied earlier by e.g. Gambacorta et al. (2014) and Rahal (2016) and in Denmark by e.g. Behrendt (2013).

The aim of this paper is to study the impact of conventional and unconventional monetary policy on house prices in the Scandinavian countries, covering the central banks’ policy rate and balance sheet policies over a period of nearly 30 years. I address three questions in this paper. First, I study the effect of conventional and unconventional monetary policy on house prices within each of the three Scandinavian country. Second, I investigate whether there are differences in the timing and the magnitude of the effects between the two types of monetary policy shocks. Third, I explore if there are differences in the effects across the three countries. I employ Bayesian structural vector autoregressive (SVAR) models identified with a combination of sign and zero restrictions, following e.g. Baumeister and Benati (2010), Peersman (2011), Schenkelberg and Watzka (2013), Boeckx et al. (2017), Rahal (2016), Weale and Wieladek (2016). This approach enables to sharpen the identification of the structural shocks and hence, by using additional economic information, to better interpret the impulse response functions.

The estimation results show that expansionary shocks of the policy rate and the central bank’s balance sheet both have a positive effect on house prices in all the Scandinavian countries. Based on previous literature I expected the effects of a balance sheet shock on house prices to be more sluggish than the effect of a policy rate shock. This was the case for Sweden and Denmark. In Norway the speed of the reaction is similar in case of both types of monetary policy shocks. In all the Scandinavian countries the effect of a balance sheet shock peaks higher and is more persistent than the effect of a policy rate shock. The results are robust to different model specifications. It is striking how different the responses to each type of monetary policy shocks are within each of the country, whereas the responses of each variable to each monetary policy shock are very similar across countries.

There is an extensive empirical literature suggesting that house price dynamics are closely interrelated with macroeconomic variables. For example, Englund and Ioannides (1997), Tsatsaronis and Zhu (2004), Égert and Mihaljek (2007) and Goodhart and Hoffmann (2008) study the determinants of house prices in a range of industrialized countries, including the three Scandinavian countries. Capozza et al. (2002) and Case and Shiller (2003) explore the

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2 According to Eurostat the owner-occupancy rate in 2016 was 65.2% in Sweden, 82.7% in Norway and 62.0% in Denmark.
relationship between US house prices and other key variables. Kasparova and White (2001) examine the degree of similarity in housing market responses to changes in macroeconomic forces in four countries, including Sweden. Iacoviello (2000) identifies the main macroeconomic factors behind house price fluctuations in six countries, including Sweden.

The impact of monetary policy rate shocks on house prices has also been studied in a number of papers, e.g. Iacoviello (2000), Iacoviello and Minetti (2003), Goodhart and Hoffmann (2008), Musso et al. (2011), Aspachs-Bracons and Rabanal (2011). They find that monetary policy rate shocks are important determinants of house price dynamics; a change in the monetary policy rate changes house prices in the opposite direction. The effect is temporary in Iacoviello (2000) and Iacoviello and Minetti (2003) but it is permanent or very persistent in Goodhart and Hoffmann (2008), Musso et al. (2011) and Aspachs-Bracons and Rabanal (2011).

There is a growing number of studies exploring the effect of unconventional monetary policy on macroeconomic variables, and the interest in that field has increased markedly after the global financial crisis. The effects of an unconventional monetary policy shock on output and consumer prices have been explored, using a combination of zero and sign restrictions in VAR models, in e.g. Schenkelberg and Watzka (2013) and Gambacorta et al. (2014). Gambacorta et al. (2014) study the macroeconomic effects of unconventional monetary policies in eight advanced economies, including Norway and Sweden. Their panel VAR results show that the effects on output and prices are statistically significant but temporary. Individual country results display a temporary effect on output and a temporary but quite persistent effect on prices in case of Sweden. In case of Norway the effects on output and prices are not statistically significant. Schenkelberg and Watzka (2013) explore the effects of quantitative easing in Japan and find that the effects on output and prices are statistically significant but temporary. The effect on unconventional monetary policy on consumer prices and stock market indices in nine countries, including Sweden and Denmark, has been explored by Behrendt (2013), using Cholesky decomposition for identification. The effects on consumer prices are statistically insignificant in case of Denmark and initially negative and after a few months become statistically insignificant in case of Sweden.

Peersman (2011) and Baumeister and Benati (2013) use zero and sign restrictions and include conventional and unconventional shocks in one VAR model as I do in this paper but they do not include house prices as a variable. They have the consumer prices/GDP deflator in the model instead. According to Peersman (2011) conventional monetary policy shocks are innovations to credit supply resulting from a shift in the monetary policy rate and unconventional monetary policy shocks are innovations to credit supply caused by monetary policy actions that are orthogonal to the policy rate. The results of Peersman (2011) indicate that both conventional and unconventional monetary policy shocks have statistically significant temporary effects on output and permanent effects on the level of prices. The effect of the unconventional monetary policy shock is more sluggish; the increases in output and prices only become statistically significant after approximately one year and the peak effect is at least six months later than in the case of a conventional monetary policy shock. Baumeister and Benati (2013) use a time-varying VAR model and find statistically significant temporary effects on output and price.

There is only little literature on the impact of unconventional monetary policy shocks on the housing market. It has been studied by Rahal (2016), Gabriel and Lutz (2017), Smith (2014) and Huber and Punzi (2016). Rahal (2016) uses zero and sign restrictions as I do in this paper and explores the impact in eight OECD countries (including Sweden and Norway) in panel VAR and also separately for each country. His results (only medians are displayed) show a temporary effect on house prices in Sweden and a hump-shaped but eventually permanent effect in Norway. Gabriel and Lutz (2017) do not include house prices as a variable and they identify the monetary policy shock assuming that the variance of the shock is heteroskedastic
across event and non-event days. Smith (2014) concentrates mainly on developing a financial mechanism connecting housing and real economics using USA data. He also compares the impacts of alternative unconventional monetary policy measures’ announcements to output and house prices, simulating different scenarios, using Cholesky decomposition for identification. Rahal (2016), Gabriel and Lutz (2017) and Smith (2014) analyse only unconventional monetary policy shocks in the model. I will include both types of monetary policy shocks in my model and use longer time series. Huber and Punzi (2016) apply time-varying VAR, use shadow interest rate for the unconventional monetary policy variable and identify the unconventional monetary policy shock using only sign restrictions in their main analysis. In the robustness check (only presented for the USA) they label the spread shock as the unconventional monetary policy shock, and use zero and sign restrictions. They also have the conventional monetary policy shock in their robustness check’s identification scheme, but they do not show or comment the results or compare them with the impact of the unconventional monetary policy shock.

My paper contributes to literature in two ways. First, I develop a unique identification scheme in which I study the impact of two types of monetary policy shocks on house prices in one model, using zero and sign restrictions. Second, to my best knowledge, I am the first to compare the impacts of the two types of monetary policy shocks on house prices in each of the Scandinavian country and the differences in the impacts across the three countries with a very similar economic background and different monetary policy regimes.

The remainder of the paper is organized as follows. Section 2 introduces the model and describes the data. Section 3 discusses the details of the identification scheme. Section 4 presents the results and Section 5 concludes.

2. Model Specification and Data

I use as a proxy for conventional monetary policy shocks the innovations in the monetary policy rate (hereinafter labelled as policy rate shocks) and I use as a proxy for unconventional monetary policy shocks the innovations in central bank’s total assets, leaving the policy rate unchanged (hereinafter labelled as balance sheet shocks).

As common for sign-identified VAR models, I employ the Bayesian SVAR approach (e.g. Kilian and Lütkepohl, 2017) to study the dynamic effects of policy rate and balance sheet shocks on house prices. First, the following benchmark reduced-form VAR model is estimated:

\[ Y_t = c + \sum_{i=1}^{n} b_i Y_{t-i} + u_t \]  (1)

Where \( c \) is a vector of intercepts, \( Y_t \) is a vector of endogenous variables, \( b_i \)-s are matrices of autoregressive coefficients of the lagged values of \( Y_t \), \( i \) is the number of lags in the model and \( u_t \) is a vector of residuals.

In order to identify the monetary policy shocks I transform the reduced-form VAR model into the structural form:

\[ A_0 Y_t = B_0 + \sum_{i=1}^{n} B_i Y_{t-i} + \varepsilon_t \]  (2)

where \( A_0 \) is the structural matrix of contemporaneous impact effects, \( B_i \)-s are matrices of structural coefficients of the lagged values of \( Y_t \) and the reduced-form error terms are related to the mutually uncorrelated structural errors (shocks) \( \varepsilon_t \):

\[ u_t = A_0^{-1} \varepsilon_t \]  (3)
I assume that the VAR is of finite order as in most of the sign restriction literature (Fry and Pagan, 2007).

The vector of the six endogenous variables of the VAR model is:

\[ Y_t = [GDP_t, HP_t, BP_t, M_t, R_t, T_t]' \]  (4)

where \( GDP_t \) denotes the real GDP per capita, \( HP_t \) denotes the real house price index of residential real estate, \( BP_t \) is the variable of building permits granted, \( M_t \) is the nominal mortgage interest rate, \( R_t \) indicates the nominal overnight/repo interest rate, and \( T_t \) is the real central bank’s total assets (M3 in the case of Sweden).

GDP is used as a variable in most papers that study monetary policy shocks. The house price is the variable the dynamics of which I am interested in. Housing starts following e.g. Case and Shiller (2003) are representing the supply side of the housing market in the model3. I use the mortgage interest rate as the long-term interest rate, following e.g. Rahal (2016), Case and Shiller (2003) and Musso et al. (2011). Peersman (2011) uses the bank lending interest rate4. I use the overnight/repo rate, following several authors who use the federal funds rate in case of the USA (e.g. Jarociński and Smets (2008), Rav and Simonelli (2007), Stock and Watson (2001), Uhlig (2005), Christiano et al. (2005), Sims and Zha (2006), Guerrieri and Iacoviello (2017), Peneva (2013), Uusküla (2016)). Peersman (2011) and Boeckx et al. (2017) who use the main refinancing operations (MRO) policy rate.

There are two connected interest rates in the VAR, because it is necessary to distinguish between the two types of monetary policy shocks (see detailed information on the identification scheme in the next subsection). In the papers that identify both the conventional and the unconventional monetary policy shock Baumeister and Benati (2010) use the short-term interest rate and the 10-year government bond yield spread, while Peersman (2011) uses the MRO policy rate and the bank lending interest rate. Among the papers that identify only the unconventional monetary policy shock, Boeckx et al. (2017) use the MRO policy rate and the EONIA-MRO spread, Schenkelberg and Watzka (2013) use only the 10-year government bond yield and Rahal (2016) and Case and Shiller (2003) use only the mortgage interest rate. Musso et al. (2011) identify the conventional monetary policy shock and they use the 3-month interbank interest rate and the mortgage interest rate.

I use central bank’s total assets as the balance sheet variable following e.g. Gambacorta et al. (2014), Boeckx et al. (2017) and Rahal (2016). Peersman (2011) uses as the monetary base the sum of banknotes in circulation and bank reserves (credit institutions’ current accounts and deposit facility). Schenkelberg and Watzka (2013) use the average outstanding current account balances held by financial institutions at the Bank of Japan. Since I found quarterly data of total assets of the Riksbank starting from 2004Q1 only, I use in case of Sweden M3 as the balance sheet policy variable, following e.g. Peersman (2011). To check whether changing the variable affects the results I also estimated the impulse responses for the same length of time series as with total assets. The IRFs (available upon request) using total assets are very similar to the ones using M3 and hence there is an argument for using M3 in the model as a variable.

The data are in levels, which allows for implicit cointegrating relationships (Sims, Stock and Watson, 1990). All the variables are quarterly, seasonally adjusted, using the multiplicative X12-ARIMA method. The GDP per capita, the house price index and the central bank’s total assets are deflated by the CPI. All variables except the interest rates are transformed using

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4 A weighted average of interest rates of MFIs to households, non-financial corporations and non-MFI financial intermediaries.
natural logarithms (and multiplied by 100 for a better display of results). Two lags are used, based on the usual lag order selection criteria. The sample periods are based on data availability and are 1989Q1-2017Q1 for Sweden, 1988Q4-2017Q1 for Norway and 1990Q1-2017Q1 for Denmark. Hence, the Nordic Banking Crisis period is also included. I also estimated the impulse responses in case of identical period lengths across countries, but it did not make any notable difference. See Appendix A for a detailed description of data and data sources and Appendix B for the descriptive statistics.

The estimations are done in Matlab, using the BEAR toolbox (Dieppe et al., 2016). I use the Normal-Wishart (sigma as univariate AR) prior, following e.g. Uhlig (2005), Peersman (2011), Schenkelberg and Watzka (2013) and Boeckx et al. (2017). The toolbox’s default values (which are also the typical values found in the literature) for the hyperparameters to compute the mean and variance of the prior distribution for the VAR coefficients are used (autoregressive coefficient = 0.8, overall tightness = 0.1, lag decay = 1, exogenous variable tightness = 100). A total of 10,000 successful draws (following e.g. Boeckx et al., 2017) from the posterior are used for the impulse response functions. The 16\(^{th}\) and 84\(^{th}\) percentiles (i.e. the 68\% credible set) of the IRFs are reported as standard in the sign restriction literature, reflecting model uncertainty and sampling uncertainty (Gambacorta et al., 2014). Also the median is shown (as in e.g. Uhlig, 2005).

3. Identification Scheme

I use a combination of sign and zero restrictions on the contemporaneous impact matrix as in e.g. Baumeister and Benati (2010), Peersman (2011), Schenkelberg and Watzka (2013), Gambacorta et al. (2014), Boeckx et al. (2017), Rahal (2016), Weale and Wieladek (2016) in order to sharpen the identification of the structural shocks and hence, by using additional economic information, to better interpret the impulse response functions.

I use as a proxy for conventional monetary policy shocks the innovations in the monetary policy rate (labelled in the current paper as policy rate shocks) and I use as a proxy for unconventional monetary policy shocks the innovations in central bank’s total assets, leaving the policy rate unchanged (labelled in the current paper as balance sheet shocks). Hence, to distinguish the two monetary policy shocks I assume that the balance sheet shock has zero contemporaneous effect on the monetary policy rate, following e.g. Baumeister and Benati (2010), Peersman (2011) and Boeckx et al. (2017). A balance sheet shock is identified as an orthogonal innovation to the central bank’s total assets (M3 in case of Sweden).

The effect of an unconventional monetary policy shock on real estate markets has been studied by Rahal (2016), Gabriel and Lutz (2017), Smith (2014) and Huber and Punzi (2016). Gabriel and Lutz (2017) and Smith (2014) do not use sign restrictions for identification. Rahal (2016) and Huber and Punzi (2016) use a combination of zero and sign restrictions as I do in my paper, but Huber and Punzi (2016) use only sign restrictions in the identification scheme of their main analysis and add a zero restriction in the robustness check.

I have used the papers of Peersman (2011) and Rahal (2016) as a basis for developing the identification scheme for my paper. Rahal (2016) has identified only the unconventional monetary policy shock and he has not included the monetary policy rate. In order to sharpen the distinguishing between the two types of monetary policy shocks, I add to the Rahal (2016) model the monetary policy interest rate, with a zero restriction on the contemporaneous impact matrix. Different from the model in Rahal (2016) I also have the policy rate shock in the model as in Peersman (2011). Peersman (2011) has both the conventional and unconventional

\(^{5}\) In case of Sweden the use of two lags was proposed by HQ criterion, in case of Denmark by AIC, SC and HQ criteria and in case of Norway by AIC and HQ. The results are robust to various lag lengths.
monetary policy shocks in the model; however, he does not include house prices or the housing supply.

Table 1 presents the identification scheme of my paper. Two types of monetary policy shocks are identified: a monetary policy rate shock and a balance sheet shock. The zero restrictions are binding on impact and the sign restrictions are imposed on impact and the following two quarters after the shock, following e.g. Rahal (2016).

Table 1. Identification of monetary policy shocks

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>HP</th>
<th>BP</th>
<th>M</th>
<th>R</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy rate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;0</td>
<td>&lt;0</td>
<td>?</td>
</tr>
<tr>
<td>Balance sheet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;0</td>
<td>0</td>
<td>&gt;0</td>
</tr>
</tbody>
</table>

Note: “?” denotes leaving the impact of the shock on the variable unrestricted.

For both shocks I assume that there is only a lagged impact of the monetary policy shocks on GDP and house prices following e.g. Schenkelberg and Watzka (2013), Peersman (2011), Gambacorta et al. (2014) and Boeckx et al. (2017). They have consumer prices in their models, but according to the characteristics of housing markets, I assume that the responses can be even slower in case of house prices. A lagged impact on GDP, house prices and housing supply variable has been assumed in e.g. Rahal (2016). Hence, I restrict the contemporaneous impact on those three variables to be zero.

I restrict the mortgage interest rate to decrease in case of both types of monetary policy shocks, following e.g. Peersmann (2011), Rahal (2016) and Weale and Wieladek (2016). Since a restriction on the monetary policy rate variable is needed for distinguishing between the two types of monetary policy shocks, I restrict that variable to decrease in case of a policy rate shock and to have only a lagged impact in case of a balance sheet shock. I restrict the central bank’s total assets to increase contemporaneously following the balance sheet shock, following e.g. Schenkelberg and Watzka (2013), Gambacorta et al. (2014) and Rahal (2016).

4. Results

Figures 1-3 show the impulse responses to policy rate and balance sheet shocks. For better comparability the effects of both types of monetary policy shocks are displayed on the same figure. Areas bordered by lines represent the 68% credible sets of the responses to expansionary policy rate shocks while shadowed areas show the 68% credible sets of the effects of expansionary balance sheet shocks. The lines within the credible sets represent the median impulse responses.

4.1. Sweden

Figure 1 shows the IRFs of the monetary policy shocks of Sweden. The impulse responses indicate that an expansionary policy rate shock of the size of one standard deviation (amounting to a decrease in the repo rate of about 1 percentage point) is followed by a temporary rise in house prices peaking in the 14th quarter. A positive balance sheet shock of the size of one standard deviation (an increase in M3 of about 1.5%) is followed by a permanent rise in house prices peaking at the end of the 7th year. By the 15th quarter the magnitude of the impact on house prices to a 2% increase in M3 is similar to the effect of a 150 basis points decrease in the

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6 Peersman (2011) imposes this restriction on the interest rate in case of the conventional monetary policy as a non-strict inequality; however, I believe that imposing a strict inequality improves the orthogonality of the shocks.
repo rate. These results suggest that in times when unconventional monetary policy measures are used, the effect on house prices may be a prolonged or permanent increase. One reason that the response of house prices to a balance sheet shock is more persistent than to a policy rate shock may be that the households in Scandinavia have a very high level of debt relative to income\(^7\). This means that they are very sensitive to mortgage interest rate changes and as the balance sheet shock results in more persistent decline in mortgage interest rates then the house price rise is also more persistent.

Figure 1. Impulse responses to policy rate and balance sheet shocks in Sweden

*Note:* Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68\% credible set). The line within a credible set represent the median impulse response.

The responses of house prices and GDP to balance sheet shocks are more sluggish, very persistent and peak at higher levels than the responses to policy rate shocks. The result that the responses of output and prices are more sluggish in case of balance sheet shocks is consistent with the findings in e.g. Peersman (2011) and may be possibly ascribed to differences in the transmission mechanisms of the two types of monetary policy shocks, as described in the Introduction.

It is striking how different the responses of house prices are in case of the two types of monetary policy shocks. Looking at earlier studies, Peersman (2011) finds the response of consumer prices is temporary in the case of interest rate shocks and permanent in the case of non-standard policy shocks. The results of my paper indicate that this kind of pattern also applies to the response of house prices.

In case of housing starts, the response on impact is restricted to zero and there is a positive response to a policy rate shock after the period of impact, but the value zero is within the credible interval until the 10\(^{th}\) quarter. The subdued effect could potentially be explained by the low housing supply in relation to the demand, a feature that has been characteristic to Swedish housing market for decades (Emanuelsson, 2015). There is at first a negative impact

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\(^7\) According to OECD Data the Scandinavian countries have some of the highest levels of household debt to disposable income; in 2016 it was 290\% in Denmark, 230\% in Norway, and 183\% in Sweden.
on housing starts to a balance sheet shock, then zero inside the credible interval from the 10th until the 24th quarter after which it becomes positive. The upper band of the credible set is very close to zero during the first quarters and in case of a larger credible set zero would have been inside the credible interval.

In line with the imposed sign restrictions the mortgage interest rate falls on impact and stays negative for the two following quarters in case of both types of monetary policy shocks; the response remains negative until it dies out, consistent with e.g. the response to unconventional monetary policy shocks in Rahal (2016). The effect fades out sooner in case of conventional monetary policy shocks; the value zero is included in the credible set already in the 7th quarter. The effect is much more persistent in case of balance sheet shocks.

4.2. Norway

The IRFs of the two types of monetary policy shocks for Norway are reported in Figure 2. An expansionary policy rate shock of one standard deviation (amounting to a ca. 0.3 percentage points decrease in the overnight lending rate) is followed by a rise in house prices, peaking, similarly to Sweden, around the 14th quarter. After that, the impact slowly starts diminishing. A positive balance sheet shock of the size of one standard deviation (amounting to an increase in central bank’s total assets of about 3%) is also followed by a rise in house prices, reaching a peak by the 14th quarter just as in case of the policy rate shock. To compare the responses of house prices to different types of monetary policy shocks it can be said that in, for example, the 7th quarter the effect on house prices of a decrease in overnight lending rate of ca. 50 basis points is equivalent to a 1% increase in central bank’s total assets. The response of house prices to balance sheet shocks peaks at a similar time but at a higher level than the response to policy rate shocks. The effect of policy rate shocks fades out much sooner than the effect of balance sheet shocks. The response to a balance sheet shock to house prices of Norway is very similar to the results of Rahal (2016). He, however, does not study the effect of conventional monetary policy shocks and thus no comparison is available for the differences of the impacts of the two types of shocks.

![Figure 2. Impulse responses to policy rate and balance sheet shocks in Norway](image-url)
The effect on GDP is positive in case of both types of monetary policy shocks, but it is more sluggish, peaks at a lower level and the value zero is outside the credible interval later in case of the balance sheet shock. The persistence of the response of GDP is arguably quite surprising.

Turning to housing starts, Figure 2 shows that after impact there is a positive response of housing starts to a policy rate shock but zero belongs to the credible set until the 2nd quarter. Zero is included in the credible set of the response of housing starts to a balance sheet shock in all quarters. This may be explained by a low housing supply relative to demand in Norway, similarly to the situation in Sweden. The possible reasons for that could be rapid population growth, a lack of suitable land in the urban areas and planning delays at the municipality level.

The response of the mortgage interest rate is initially negative due to the restrictions imposed and it stays negative until the effect dies out. The effect fades out sooner in case of a policy rate shock, but broadly the responses to the two types of monetary policy shocks are quite similar.

4.3. Denmark

Figure 3 plots the IRFs of policy rate and balance sheet shocks of Denmark. An expansionary policy rate shock of the size of one standard deviation (an about 0.3 percentage points decrease in repo rate) is followed by a temporary rise in house prices peaking by the 14th quarter. A positive balance sheet shock of the size of one standard deviation (ca. 7% increase in central bank’s total assets) is followed by a temporary rise in house prices reaching a peak by the 20th quarter. By the 7th quarter, the response of house prices to a 45 basis points decrease in the repo rate is equivalent to a ca. 7% increase in central bank’s total assets. Similar to the results of Sweden the response of house prices to balance sheet shocks is more sluggish and peaks higher than the responses to the policy rate shocks.
Looking at the effect of the monetary policy shocks on other variables it follows that after the period of impact there is a positive effect on GDP in case of both types of monetary policy shocks; the response is more sluggish and peaks at a higher level in case of a balance sheet shock. Zero is within the credible interval of the IRFs of GDP until the beginning of the second year. The credible set of the response of housing starts to both types of monetary policy shocks includes zero and, like in case of the two other Scandinavian countries, could perhaps be explained by the low supply of housing relative to the demand (Pedersen and Isaksen, 2015). The response of the mortgage interest rate is initially negative by identification restrictions and it stays negative until the effect dies out. The effect fades out sooner in case of a policy rate shock.

4.4. Comparison of the Responses Across the Countries

Figure 4 displays the impulse responses of all the six variables to expansionary policy rate and balance sheet shocks in the Scandinavian countries. For each variable the scales of the figures are the same across countries for better comparability of the magnitudes of the responses across countries. The shocks are the size of one standard deviation, which makes it easier to compare the responses as the balance sheet policy measures vary across the countries.
The effect of policy rate shocks on house prices is positive in case of all the three countries, which coincides with the findings of earlier literature. The magnitudes of the responses and the timing of reaching the peak are very similar across the three countries, which suggests that the differences in the monetary policy regimes and the housing market characteristics do not seem to play an important role. The response of house prices to balance sheet shocks, however, is not so similar across the countries compared to the response in case of policy rate shocks, although the magnitudes of the impacts are broadly the same for all the Scandinavian countries. The effect of balance sheet shocks is more persistent and peaks higher than the response of policy rate shocks in all the Scandinavian countries. The response of house prices to balance sheet shocks is more sluggish than the response of policy rate shocks for Sweden and Denmark. All the Scandinavian countries have very high levels of household debt to disposable income ratio that could also account for a proportion of the similarity across the impact responses across countries. It is surprising how different the effects of the two different types of monetary policy shocks are within each country, but the effects of each type of monetary policy shock compared across the countries are quite similar.

Turning now to other variables it can be seen from Figure 4 that the effect of both types of monetary policy shocks on GDP is positive in case of all the three countries, consistent with the results of earlier studies (e.g. Peersman, 2011). The response to balance sheet shocks is more sluggish than the response to policy rate shocks in all the three countries. The peak of the response to balance sheet shocks is very similar in magnitude, possibly showing that the choice of balance sheet policy measures does not play an important role on the response of GDP. In case of Norway zero is outside the credible set of the response much later. The effect of balance sheet shocks is more persistent in case of Sweden and Denmark than the effect of policy rate shocks. For Norway the responses to both types of shocks are similar in persistence.

The response of housing starts to policy rate shocks is similarly shaped in all the Scandinavian countries. The magnitudes of the responses are, however, different: the effect is the largest for Sweden and the smallest for Norway, while zero is within the credible set for Denmark. The response of housing starts to balance sheet shocks has zero barely outside the credible set at first in case of Sweden and zero within the credible set in case of Norway and Denmark. In all the three countries the housing supply is quite inelastic: the population is growing in the more popular areas faster than the housing supply. This could possibly be one explanation for the small impact of the monetary policy shocks on the housing supply variable.

In case of mortgage interest rate the response to both types of monetary policy shocks is negative in all the three countries. The responses are similar in magnitude in case of Norway and Denmark and a bit larger in case of Sweden. The responses to balance sheet shocks are similar in shape in case of all the three countries. The responses of Norway and Denmark are similar across the two types of monetary policy shocks despite the differences in e.g. mortgage interest rate systems.\(^8\)

The responses of overnight/repo rate to both types of monetary policy shocks are negative and similar in shape in all the three countries. The responses to a policy rate shock are similar in magnitude in case of Norway and Denmark and the largest in case of Sweden. The responses

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\(^8\) For example, in Denmark mortgage credit bonds are used. The market price of the bonds is determining the mortgage loan interest rates.
of the monetary policy rate to balance sheet shocks are similar in magnitude in case of Sweden and Denmark and the smallest in case of Norway.

The responses of central bank’s total assets (M3 in case of Sweden) to a balance sheet shock are permanent or very persistent in case of all the three countries. The effect is the smallest in Sweden, although it is the only country among the three that has had “official” unconventional monetary policy measures. The responses to a policy rate shock have initially zero outside the credible set for a number of periods in case of all the countries. The response has zero within the credible set in case of Sweden and zero is outside the credible set in case of Norway and Denmark starting from around the 14th quarter.

4.5. Robustness analysis

For robustness I ran the regressions for a period starting from 2007 to see if using only the period since the start of the financial crisis would make a difference in the impact of the shocks on house prices. The impulse responses for the shorter period are plotted in Appendix C. The response of house prices to unconventional monetary policy shocks is more sluggish that the response to conventional monetary policy shocks in case of all the Scandinavian countries. This was the same in case of Sweden and Denmark, using the longer period. In case of the shorter period the effect of conventional monetary policy shocks peaks at higher levels compared to the effect of unconventional monetary policy shocks in case of Norway and Denmark.

I also produced an extended model with CPI as an additional variable to check whether the very persistent impact on GDP and house prices could be partly explained by containing also the response of consumer prices. The main results of the analysis, however, do not change notably with CPI added to the model (Appendix D).

5. Conclusion

In this paper, I have analysed the impact of conventional and unconventional monetary policy on house prices in the three Scandinavian countries: Sweden, Norway and Denmark. Within a Bayesian structural VAR framework, I have identified, using a mixture of zero and sign restrictions, two types of monetary policy shocks (a policy rate shock and a balance sheet shock) and computed the impulse response functions for the variables of the model, using a data period of nearly 30 years.

The empirical analysis of this paper yields the following main findings. I find that there is a positive effect of both an expansionary policy rate shock and an expansionary balance sheet shock on house prices in all the Scandinavian countries. The effect of a balance sheet shock on house prices is more sluggish than the effect of a policy rate shock in Sweden and Denmark while in Norway the speed of the reaction is similar in case of both types of monetary policy shocks. The effect of a balance sheet shock on house prices peaks higher and is more persistent than the effect of a policy rate shock in all the Scandinavian countries. The effects of each type of a monetary policy shock are quite similar across the three countries, which is an interesting result, considering the differences in their monetary policy regimes. This could indicate that the differences in the monetary policy regimes in those countries do not appear to play an important role for the effects of monetary policy shocks in these countries. Moreover, it could also suggest that the unconventional monetary measures chosen do not change the impact notably. Among the Scandinavian countries, only Sweden has implemented official unconventional monetary
policy measures, but interestingly the responses to changes in balance sheet variables are nevertheless very similar across the countries.

The upshot would be that in a situation when it is not possible to implement conventional monetary policy measures and unconventional monetary policy measures that influence the central bank’s balance sheet are used instead, house prices could possibly also be affected.

A number of important venues of research remain. First, it has to be borne in mind that the estimations of the paper are based on a period that contains “normal times” as well as crisis times. Further research could study the impact of the two types of monetary policy shocks in those countries, using a time-varying VAR framework. Second, the current paper focuses on the domestic responses to domestic monetary policy shocks. Hence, the spill-over effects of the monetary policy shocks in one Scandinavian country to house prices in other Scandinavian countries could possibly be studied in the future.


## Appendix A

### Description and Sources of the Data

#### Table A1. Description and Sources of the Data, Sweden

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita</td>
<td>GDP in market values (SEK) divided by total population. The population figure is monthly, quarterly averages are calculated.</td>
<td>GDP from Statistics Sweden, monthly population from Eikon/Statistics Sweden</td>
</tr>
<tr>
<td>House prices</td>
<td>House price index (1995=100); up to 2004Q4 residential property prices, from 2005Q1 all types of dwellings</td>
<td>BIS Residential Property Base database</td>
</tr>
<tr>
<td>Housing starts</td>
<td>Number of building permits (the available data series about the m2 is much shorter).</td>
<td>Thomson Reuters Eikon / Statistics Sweden</td>
</tr>
<tr>
<td>Mortgage interest rate</td>
<td>Interest rate on outstanding loans (up to 2005Q2 there are data just about the fixed rate, from 2005Q3 there are data on fixed and floated interest rates; to have consistency in the data fixed interest rate was used for the whole time series) to households (loans secured on dwellings). The series for new loans is a lot shorter, because of that the interest rates of outstanding loans are used.</td>
<td>Statistics Sweden</td>
</tr>
<tr>
<td>Short term interest rate</td>
<td>The repo rate is used in this paper as the Swedish monetary policy rate. The data are monthly, quarterly averages are calculated. The dynamics of the repo and overnight rates are historically very similar. The repo rate is used because the available time series of repo rate are much longer.</td>
<td>Thomson Reuters Eikon / Sveriges Riksbank</td>
</tr>
<tr>
<td>M3</td>
<td>Since no data are available about total assets for earlier periods than 2004, M3 is used as the balance sheet variable.</td>
<td>International Financial Statistics</td>
</tr>
</tbody>
</table>

#### Table A2. Description and Sources of the Data, Norway

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita</td>
<td>GDP in market values (NOK) divided by total population.</td>
<td>GDP from Statistics Norway, total population 1978-1997 from Eurostat, 1997Q4-2016Q3 from Statistics Norway.</td>
</tr>
<tr>
<td>House prices</td>
<td>House price index (1995=100); up to 1991Q4 house prices, from 1992Q1 onwards residential property prices</td>
<td>BIS Residential Property Base database</td>
</tr>
<tr>
<td>Housing starts</td>
<td>Building permits – m2 of utility area of dwellings</td>
<td>Thomson Reuters Eikon / Statistics Norway</td>
</tr>
<tr>
<td>Mortgage interest rate</td>
<td>Interest rate on outstanding loans (weighted average of fixed and floated interest rates) to households</td>
<td>Statistics Norway</td>
</tr>
</tbody>
</table>
(loans secured on dwellings) by mortgage companies. The series for new loans is a lot shorter, because of that the interest rates of outstanding loans are used.

**Short term interest rate**
The overnight lending rate is used as the Norwegian monetary policy rate in this paper. Quarterly averages are calculated.

**Central bank’s total assets**
Total assets of the central bank’s balance sheet

---

**Table A3. Description and Sources of the Data, Denmark**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita</td>
<td>GDP per capita at current prices (DKK)</td>
<td>Statistics Denmark</td>
</tr>
<tr>
<td>House prices</td>
<td>House price index (1995=100); up to 2001Q4 residential property prices (single family houses), from 2002Q1 all types of dwellings</td>
<td>BIS Residential Property Base database</td>
</tr>
<tr>
<td>Housing starts</td>
<td>The number of residential buildings started are available for a longer period than the data about the residential building permits total floor area</td>
<td>Eikon/Statistics Denmark</td>
</tr>
<tr>
<td>Mortgage interest rate</td>
<td>The mortgage credit bonds’ rate with the maturity of 30 years for 1990Q1-2012Q4 and for 2013Q1-2017Q1 the mortgage credit bonds’ rate (long-term) are used as a proxy of housing loan interest rate The 30-year bonds rate is the closest to the long-term credit bonds’ rate of FinansDanmark. Danmarks Nationalbank’s data are monthly and quarterly averages are calculated. FinansDanmark’s data are weekly and quarterly averages are calculated.</td>
<td>Danmarks Nationalbank, FinansDanmark</td>
</tr>
<tr>
<td>Short term interest rate</td>
<td>The repo rate on Certificates of Deposit is used in this paper as the Danish monetary policy rate. Data are monthly, quarterly averages are calculated.</td>
<td>IMF, Statistics Denmark</td>
</tr>
<tr>
<td>Central bank’s total assets</td>
<td>Total assets of the central bank’s balance sheet</td>
<td>Danmarks Nationalbank</td>
</tr>
</tbody>
</table>
## Appendix B

### Descriptive Statistics of the Data

**Table B1. Descriptive Statistics, Sweden**

<table>
<thead>
<tr>
<th></th>
<th>Ln Real GDP</th>
<th>Ln House Prices</th>
<th>Ln Housing Starts</th>
<th>Mortgage Interest Rate</th>
<th>Repo Interest Rate</th>
<th>Ln M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1078.17</td>
<td>481.47</td>
<td>874.44</td>
<td>7.17</td>
<td>4.49</td>
<td>1368.60</td>
</tr>
<tr>
<td>Median</td>
<td>1079.66</td>
<td>473.36</td>
<td>873.00</td>
<td>6.13</td>
<td>3.59</td>
<td>1363.97</td>
</tr>
<tr>
<td>Maximum</td>
<td>1108.61</td>
<td>557.24</td>
<td>978.82</td>
<td>17.17</td>
<td>28.88</td>
<td>1440.69</td>
</tr>
<tr>
<td>Minimum</td>
<td>1045.93</td>
<td>426.26</td>
<td>756.36</td>
<td>1.95</td>
<td>-0.51</td>
<td>1309.38</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>18.43</td>
<td>39.20</td>
<td>57.78</td>
<td>4.25</td>
<td>4.47</td>
<td>41.93</td>
</tr>
<tr>
<td>Probability</td>
<td>0.01</td>
<td>0.02</td>
<td>0.13</td>
<td>0.001</td>
<td>0</td>
<td>0.007</td>
</tr>
<tr>
<td>Observations</td>
<td>113</td>
<td>113</td>
<td>113</td>
<td>113</td>
<td>113</td>
<td>113</td>
</tr>
</tbody>
</table>

Note: All data in natural logarithms have been multiplied by 100 for better display of IRFs

**Table B2. Descriptive Statistics, Norway**

<table>
<thead>
<tr>
<th></th>
<th>Ln Real GDP</th>
<th>Ln House Prices</th>
<th>Ln Housing Starts</th>
<th>Mortgage Interest Rate</th>
<th>Overnight Interest Rate</th>
<th>Ln Total assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1104.79</td>
<td>493.83</td>
<td>1359.86</td>
<td>6.80</td>
<td>6.01</td>
<td>1342.87</td>
</tr>
<tr>
<td>Median</td>
<td>1106.26</td>
<td>494.64</td>
<td>1361.54</td>
<td>6.57</td>
<td>5.96</td>
<td>1346.03</td>
</tr>
<tr>
<td>Maximum</td>
<td>1143.36</td>
<td>565.65</td>
<td>1406.32</td>
<td>14.74</td>
<td>12.37</td>
<td>1539.58</td>
</tr>
<tr>
<td>Minimum</td>
<td>1056.53</td>
<td>416.54</td>
<td>1293.17</td>
<td>2.41</td>
<td>1.49</td>
<td>1181.32</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>31.39</td>
<td>45.40</td>
<td>22.33</td>
<td>3.37</td>
<td>2.98</td>
<td>120.60</td>
</tr>
<tr>
<td>Probability</td>
<td>0.003</td>
<td>0.01</td>
<td>0.04</td>
<td>0.001</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Observations</td>
<td>114</td>
<td>114</td>
<td>114</td>
<td>114</td>
<td>114</td>
<td>114</td>
</tr>
</tbody>
</table>

Note: All data in natural logarithms have been multiplied by 100 for better display of IRFs

**Table B3. Descriptive Statistics, Denmark**

<table>
<thead>
<tr>
<th></th>
<th>Ln Real GDP</th>
<th>Ln House Prices</th>
<th>Ln Housing Starts</th>
<th>Mortgage Interest Rate</th>
<th>Repo Interest Rate</th>
<th>Ln Total assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1077.37</td>
<td>482.92</td>
<td>840.29</td>
<td>6.24</td>
<td>3.65</td>
<td>1230.88</td>
</tr>
<tr>
<td>Median</td>
<td>1079.18</td>
<td>483.54</td>
<td>837.94</td>
<td>5.88</td>
<td>3.47</td>
<td>1243.22</td>
</tr>
<tr>
<td>Maximum</td>
<td>1096.10</td>
<td>532.64</td>
<td>922.11</td>
<td>11.15</td>
<td>12.84</td>
<td>1312.26</td>
</tr>
<tr>
<td>Minimum</td>
<td>1050.64</td>
<td>418.23</td>
<td>775.29</td>
<td>2.30</td>
<td>-0.77</td>
<td>1121.60</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>14.62</td>
<td>34.92</td>
<td>33.50</td>
<td>2.34</td>
<td>3.36</td>
<td>44.45</td>
</tr>
<tr>
<td>Probability</td>
<td>0.004</td>
<td>0.01</td>
<td>0.30</td>
<td>0.12</td>
<td>0.001</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: All data in natural logarithms have been multiplied by 100 for better display of IRFs
Appendix C
Impulse response functions for 2007Q1-2017Q1

Figure C1. Impulse responses to policy rate and balance sheet shocks in Sweden (2007Q1-2017Q1)

Note: Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68% credible set). The line within a credible set represent the median impulse response.

Figure C2. Impulse responses to policy rate and balance sheet shocks in Norway (2007Q1-2017Q1)

Note: Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68% credible set). The line within a credible set represent the median impulse response.
Figure C3. Impulse responses to policy rate and balance sheet shocks in Denmark (2007Q1-2017Q1)

Note: Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68% credible set). The line within a credible set represent the median impulse response.
Appendix D
Impulse response functions with CPI as an additional variable

Figure D1. Impulse responses to policy rate and balance sheet shocks in Sweden with CPI as an additional variable

Note: Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68% credible set). The line within a credible set represent the median impulse response.

Figure D2. Impulse responses to policy rate and balance sheet shocks in Norway with CPI as an additional variable

Note: Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68% credible set). The line within a credible set represent the median impulse response.
Figure D3. Impulse responses to policy rate and balance sheet shocks in Denmark with CPI as an additional variable

Note: Area bordered by lines displays the impact of policy rate shocks, shadowed area the impact of balance sheet shocks (68% credible set). The line within a credible set represent the median impulse response.
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