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The role of loan supply and demand dynamics in housing loan expansion and housing price cycles

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ABSTRACT

This study provides the first investigation of the joint contributions of loan supply and demand shocks, together with housing market shocks, on housing loan expansion and housing prices. A 6-variate structural vector-error correction model is specified with identification of the shocks achieved by a combination of short- and long-run restrictions, and restrictions arising from the presence of cointegration. An important feature of the model is the identification of a full set of shocks across loan, housing, goods and money markets, including the identification of supply and demand shocks in the loan market. Using quarterly Finnish data from 1985 to 2024, the empirical results show that both loan supply and demand shocks can influence financial stability by significantly affecting housing loan expansion and housing prices over the short and mid term. The findings further indicate that housing price movements are more likely to respond to loan market shocks rather than to cause loan expansion. Implications for Europe through the lens of the Finnish market of the Russian war of aggression in Ukraine are also investigated.

1. Introduction

After the occurrence of the global financial crisis (GFC) of the early 2000s, it is generally accepted that housing and housing loan markets play an important role in credit cycles and the macroeconomy. The interplay between these markets has been linked to housing price bubbles, deeper recessions, slower recoveries and to greater distresses in the banking sector (Koetter and Poghosyan, 2010; Jordà et al., 2015, 2016). Brunnermeier (2009) and Mian and Sufi (2011) argue that the interaction between loan and housing markets is a major contributor to the GFC, and Richter et al. (2021) show that credit booms are more likely to end in a systemic banking crisis if they are accompanied by house price booms. The importance of housing and other real estate mortgage loans may have further increased since the GFC as the ratio of these loans to total non-financial private loans has notably grown after the crisis (Calomiris and Jaremski, 2024).[2]

Given the significance of loan and housing markets for financial stability and thereby for the whole economy, loan market dynamics and the interplay between loan and housing markets is of great academic and policy interest (Wang, 2022; Cokayne et al., 2024). This study contributes to the literature on the topic by identifying loan supply and demand shocks within the same system, and investigating their influences on housing loan expansion and housing prices. We also apply this framework to understanding the effects of the current Russian war of aggression in Ukraine on loan and housing markets.

A common problem in empirical work is being able to distinguish between loan supply and demand shocks, with identification of loan demand shocks being particularly troublesome (Peek et al., 2003; Gambetti and Musso, 2017). Previous approaches tend to focus on loan supply or monetary policy shocks with identification in structural vector autoregressions (SVARs) often based on using sign restrictions (Vargas-Silva, 2008; Hristov et al., 2012, amongst others). More recently, Budnik and Rünstler (2023) specify a SVAR model with identification of specific regulatory shocks to loan supply based on external instruments using information on the signs of shocks in particular periods.

From a theoretical point of view loan demand shocks can also be important for loan and credit cycles (Mian et al., 2017). Gambetti

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[2] The interaction between the loan market and housing prices is sometimes referred to as a financial accelerator mechanism (Bernanke et al., 1996, 1999, Kiyotaki and Moore, 1997, Almeida et al., 2006, and Koetter and Poghosyan, 2010).

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and Musso (2017) specify a model that identifies loan supply and monetary policy shocks, by combining loan demand and aggregate demand shocks into a general "demand" shock. As a robustness check on this approach they also specify a model containing loan supply and demand shocks, but without monetary policy shocks, by replacing the money rate with the output-to-loan ratio. As of yet, there does not exist a general model combining loan supply and demand shocks within a macroeconometric system that allows for money market shocks together with aggregate supply and demand shocks from the goods market. There also does not exist models allowing for the interaction between loan and housing markets while still preserving the full set of shocks originating in the loan market.

This study provides an alternative approach to model the interaction between loan and housing markets based on a dynamic structural vector error-correction model (SVECM).[3] The model contains six equations with three of the equations representing cointegrating relationships. An important feature of the proposed approach is that identification is based on a combination of short-run and long-run restrictions together with restrictions arising from the presence of cointegration. The cointegrating restrictions exploit the integration and cointegration properties of the data by decomposing the shocks into permanent and transitory components with the latter having no long-run effects on variables affected by permanent shocks (Pagan and Pesaran, 2008). This approach to identification contrasts with the use of sign restrictions which focuses on imposing short-run restrictions, often within a year, on the signs of shocks affecting the variables in the model. The paper makes four important contributions to the literature.

The first is methodological whereby housing loan shocks are identified together with housing market shocks. As discussed above, it is important to investigate the impacts of loan demand shocks too, and we provide apparently the first analysis comparing the influences of loan supply and demand shocks. While a positive loan supply shock decreases the loan rate and causes loan expansion, a positive loan demand shock raises both the stock of loans and the loan rate. The supply shocks reflect innovations that shift the supply curve for loans due to, for example, regulatory changes such as alterations in required bank capital, or innovations in the banking industry such as increased competition, that lower loan margins. For instance, the results of Damen and Schildermans (2022) show that tighter capital requirements imposed on housing loans increase the loan rate, thereby shifting the supply curve for housing loans, while Vandenbussche et al. (2015) find that capital requirements also influence housing prices. The demand shocks, in turn, are exogenous innovations in the demand of housing loans that can take place due to changes in expected permanent income, demographics, or loosening in households' liquidity constraints (Mian and Sufi, 2018). Innovations in loan-to-value ratios and maximum loan maturities represent loan demand shocks, at least in the SVAR framework, as they essentially affect households' liquidity (loan) constraints (Justiniano et al., 2019). Global liquidity shocks – which transmit to local banks and thereby influence local housing prices (Banti and Phylaktis, 2019) – move the supply curve for loans and are therefore loan supply shocks in the SVAR framework as well.

The second contribution of the paper is that the full set of shocks are identified. By embedding loan and housing markets within a general dynamic macroeconometric model, we also identify money market shocks, together with aggregate supply and demand shocks stemming from the goods market. In total six shocks are identified. Important advantages of identifying all shocks within the system is that past movements in the housing loan-to-output ratio and in housing prices can be decomposed in terms of all of the six shocks based on a historical decomposition of the SVECM, and the volatility of these variables can be decomposed in terms of the shocks over alternate time horizons. This appears to be the first study to investigate the historical decompositions of loan expansion and housing prices based on a broad set of shocks. Even though all shocks are identified, nonetheless our main interest and focus is on the role of loan market shocks and the influences of various shocks on housing loan expansion and housing prices.

The third contribution is empirical as the approach is applied to understanding the relationships between loan and housing markets in Finland based on quarterly data from 1985 to 2024. Using country-level time series data that are sufficiently long to cover several episodes, enables the identification of loan supply and demand shocks and how these shocks interact with the housing market (see also Mian and Sufi, 2018).[4] The Finnish market makes an interesting case to study and provides interesting insights for the international audience. The abolishment of credit controls in Finland during the late 1980s induced a substantial shock in the loan market that was followed by a prominent boom–bust cycle in the economy. The Finnish cycle of the late 1980 to mid 1990s is viewed by Reinhart and Rogoff (2008) as one of the five most catastrophic international cycles, which is also discussed as a prominent example of a financial cycle in the Handbook of the Economics of Finance (Brunnermeir and Oehmke, 2013). We bring new information on the cycle by examining the contributions of the different shocks to it. From the mid 1990s and continuing on to after the GFC, represents a period with innovations that gradually increase loan expansion and the housing loan-to-output ratio in the country. Unlike in many other countries, housing prices exhibit only a small decrease in Finland during the GFC. We explore the role of different shocks during these episodes as well.

Moreover, we investigate the influence of the Russian war of aggression in Ukraine, out-of-sample, based on the estimated SVECM. Similar to other European countries, Finland faced a dramatic increase in inflation and interest rates since the start of the attack. However, as a country sharing over a 1300 kilometre border with Russia, corresponding to almost the entire eastern border of the country, Finland has suffered from the war of aggression even more seriously than most other European countries.

The empirical results show that loan supply shocks as well as loan demand shocks can lead to significant housing loan expansion over the short and mid term, and can thereby influence financial stability. Both shocks have a significant role in the rapid increase of the housing loan-to-output ratio in Finland, with loan demand and supply shocks jointly driving the dramatic cycle in the ratio in the late 1980 to mid 1990s. The loan market shocks also have a substantial influence on housing price developments, including the late 1980s to mid 1990s boom–bust cycle in housing prices. While housing price shocks explain some part of housing price cycles, they have little effect on loan expansion.

These findings are consistent with previous empirical evidence showing that housing price movements are more likely to respond to loan market shocks rather than to cause loan expansion (Mian and Sufi, 2018), as well as being robust to alternative variations of the model specification. The robustness analysis includes an investigation of the potential role of housing co-op loans in the dynamics between loan and housing markets, which provides an additional contribution to the literature.[5] Finally, despite the Russian war of aggression causing many kinds of shocks in the economy – not least in the Finnish economy – our results emphasize the role of shocks stemming from the interplay between inflation, and nominal and real interest rates in the recent notable decrease in housing prices and loan-to-output ratio.

[3] Anundsen and Jansen (2013) specify bivariate and trivariate SVECMs, but concentrate on analysing the interaction between housing prices and credit without distinguishing between supply and demand shocks in credit or goods markets.

[4] An alternative approach adopted in the literature is to concentrate on specific macroeconomic episodes using cross-section data (Mian and Sufi, 2018).

[5] The Finnish housing co-ops are similar to the U.S. condominiums and the U.K. commonholds.

The rest of the paper proceeds as follows. Section 2 presents the theoretical model and discusses the restrictions used to identify the full set of shocks in the SVECM. The model is applied in Section 3 to investigating loan and housing shocks in Finland, with robustness and sensitivity experiments of the model performed in Section 4. The estimated model is used to study the effects of the Russian war of aggression on the Finnish market in Section 5. Concluding remarks and a discussion of policy implications of the results are contained in Section 6, with additional empirical results presented in an online Appendix.

2. Theoretical model and identification

To investigate the effects of shocks on the loan-to-output ratio and housing prices within a dynamic macroeconomic system, a 6-variate SVECM is specified covering loan and housing markets, as well as more traditional goods and money markets. The loan market consists of the (log) ratio of the housing loan stock to output (d_t), and the nominal rate of interest on housing loans (r_t). The loan-to-output ratio is an important policy variable as it provides an indicator of indebtedness by measuring the volume of debt relative to the size of the economy and is shown to have forecast power regarding macroeconomic cycles (Drehmann and Juselius, 2014; Mian et al., 2017). According to Jordà et al. (2016) the mortgage credit-to-GDP ratio at the beginning of a recession has played an especially important role in predicting the severity of recessions in advanced economies since World War II.

The housing market is captured by (log) real housing prices (h_t) (Iacoviello and Minetti, 2008; Oikarinen, 2009a; Anundsen and Jansen, 2013). The goods market includes (log) real output (y_t) and the inflation rate (π_t), which are commonly adopted variables in dynamic macroeconometric models (Goodhart and Hofmann, 2008; Hristov et al., 2012, amongst many others). The money market is represented by the nominal money market rate (m_t) which commonly represents a measure of the stance of monetary policy (for example Galí, 1992, 1999; Hristov et al., 2012; Gambetti and Musso, 2017). The set of variables in the model is in general broader than that used in many previous papers of loan and housing markets, including for example, Goodhart and Hofmann (2008), Oikarinen (2009a,b) and Hristov et al. (2012).

Let $x_t = (d_t, r_t, h_t, y_t, \pi_t, m_t)'$ be a set of $I(1)$ variables. The SVECM representation of x_t, with n cointegrating vectors is

$$\Delta x_t = \alpha\beta' x_{t-p} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + S\varepsilon_t, \tag{1}$$

where Δ is the first difference operator, and ε_t is a (6×1) vector of structural shocks satisfying $E(\varepsilon_t) = 0$ and diagonal covariance matrix $E(\varepsilon_t\varepsilon_t') = D$. The error-correction parameters are given by the $(6\times n)$ matrix α, and the cointegrating parameters by the $(6\times n)$ matrix β. The (6×6) matrix S identifies the structural shocks such that $E(S\varepsilon_t\varepsilon_t'S') = E(v_t v_t')$, where $v_t = S\varepsilon_t$ are the VECM disturbances. Finally, Γ_i are (6×6) parameter matrices capturing the short-run dynamics.

An important feature of the model is the identification of a full set of shocks across loan, money, goods and housing markets, including the joint identification of supply and demand shocks in the loan market. Loan supply shocks capture innovations in loan supply by jointly increasing the loan-to-output ratio and reducing the rate of interest on loans, whereas loan demand shocks simultaneously increase both. Shocks to the money market represent positive shocks to the nominal money market rate resulting in contractions of output and inflation. Aggregate supply shocks simultaneously increase output and lower inflation, whereas aggregate demand shocks have the effect of simultaneously increasing output and inflation. Housing price shocks can originate either from the demand or supply side of the housing market. On the demand side, the shocks could relate to innovations in household preferences, demographic factors, demand subsidies, or expectations. Supply side shocks in turn can originate from innovations in the real construction costs or in supply side subsidies and regulations.

Table 1
Sign restrictions used in the SVAR literature.

Shock	Responses to an expansionary shock				
	Output	Inflation	Loan stock	Loan rate	Money rate
Loan supply	+	+	+	–	+
Loan demand			+	+	
Money	+	+		–	–
Aggregate supply	+	–			
Aggregate demand	+	+		+	+

By way of comparison Table 1 summarizes the sign restrictions typically applied in the literature (Mountford, 2005; Hristov et al., 2012; Bijsterbosch and Falagiarda, 2015; Gambetti and Musso, 2017, among others) regarding positive shocks in the goods and loan markets, and expansionary shocks in the money market. These sign restrictions are based on theoretical models and give clear guidance regarding the nature of the shocks thus indicating how the impulse responses should look like in our system in order to be interpreted as such shocks.[6] The sign restrictions in Table 1 show that loan supply shocks are distinguished from loan demand shocks as they have the same effect on the loan stock, but different effects on the loan rate. While money market and loan supply shocks have the same effect on the loan rate and loan stock, as well as on the goods market variables output and inflation, the shocks are distinguished by their different effects on the money rate. The loan margin, the spread between the loan and money rates, is unambiguously negative for an expansionary loan supply shock, but ambiguous in the case of an expansionary money market shock as it depends upon the relative strength of the falls in loan and money rates.[7] Gambetti and Musso (2017) distinguish between loan demand and aggregate demand shocks by imposing sign restrictions on the loan-to-output ratio, with expansionary loan demand (aggregate demand) shocks raising (lowering) this ratio.

2.1. Cointegration

The model consists of $n = 3$ cointegrating equations resulting in the six shocks being decomposed into three permanent and three transitory structural shocks.[8] Following Oikarinen (2009a,b), the first cointegrating equation represents a long-run relationship between real housing prices (h_t), real output (y_t) and the housing loan-to-output ratio (d_t), all expressed in natural logarithms, given by

$$h_t = \gamma_0 + \gamma_1 y_t + \gamma_2 d_t + e_{1,t}, \tag{2}$$

where $\gamma_0, \gamma_1, \gamma_2$ are the (unknown) cointegrating parameters, and $e_{1,t}$ is the housing market error-correction term capturing transitory deviations of actual housing prices from their long-run level. Real output is a

[6] While there is general agreement about the effects of supply and demand shocks originating in a particular market on own price and quantity variables, there are still differences in the literature on the spillover effects of how these shocks impact other markets (see for example, Hristov et al., 2012 and Gambetti and Musso, 2017). For this reason the signs of shocks listed in Table 1 represent a basis of shocks needed for identification.

[7] In fact, Gambetti and Musso (2017, Table 1, p.770) do not impose any sign restrictions on the effects of money shocks on the loan rate and hence on the loan margin. Hristov et al. (2012) highlight the relationship between the loan margin (or credit spread) and a loan supply shock in their empirical application. In the next section, an alternative identification mechanism based on the loan margin and the institutional properties of loan markets, is adopted to distinguish between loan supply and money shocks.

[8] The results of unit root tests support the $I(1)$ assumption, while cointegration tests support the presence of three cointegrating equations amongst the six variables in the model. Details of these results are presented in Appendix A of the online appendix.

commonly applied determinant of long-run housing prices by capturing the key long-run fundamentals of housing demand (Hui and Yue, 2006; Oikarinen, 2009a, and van Dijk et al., 2011). The loan-to-output ratio is aimed at capturing trends in households' housing loan constraints over time that also affect housing demand and thereby housing prices (e.g. Oikarinen, 2009b, and Karpestam and Johansson, 2019).

The second cointegrating equation represents the Fisher equation applied to the money market, whereby the nominal money market rate (m_t) and the inflation rate (π_t), are cointegrated

$$e_{2,t} = m_t - \pi_t. \tag{3}$$

The error-correction term $e_{2,t}$ captures movements in the real money market rate. This specification is widely adopted in empirical macroeconomic models, dating back to Galí (1992) for example.

The third and final cointegrating equation is the analogous Fisher equation in the loan market, given by the difference between the nominal rate on loans (r_t) and the inflation rate (π_t)

$$e_{3,t} = r_t - \pi_t, \tag{4}$$

where the error-correction term $e_{3,t}$, represents movements in the real loan rate. The imposition of this cointegrating relationship provides a natural restriction as the real loan rate is the appropriate price variable on real loans (Oikarinen, 2009a; Anundsen and Jansen, 2013).[9] Defining $e_t = (e_{1,t}, e_{2,t}, e_{3,t})'$ as the error-correction terms in (2) to (4), the system of cointegrating equations in (1) is given by

$$e_t = \beta' x_t$$

$$\begin{pmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \end{pmatrix} = \begin{pmatrix} -\gamma_1 & -\gamma_2 & 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 & 1 & 0 \\ 0 & 0 & -1 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} y_t \\ d_t \\ \pi_t \\ h_t \\ m_t \\ r_t \end{pmatrix}. \tag{5}$$

2.2. Identifying restrictions

Identification of the six structural shocks ε_t in (1) requires identification of S. In total 15 restrictions are needed consisting of short-run and long-run restrictions on the x_t variables, as well as a set of restrictions arising from the presence of the cointegrating equations in (5). This last set of restrictions ensures that the error-correction terms e_t, have no long-run effects on variables in equations containing permanent shocks, referred to as the Pagan and Pesaran (2008) condition.

To implement the identifying restrictions the SVECM in x_t is re-expressed as a Structural VAR (SVAR) containing the error-correction terms and a subset of the x_t variables. As there are $n = 3$ cointegrating equations, x_t is partitioned as $x_t = (x_{1,t}, x_{2,t})'$, where $x_{1,t} = (y_t, d_t, \pi_t)'$ and $x_{2,t} = (h_t, m_t, r_t)'$, resulting in the SVAR being expressed in terms of x_{1t} and $e_t = (e_{1,t}, e_{2,t}, e_{3,t})'$. To express the SVECM as a SVAR in terms of x_{1t} and e_t, define the matrix of cointegrating vectors as $\beta' = (\beta_1', \beta_2')$, and reexpress the cointegrating system in (5) in terms of x_{2t} according to

$$x_{2t} = (\beta_2')^{-1}(e_t - \beta_1' x_{1,t}), \tag{6}$$

where[10]

$$\beta_1' = \begin{pmatrix} -\gamma_1 & -\gamma_2 & 0 \\ 0 & 0 & -1 \\ 0 & 0 & -1 \end{pmatrix}, \qquad \beta_2' = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}. \tag{7}$$

Using (6) to substitute out $x_{2,t}$ in (1) together with the result that $\beta_2 = I_3$ from (7), gives after rearranging the SVAR representation of the SVECM

$$S^{-1}\begin{pmatrix} \Delta x_{1,t} \\ \Delta e_t - \beta_1' \Delta x_{1,t} \end{pmatrix} = S^{-1}\begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} e_{t-p} + S^{-1}\sum_{i=1}^{p-1} \Gamma_i \begin{pmatrix} \Delta x_{1,t-i} \\ \Delta e_{t-i} - \beta_1' \Delta x_{1,t-i} \end{pmatrix} + \varepsilon_t, \tag{8}$$

where the disturbances of the SVAR are the structural shocks ε_t as in the SVECM given in (1). This is a 6-variate SVAR containing the variables $z_t = (\Delta x_{1,t}, e_t)'$. From the integration properties of the first three variables, and the cointegration properties of the three error-correction terms, all of the variables are $I(0)$. To satisfy the Pagan–Pesaran condition that error-correction terms have no long-run effect on $x_{1,t}$, e_t needs to enter the first block of equations in (8) in first differences, which is achieved by imposing the restrictions $\alpha_1 = 0$. This feature of the model is in contrast with the second block of equations corresponding to e_t, where the error-correction terms are in levels.

The following set of SVAR equations arise from imposing the cointegrating restrictions, as well as the short-run and long-run restrictions. In presenting the SVAR model the lag structure is set at $p = 1$, with each equation normalized with respect to the pertinent variable being modelled.[11]

Output equation

The first equation of the SVAR is the real output equation

$$\Delta y_t = a_{1,0} + a_{1,2}\Delta^2 d_t + a_{1,3}\Delta^2 \pi_t + a_{1,4}\Delta e_{1,t} + a_{1,5}\Delta e_{2,t} + a_{1,6}\Delta e_{3,t} + a_{1,7}\Delta y_{t-1} + \varepsilon_{1,t}, \tag{9}$$

where $\varepsilon_{1,t}$ is the aggregate supply shock which is treated as permanent. Identification of $\varepsilon_{1,t}$ is achieved by assuming a long-run Phillips curve whereby only aggregate supply shocks have a permanent effect on output. This restriction is standard in this class of models dating back to Blanchard and Quah (1989) and Galí (1992, 1999), and more recently to Rubio-Ramirez et al. (2010) and Ouliaris et al. (2018). Expressing the equation in terms of $\Delta^2 d_t$ and $\Delta^2 \pi_t$ ensures that the respective shocks to the loan supply and aggregate demand have no long-run effects on real output. In total there are five restrictions applied to the output equation.

The first long-run restriction is consistent with the technological shock model of Galí (1999) where financial and monetary variables are assumed to have no permanent effect on output. Recent models by Moran and Queralto (2018) highlight the importance of financing on total factor productivity through R&D expenditure and the adoption of innovations by firms, although their empirical results do not find any significant long-term effects between output and financial variables in the case of monetary policy in particular. In the present context the loan market is restricted to housing loans rather than loans for more general types of investments. This distinction is important as innovations in housing loans are not expected to have the same impact on investments as would other types of loans have.[12] The restriction that aggregate demand shocks have no long-run effect on output stems from Blanchard and Quah (1989) which is widely applied in SVAR models; see for example, Peersman (2005). We provide tests of the long-run restriction in the empirical application using local projection regressions of Jordà (2005), which produces results supporting the restriction.[13]

[9] Related work is by Hristov et al. (2012) and Gambetti and Musso (2017), who instead use nominal variables to model loan markets.

[10] The derivation of Eq. (6) requires that β_2 is non-singular which from (7) is satisfied.

[11] In the empirical application the model includes $p = 2$ lags based on the Schwarz and Hannan–Quinn information criteria. Also included are deterministic variables to allow for intercepts and indicator variables to capture structural breaks.

[12] This claim is supported by the empirical results presented in the application to Finland, together with robustness experiments showing no significant permanent relationship between output and loan supply shocks when the long-run restriction is relaxed.

The restrictions that the three error-correction terms $e_{1,t}, e_{2,t}, e_{3,t}$, only enter the output equation in first differences, ensures that shocks to these variables have no long-run effect on y_t, which follows from imposing the Pagan–Pesaran condition in order to satisfy the cointegrating properties of the model. The restriction with respect to the real money rate $e_{2,t}$, is consistent with traditional SVAR models assuming long-run monetary neutrality (Peersman, 2005).[14] The long-run restriction with respect to loan demand shocks is consistent with the treatment of money market shocks as the former are identified from the Fisher analogue in the loan market, which by definition yields an error-correction term that is transitory. Moreover, as discussed above in the case of loan supply shocks, the loan market is for housing loans and not more general investments where R&D expenditure can have longer-term effects on total factor productivity.

Loan-to-output ratio equation

The second equation of the SVAR is the loan-to-output ratio equation

$$\begin{aligned}\Delta d_t &= a_{2,0} + a_{2,1}\Delta y_t + a_{2,3}\Delta\pi_t + a_{2,4}\Delta e_{1,t} + a_{2,5}\Delta e_{2,t} + a_{2,6}\Delta e_{3,t} \\ &\quad + a_{2,7}\Delta y_{t-1} + a_{2,8}\Delta d_{t-1} + a_{2,9}\Delta\pi_{t-1} + \varepsilon_{2,t},\end{aligned} \tag{10}$$

where $\varepsilon_{2,t}$ is the loan supply shock which is treated as permanent. Given that $\varepsilon_{1,t}$ in (9) is identified, $\varepsilon_{2,t}$ is identified by imposing four restrictions. Three of these restrictions come from imposing the Pagan–Pesaran cointegration condition that the error-correction terms only enter the d_t equation in first differences and not in levels. The remaining restriction disentangles the effects of loan supply shocks on d_t to ensure that $\varepsilon_{2,t}$ affects loans and not output, in the short run. This restriction guarantees that a loan supply shock represents a shock to the housing loan stock rather than a shock to output. The restriction is imposed by setting $S_{1,2} = 0$, in the S matrix in (8).

Inflation equation

The third equation of the SVAR is the inflation equation

$$\begin{aligned}\Delta\pi_t &= a_{3,0} + a_{3,1}\Delta y_t + a_{3,2}\Delta d_t + a_{3,4}\Delta e_{1,t} + a_{3,5}\Delta e_{2,t} + a_{3,6}\Delta e_{3,t} + a_{3,7}\Delta y_{t-1} \\ &\quad + a_{3,8}\Delta d_{t-1} + a_{3,9}\Delta\pi_{t-1} + \varepsilon_{3,t},\end{aligned} \tag{11}$$

where $\varepsilon_{3,t}$ represents the aggregate demand shock which is also treated as permanent. Given that $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are identified respectively by Eqs. (9) and (10), three restrictions are needed to identify $\varepsilon_{3,t}$. These restrictions are obtained by imposing the Pagan–Pesaran condition again on the three error-correction terms which enter the π_t equation in first differences and not in levels.

Housing error-correction equation

The fourth equation of the SVAR is the housing error-correction equation

$$\begin{aligned}e_{1,t} &= a_{4,0} + a_{4,1}\Delta y_t + a_{4,2}\Delta d_t + a_{4,3}\Delta\pi_t + a_{4,5}e_{2,t} + a_{4,6}e_{3,t} + a_{4,7}\Delta y_{t-1} \\ &\quad + a_{4,8}\Delta d_{t-1} + a_{4,9}\Delta\pi_{t-1} + a_{4,10}e_{1,t-1} + a_{4,11}e_{2,t-1} + a_{4,12}e_{3,t-1} + \varepsilon_{4,t},\end{aligned} \tag{12}$$

where $\varepsilon_{4,t}$ is the housing market shock which is transitory. This equation stands in sharp contrast with the structural equations in (9) to (11) as the error-correction terms now enter in levels. Given that the structural shocks $\varepsilon_{1,t}$, $\varepsilon_{2,t}$ and $\varepsilon_{3,t}$ are identified by the first three structural equations, two more restrictions are needed to identify $\varepsilon_{4,t}$. As the housing cointegrating equation consists of housing prices, output and the loan-to-output ratio, to ensure that the initial impact of $\varepsilon_{4,t}$ is on the housing price and not on y_t or d_t, $\varepsilon_{4,t}$ is restricted to have no contemporaneous effects on y_t and d_t. These restrictions guarantee that a positive housing market shock represents a positive shock to housing prices rather than a drop in the long-run fundamentals. The short-run restrictions are imposed by setting $S_{1,4} = S_{2,4} = 0$, in the S matrix in (8).

Real money rate equation

The fifth equation of the SVAR is the real money market error-correction equation

$$\begin{aligned}e_{2,t} &= a_{5,0} + a_{5,1}\Delta y_t + a_{5,2}\Delta d_t + a_{5,3}\Delta\pi_t + a_{5,4}e_{1,t} + a_{5,6}e_{3,t} + a_{5,7}\Delta y_{t-1} \\ &\quad + a_{5,8}\Delta d_{t-1} + a_{5,9}\Delta\pi_{t-1} + a_{5,10}e_{1,t-1} + a_{5,11}e_{2,t-1} + a_{5,12}e_{3,t-1} + \varepsilon_{5,t},\end{aligned} \tag{13}$$

where $\varepsilon_{5,t}$ is the money market shock which is transitory. As the structural shocks $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$ and $\varepsilon_{4,t}$ are identified by Eqs. (9) to (12), this leaves one restriction needed to identify $\varepsilon_{5,t}$. From the definition of the error-correction term in Eq. (3), the real money rate is affected by shocks to the nominal money market rate and inflation. As it is the former channel that represents shocks to the money market, inflation is restricted not to react contemporaneously to $\varepsilon_{5,t}$.

Real loan rate equation

The final equation of the SVAR is the real loan rate error-correction equation

$$\begin{aligned}e_{3,t} &= a_{6,0} + a_{6,1}\Delta y_t + a_{6,2}\Delta d_t + a_{6,3}\Delta\pi_t + a_{6,4}e_{1,t} + a_{6,5}e_{2,t} + a_{6,7}\Delta y_{t-1} \\ &\quad + a_{6,8}\Delta d_{t-1} + a_{6,9}\Delta\pi_{t-1} + a_{6,10}e_{1,t-1} + a_{6,11}e_{2,t-1} + a_{6,12}e_{3,t-1} + \varepsilon_{6,t},\end{aligned} \tag{14}$$

where $\varepsilon_{6,t}$ is the loan demand shock which is transitory. Since the five structural shocks in Eqs. (9) to (13) are all identified, no additional restrictions are needed to identify $\varepsilon_{6,t}$.

In total the six structural shocks of the SVAR are identified by imposing the nine restrictions from cointegration, with the remaining six restrictions consisting of two long-run restrictions assuming a long-run Phillips schedule and four short-run restrictions used to disentangle the effects of the structural shocks on the model. In the case of distinguishing between loan supply and money shocks the strategy is not to consider how these shocks impact loan and money rates as is the approach of the sign restriction literature, but rather to consider the reactions of the housing loan margin. This strategy is motivated by the institutional features of the loan market in Finland. In part of the housing loan contracts, the loan rate is tied to rates that are set by the banks' and revised only in certain intervals. As these rates, often called banks' "Prime rates", adjust with a lag to money rate movements, the reaction of the mean loan rate of new contracts to money shocks is sluggish. Given the sluggishness of loan rate adjustments, the spread between the loan rate and money rate should initially increase after an expansionary money shock, as the money rate decreases more than the loan rate. In contrast, a positive loan supply shock decreases the loan margin in the short run, a result that is consistent with the sign restrictions reported in Table 1. As noted above, the sign restriction literature is silent on the effects of money shocks on the loan margin as in that literature money shocks result in falls in both the loan and money rates, without considering the relative size of the falls.

3. Application to Finland

The 6-variate SVECM discussed in Section 2 is now applied to examining the effects of loan supply and demand shocks together with housing price shocks, on housing loan expansion and housing prices in Finland. Investigating the Finnish market is particularly interesting given the occurrence of a number of changes in policies over time, the substantial housing price cycles encountered in Finland during the

[13] Chen and Natšunajev (2016) provide alternative tests of the long-run restriction of the Blanchard–Quah model where identification is based on heteroskedaticity. It is demonstrated in the empirical application to Finland that the conditions needed to achieve over-identification for testing this restriction are not satisfied (see the online Appendix for details).

[14] Recently, Jordà et al. (2026) provide empirical evidence based on local projection regressions showing that monetary policy can have a permanent effect on output. In the empirical results presented below for Finland, the tests fail to reject the monetary neutrality hypothesis (see the online Appendix for details).

sample period, and the effects of the recent Russian war of aggression on the Finnish market.

3.1. Data

The data are quarterly beginning 1985Q1 and ending 2024Q2. The sample period begins in 1985 which is based on previous work by Oikarinen (2009a) who presents evidence of a structural change in the short-term dynamics between loans and housing prices due to the credit market deregulation, which resulted in the interaction between housing loans and prices becoming stronger since the deregulation. The Finnish data consist of the (log) real output (y_t), the annualized inflation rate (π_t), the annualized nominal money market rate (m_t), the (log) ratio of the real housing loan stock to real output (d_t), the (log) real housing price index (h_t), and the annualized nominal rate of interest on housing loans (r_t). As Finland joined the European Monetary Union (EMU) at the beginning of 1999, the money market rate is the 12 month Euribor rate since 1999, while the Finnish 12 month Helibor rate is used for the earlier period,1985–1998.[15] All variables are seasonally adjusted, with the exception of the money market and loan rates; see Appendix A for data definitions and sources.

Fig. 1 provides time series plots of the data. Real output, the loan-to-output ratio and housing prices all display strong trends over the sample period which can be broken down into five distinct periods. The first period corresponds to increasing trends for y_t and d_t from 1985 to 1990, while housing prices begin to rise rapidly in late 1986. The second period corresponds to the recession in the first half of the 1990s where, with the exception of loan and money rates, all series exhibit downward trends with real housing prices in particular falling to levels experienced before the start of the sample period in the late 1970s and early 1980s. The third period begins in the mid 1990s when the Finnish economy starts to recover from the deep recession with output, the loan-to-output ratio and housing prices exhibiting strong growth trends, ending with the GFC. In contrast with many other countries, there is only a small housing price drop during the GFC in Finland. The fourth period is from the mid 1990s to 2020 where the loan and money market rates trend downwards with the money rate reaching zero in 2016Q1, and negative thereafter. This period is also characterized by the loan-to-output, real housing price and real GDP exhibiting flat trajectories post GFC, and relatively low inflation rates between 2015 and 2020.

The last distinct period starts in 2021 when housing prices and the loan-to-output ratio begin to decline, followed by the war of aggression in Ukraine beginning in early 2022. Similar to other European countries, Finland faces a dramatic and rapid rise in the inflation rate reaching a peak of 9.7% in 2022Q2 before declining back to zero in 2024Q2. There is a consequent tightening of monetary policy in the Euro area leading to a fast and large jump in the nominal money market rate from a minimum of −0.5% in 2021Q4 to 4.2% in 2023Q3, combined with similar movements in the nominal loan rate, and with some lag real output declines. These drastic movements in the Finnish market, which are due to the Russian war of aggression in the Ukraine, are investigated in Section 5 by performing an out-of-sample historical decomposition of the estimated SVECM.

The financial market deregulation that took place in Finland during mid and late 1980 was followed by a prominent boom–bust period in housing prices and the economy. Until the mid-eighties the Finnish banking system was highly regulated with tightly administratively controlled and rigid lending rates and foreign capital controls that caused credit rationing. During this period housing loans had relatively short repayment periods and low loan-to-value ratios (LTVs), where a typical loan maturity was between 8–10 years and the minimum required down-payment ratio was 20%–30% of the purchase price still in the early 1980s. In the mid to late 1980s capital controls and ceilings on lending rates were abolished. This induced a huge growth of credit that was associated with a housing market boom and eventual housing price collapse. The price drop was fortified by rising real interest rates and the deep recession of the Finnish economy.

The maturities of housing loans have increased gradually since the late 1980s, being typically between 18–25 years for new loan contracts in 2024. The typical LTVs, too, have considerably grown. The maturity and LTV developments, together with foreign credit flows and increased bank competition, can be considered as loan expansion causing innovations in the banking sector. Consequently, the ratio of housing loans to output increased rapidly during the last decades similar to many other countries (see for example, Jordà et al., 2016).

3.2. Estimation methods

Estimation of the SVAR parameters consists of three steps, which are summarized in Table 2. The first step involves estimating the cointegrating parameters of the long-run housing equation in (2) and the housing error-correction term $e_{1,t}$, by the Johansen maximum likelihood procedure applied to a VECM containing $(h_t, y_t, d_t)'$. The optimal lag length of the VECM is $p = 2$ which is based on the Schwarz and Hannan–Quinn information criteria, with $\widehat{e}_{1,t}$ representing the estimated housing error-correction term. The remaining error-correction terms $e_{2,t}$ and $e_{3,t}$, in (3) and (4) respectively, are constructed from $(m_t, r_t, \pi_t)'$ as there are no cointegrating parameters to estimate.

The second step involves estimating a stationary VAR containing the variables $z_t = (\Delta y_t, \Delta d_t, \Delta\pi_t, \widehat{e}_{1,t}, e_{2,t}, e_{3,t})'$. As the set of variables in each equation of the VAR are the same, estimation is based on applying OLS to each equation separately. The VAR residuals are given by $\widehat{v}_t = \left(\widehat{v}_{1,t}, \widehat{v}_{2,t}, \widehat{v}_{3,t}, \widehat{v}_{4,t}, \widehat{v}_{5,t}, \widehat{v}_{6,t}\right)'$, which are used as instruments to impose short-run restrictions on the model. Time series plots of $\widehat{v}_t$ are given in Appendix B of the online appendix.

The third and final step consists of estimating the SVAR equations in (9) to (14) sequentially by instrumental variables (IV) using the approach of Ouliaris et al. (2018). As the final model allows for $p = 2$ lags, the instruments of the output equation in (9) are $\left\{\widehat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}, \Delta d_{t-2}, \Delta\pi_{t-2}\right\}$, where $\widehat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}$, are obtained from the first step. The lagged error-correction terms $\widehat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}$, provide instruments for the contemporaneous variables $\Delta\widehat{e}_{1,t}, \Delta e_{2,t}, \Delta e_{3,t}$, to identify the parameters $a_{1,4}, a_{1,5}$ and $a_{1,6}$, as these variables are excluded from the model due to cointegration. The variables Δd_{t-2} and $\Delta\pi_{t-2}$ are used as instruments for the contemporaneous variables $\Delta^2 d_t$ and $\Delta^2\pi_t$, to identify the parameters $a_{1,2}$ and $a_{1,3}$ since these variables are not included in the model as a result of the long-run Phillips curve restrictions. Estimates of the aggregate supply shocks are given by the residuals $\widehat{\varepsilon}_{1,t}$.

The instruments of the loan-to-output equation in (10) are $\left\{\widehat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}, \widehat{v}_{1,t}, \widehat{\varepsilon}_{1,t}\right\}$, where $\widehat{\varepsilon}_{1,t}$ is the estimate of the structural supply shocks from the previous step, and $\widehat{v}_{1,t}$ is the residual from the VAR output equation. As with the output equation, $\widehat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}$ provide instruments for $\Delta\widehat{e}_{1,t}, \Delta e_{2,t}, \Delta e_{3,t}$. The variables $\widehat{v}_{1,t}$ and $\widehat{\varepsilon}_{1,t}$ provide instruments for the remaining two contemporaneous variables, Δy_t and $\Delta\pi_t$. The instrument $\widehat{v}_{1,t}$ arises from the short-run restriction that loan supply shocks $(\varepsilon_{2,t})$ do not contemporaneously affect real output, which is formally imposed by setting $S_{1,2} = 0$, in the S matrix of the SVAR given by (8). This restriction translates into the disturbance of the Δy_t equation of the VAR representation of the SVAR, namely $v_{1,t}$, being independent of $\varepsilon_{2,t}$, thereby enabling $v_{1,t}$ to act as instrument in the Δd_t equation. The structural shock $\widehat{\varepsilon}_{1,t}$, from the output equation

[15] The money rate is allowed to be endogenous in the system for the whole sample period. However, we need to be careful with the interpretation of the impulse responses of the money market rate as the influence of the Finnish market on the Euribor rates can only be very small. This would suggest that evidence of significant responses of the real money market rate would be due to inflation reactions and because of shocks in the Finnish market often reflecting EMU wide shocks. The analysis in Section 4 indicates that the results are robust to removing the money rate from the model.

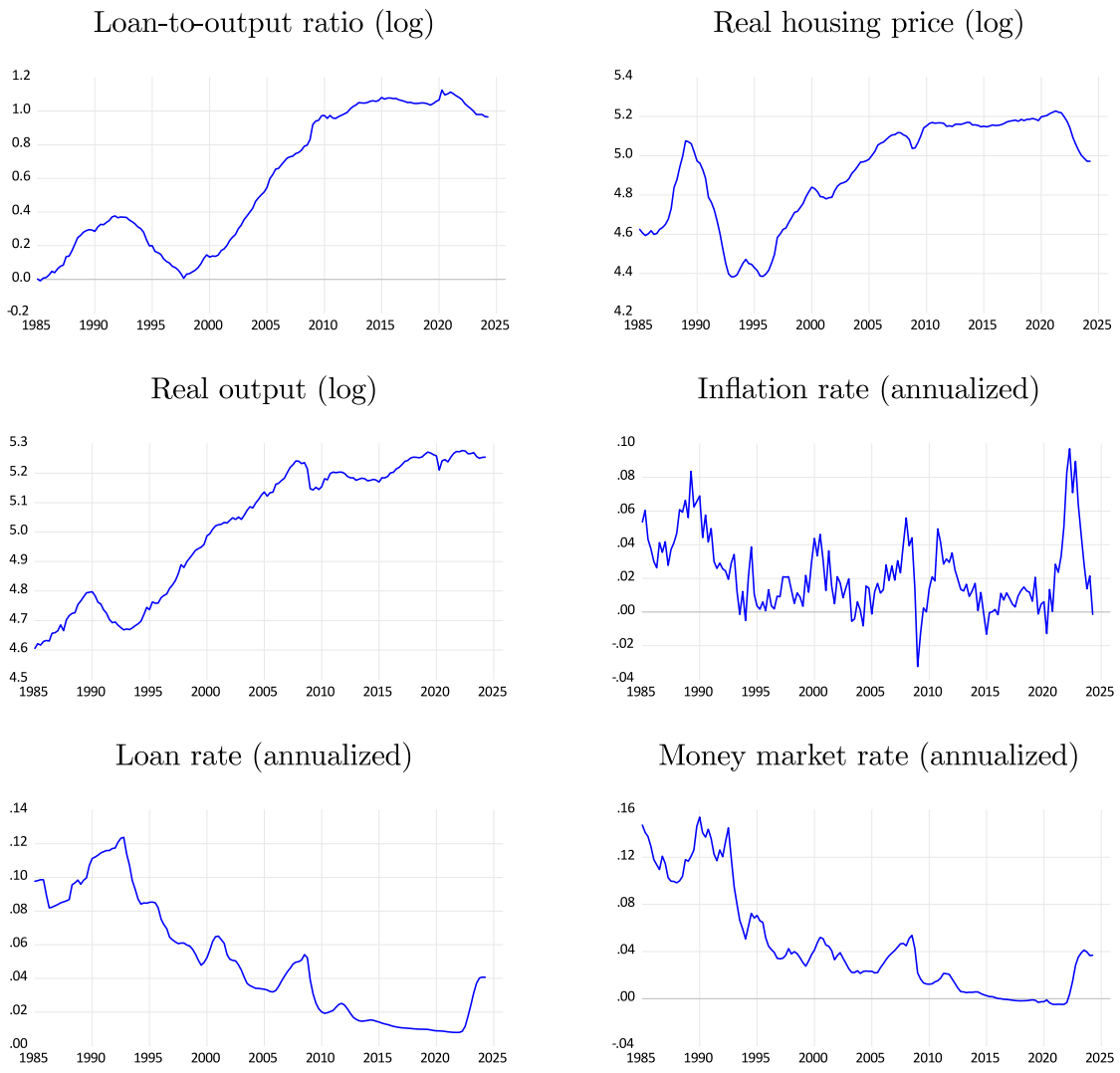


Fig. 1. Time series plots of the data, 1985Q1 to 2024Q2.

provides an additional instrument as structural shocks are independent of each other. Estimates of the loan supply shocks are given by the residuals $\widehat{\varepsilon}_{2,t}$.

Following from the previous discussion the instruments of the π_t SVAR equation are $\{\widehat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}, \widehat{\varepsilon}_{1,t}, \widehat{\varepsilon}_{2,t}\}$. Estimates of the aggregate demand shocks are given by the residuals $\widehat{\varepsilon}_{3,t}$.

The instruments to identify the parameters on the contemporaneous variables in the housing disequilibrium equation of the SVAR are $\{\widehat{v}_{1,t}, \widehat{v}_{2,t}, \widehat{\varepsilon}_{1,t}, \widehat{\varepsilon}_{2,t}, \widehat{\varepsilon}_{3,t}\}$, where $\widehat{v}_{1,t}$ and $\widehat{v}_{2,t}$ are respectively the residuals from the VAR corresponding to the Δy_t and Δd_t equations, and the remaining instruments are obtained from estimating the three previous structural equations. The $\widehat{v}_{1,t}$ and $\widehat{v}_{2,t}$ instruments arise from the two short-run restrictions that housing market shocks do not contemporaneously affect Δy_t and Δd_t respectively. Estimates of the housing market shocks are given by the residuals $\widehat{\varepsilon}_{4,t}$.

The choice of instruments for the contemporaneous variables in the real money rate equation are $\{\widehat{v}_{4,t}, \widehat{\varepsilon}_{1,t}, \widehat{\varepsilon}_{2,t}, \widehat{\varepsilon}_{3,t}, \widehat{\varepsilon}_{4,t}\}$, where $\widehat{v}_{4,t}$ is the residual from the VAR equation for π_t. This instrument results from the short-run restriction that money shocks do not affect the inflation rate contemporaneously. The money shock estimates are given by the residuals $\widehat{\varepsilon}_{5,t}$.

Finally, the instruments of the real loan rate $e_{3,t}$ SVAR equation are the estimated structural shocks $\{\widehat{\varepsilon}_{1,t}, \widehat{\varepsilon}_{2,t}, \widehat{\varepsilon}_{3,t}, \widehat{\varepsilon}_{4,t}, \widehat{\varepsilon}_{5,t}\}$. Estimates of the loan demand shocks are given by the residuals $\widehat{\varepsilon}_{6,t}$. As five instruments are used for each equation of the SVAR, the model is just-identified resulting in the IV estimator being equivalent to the Full Information Maximum Likelihood estimator. Given that the estimates of the housing price cointegrating equation are super-consistent and that the parameters of the loan rate and money rate cointegrating equations are known, the use of the error-correction terms $\widehat{e}_{1,t}, e_{2,t}, e_{3,t}$, does not affect the asymptotic distribution of the IV estimator.

3.3. Empirical results

The SVECM is estimated based on data until 2020, with data from 2021 to 2024 used to investigate the effects of the Russian war of aggression in Ukraine out-of-sample. This strategy enables us to control for the large shocks from the war on the parameter estimates. While the

Table 2
Summary of Estimation Steps. The variables are: (log) real output (y_t), (log) ratio of the housing loan stock to output (d_t), the inflation rate (π_t), (log) real housing prices (h_t), nominal money market rate (m_t), nominal loan rate (r_t).

Step 1: Cointegration/VECM		
Equation	Variables	Residuals
Housing	$e_{1,t} = h_t - \gamma_0 - \gamma_1 y_t - \gamma_2 d_t$,	$\hat{e}_{1,t} = h_t - \hat{\gamma}_0 - \hat{\gamma}_1 y_t - \hat{\gamma}_2 d_t$
Money Market	$e_{2,t} = m_t - \pi_t$	
Loan Market	$e_{3,t} = r_t - \pi_t$	
Step 2: VAR		
Equation	Variables	Residuals
$z_t = \Phi_0 + \sum_{i=1}^{p} \Phi_i z_{t-i} + v_t$,	$z_t = (\Delta y_t, \Delta d_t, \Delta\pi_t, e_{1,t}, e_{2,t}, e_{3,t})'$	$\hat{v}_{i,t}, i = 1, 2, \ldots, 6$
Step 3: SVAR		
Equation	Variables	Shock
Output (Δy_t)	Endog. $\Delta^2 d_t, \Delta^2\pi_t, \Delta e_{1,t}, \Delta e_{2,t}, \Delta e_{3,t}$	Agg. Supply $(\hat{\varepsilon}_{1,t})$
	Inst. $\hat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}, \Delta d_{t-2}, \Delta\pi_{t-2}$	
Loan-to-Output (Δd_t)	Endog. $\Delta y_t, \Delta\pi_t, \Delta e_{1,t}, \Delta e_{2,t}, \Delta e_{3,t}$	Loan Supply $(\hat{\varepsilon}_{2,t})$
	Inst. $\hat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}, \hat{v}_{1,t}, \hat{\varepsilon}_{1,t}$	
Inflation $(\Delta\pi_t)$	Endog. $\Delta y_t, \Delta d_t, \Delta e_{1,t}, \Delta e_{2,t}, \Delta e_{3,t}$	Agg. Demand $(\hat{\varepsilon}_{3,t})$
	Inst. $\hat{e}_{1,t-2}, e_{2,t-2}, e_{3,t-2}, \hat{\varepsilon}_{1,t}, \hat{\varepsilon}_{2,t}$	
Housing Market $(e_{1,t})$	Endog. $\Delta y_t, \Delta d_t, \Delta\pi_t, e_{2,t}, e_{3,t}$	Housing $(\hat{\varepsilon}_{4,t})$
	Inst. $\hat{v}_{1,t}, \hat{v}_{2,t}, \hat{\varepsilon}_{1,t}, \hat{\varepsilon}_{2,t}, \hat{\varepsilon}_{3,t}$	
Real Money rate $(e_{2,t})$	Endog. $\Delta y_t, \Delta d_t, \Delta\pi_t, e_{1,t}, e_{3,t}$	Money $(\hat{\varepsilon}_{5,t})$
	Inst. $\hat{v}_{4,t}, \hat{\varepsilon}_{1,t}, \hat{\varepsilon}_{2,t}, \hat{\varepsilon}_{3,t}, \hat{\varepsilon}_{4,t}$	
Real Loan Rate $(e_{3,t})$	Endog. $\Delta y_t, \Delta d_t, \Delta\pi_t, e_{1,t}, e_{2,t}$	Loan Demand $(\hat{\varepsilon}_{6,t})$
	Inst. $\hat{\varepsilon}_{1,t}, \hat{\varepsilon}_{2,t}, \hat{\varepsilon}_{3,t}, \hat{\varepsilon}_{4,t}, \hat{\varepsilon}_{5,t}$	

massive attack of Russia in Ukraine started in 2022Q1, we begin the out-of-sample investigation in 2021, since information on the serious threat of the attack became public in 2021 already, and this information may have affected expectations and in turn, aggregate demand as well as loan and housing demand.[16]

To understand the effects of shocks arising from loan and housing markets, Figs. 2 to 4 provide impulse responses of loan supply and demand shocks as well as housing price disequilibrium shocks. For completeness the effects of shocks stemming from money and goods markets are presented in Appendix C of the online appendix. The impulse responses of y_t, d_t and π_t, are accumulated as these variables enter the model in first differences, whereas for the error-correction terms $e_{1,t}$, $e_{2,t}$ and $e_{3,t}$, the impulse responses are non-accumulated given that these variables are expressed in levels. Impulse responses are presented with 95% confidence intervals based on the analytical asymptotic standard errors of Lütkepohl (1990).

The housing market impulse responses are presented in terms of the disequilibrium housing price $e_{1,t}$, as the aim is to identify the size and sign of the wedge between the actual and fundamental housing price levels caused by each structural shock. Given that shocks simultaneously impact the market fundamentals and short-run dynamics, this has the advantage of being able to identify the magnitude and duration that housing prices deviate from their market fundamentals, which is important for detecting disequilibria in the housing market.[17] Moreover, the deviation of housing prices from their long-run fundamental value $e_{1,t}$, is an important policy variable. Koetter and Poghosyan (2010) for instance, find that these deviations contribute to bank instability, and notable deviations from fundamental values can have widespread adverse influences throughout the economy (Glaeser and Nathanson, 2015).

3.3.1. Loan supply shock

Fig. 2 gives the impulse responses of a positive shock to loan supply. There is an instantaneous increase in the loan-to-output ratio d_t, which arises solely from an increase in the real loan stock as a result of the short-run restriction that real output y_t, does not respond contemporaneously to the shock. The loan-to-output ratio continues to grow over time converging to a higher level after about ten years. The loan supply shock results in short-run falls in the real cost of loans $e_{3,t}$, which eventually converges back to its long-run equilibrium level.

The effect of the loan supply shock on real housing prices h_t, is cyclical. The initial effect results in housing prices operating below their long-run equilibrium level with $e_{1,t} < 0$, caused by the increase in the loan-to-output ratio raising the long-run equilibrium housing price level. Within a year there is a reversal with housing prices operating above their long-run equilibrium level due to the growth in loan supply leading to increased housing demand (Goodhart and Hofmann, 2008; Mian and Sufi, 2018). Housing prices overshoot their long-run equilibrium, with the equilibrium error peaking approximately four years after the shock, before housing prices start to converge towards their long-run equilibrium level. This adjustment process is consistent with the typically observed sluggish and cyclical adjustment of housing prices, and the adjustment speed towards the long-run relation is similar to those often reported in the empirical literature (e.g. Capozza et al., 2004; Adams and Füss, 2010; Oikarinen, 2009b, 2012; Glaeser and Nathanson, 2017; Oikarinen et al., 2018).

The loan supply shock causes an immediate fall in the loan margin as the real money rate drops less than the real loan rate. The shock also affects the goods market with output and inflation both increasing. The effects on the loan margin and the goods market are consistent with Hristov et al. (2012) and Gambetti and Musso (2017) among others.

3.3.2. Loan demand shock

Fig. 3 shows that a positive loan demand shock results in simultaneous increases in the loan-to-output ratio and the real loan rate.

[16] Preliminary tests of the model based on unit root and cointegration tests support the presence of three cointegrating equations. The estimated housing price cointegrating equation is

$$h_t = 0.935 + 0.771\, y_t + 0.213\, d_t + \hat{e}_{1,t},$$

where h_t is the (log) real housing price index, y_t is (log) real output, d_t is the (log) ratio of the real housing loan stock to real output, and $\hat{e}_{1,t}$ is the estimated housing error-correction term. Tests based on local projection regressions support the long-run restrictions used to identify aggregate supply shocks. These results are presented in the online Appendix.

[17] For completeness impulse responses of the price level are presented in Section D of the online Appendix. By construction the shocks impact the housing prices through two channels: (i) the market fundamentals based on the cointegrating equation in (2), and (ii) the housing error-correction term $e_{1,t}$.

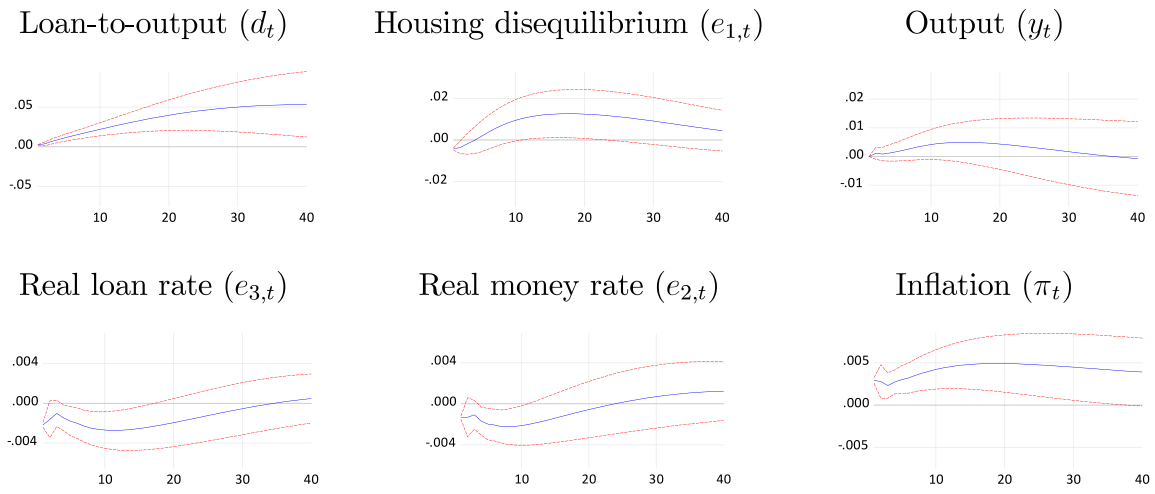


Fig. 2. Impulse responses to a loan supply shock with 95% confidence intervals based on asymptotic standard errors. Horizontal axis represents quarters.

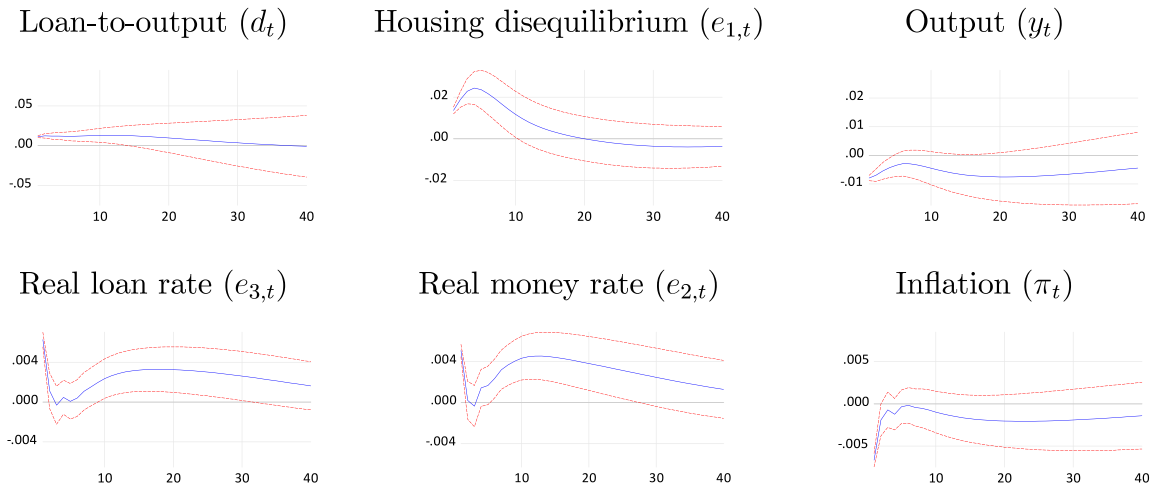


Fig. 3. Impulse responses to a loan demand shock with 95% confidence intervals based on asymptotic standard errors. Horizontal axis represents quarters.

The positive effect on the loan-to-output ratio slowly decays over time, consistent with the shock being transitory. The effect on the real loan rate tends to be cyclical.

The positive loan demand shock raises real housing prices above their long-run equilibrium level despite increases in the real loan rate and the loan-to-output ratio. The increasing impact on housing prices is not unexpected, as the exogenous innovations in housing loan demand can take place due to changes in expected permanent income, demographics, beliefs, or loosening in households' liquidity constraints (Mian and Sufi, 2018). Loosening of liquidity constraints through e.g. increasing loan-to-value ratios or longer loan maturities, in particular, can increase housing ownership demand. As with loan supply shocks, housing prices exhibit momentum effects rising further above their long-run relationship, but start to converge towards their long-run equilibrium after a year.

A comparison of the $e_{3,t}$ and $e_{2,t}$ impulse responses shows that the loan margin increases initially reflecting a loan demand shock. The margin eventually becomes negative in the mid term, which could be due to increased housing values allowing for increased loan supply (Goodhart and Hofmann, 2008). An interesting feature is that the impact on output is negative. One potential explanation is that housing loans crowd out loans to other sectors and thereby diminish investments in these sectors, having an adverse influence on the overall economy. Such effect, where a positive shock to the bank's lending opportunities for housing leads to substitution away from commercial loans, is supported by the discussion and findings of Chakraborty et al. (2018), for instance. This effect can be emphasized by the increasing effect of housing loan demand growth on real loan rates more broadly, as an increase in housing loan demand raises demand for credit overall. This could also have a decreasing impact on consumption, due to higher consumption loan rates. Overall, the impulse responses in Figs. 2 and 3 suggest that both loan supply and demand shocks can have significant influences on indebtedness and housing prices, and their cycles.

3.3.3. *Housing market shock*

Fig. 4 shows that a positive housing market shock immediately raises real housing prices above their long-run equilibrium level. The strength of the shock grows over time with housing prices deviating further from their long-run level, peaking after approximately two years before the effects of the shock start to dissipate.

The housing market shock has little impact on the loan market. There is an initial fall in the loan-to-output ratio which eventually becomes positive, although these effects are not statistically significant with the impulse responses falling within the 95% confidence intervals.

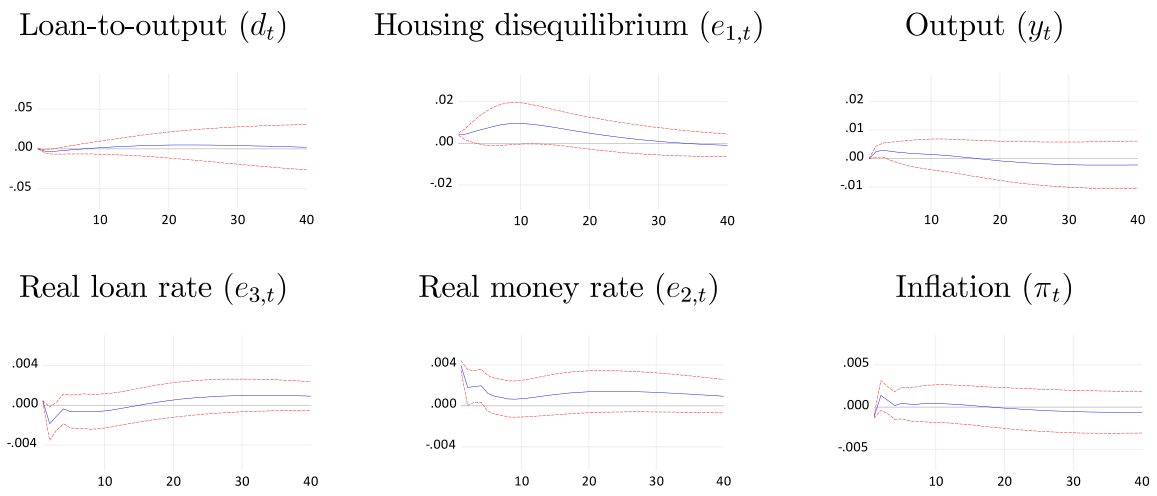


Fig. 4. Impulse responses to a housing market shock with 95% confidence intervals based on asymptotic standard errors. Horizontal axis represents quarters.

There is a negative contemporaneous effect on the real loan rate which eventually switches to being positive, although these effects are also statistically insignificant.

In contrast to the initial effects of the housing market shock on the real loan rate, the real money rate progressively increases resulting in a decline in the loan margin over time. This, together with the slight eventual increases in d_t, is consistent with the idea that housing price increases lead to greater housing loan supply and thereby lower loan margins.

The positive housing market shock translates into increases in output, together with a temporary increase in inflation. The output reaction helps to attenuate the size of the housing price disequilibrium, and is consistent with the often reported wealth effect of housing prices on consumption (Carroll et al., 2011; Berger et al., 2018).

3.3.4. Variance decompositions

Table 3 gives the cumulative forecast variance decompositions for selected time horizons in terms of the contributions of the six structural shocks to the two key policy variables of interest, namely the loan-to-output ratio (d_t) and the housing price disequilibrium $(e_{1,t})$. The variance decompositions are expressed as a percentage of total volatility at each forecast horizon. The time horizons are expressed in years by extracting every fourth (quarterly) forecast variance decomposition.

The variance decompositions of d_t in terms of the six shocks are given in the first block of Table 3. The dominant short-run factor are loan demand shocks where the contribution to the variance decomposition is just over 50%. The contributions of loan demand shocks steadily decline over time, but nonetheless still remain important being 36% in the long run. The variance contribution of loan supply shocks to d_t is relatively small in the short run, becoming progressively more important over time increasing to nearly 25% of total volatility in the long run. In contrast to loan supply shocks, the contribution of money shocks to the variance of d_t remains relatively small at less than 5% over all time horizons. The small role of these shocks on loan expansion is in line with the results of Drechsler et al. (2022) who find that the Fed's monetary policy tightening before and after the GFC had little impact on overall lending.

Shocks from the goods market are important too with total contributions from aggregate demand and supply at around 30% across all horizons. The greater contribution is from aggregate demand shocks at around 20%, followed by aggregate supply with the respective contributions remaining relatively stable over time.

The second block of variance decompositions in Table 3 shows that loan demand shocks are also the most important factor in contributing to the volatility in housing price disequilibria $e_{1,t}$, for time horizons up to three years. Money shocks are also important across all time horizons, and are the most important determinant of the volatility in $e_{1,t}$ for time horizons in excess of three years. Loan supply shocks have little impact on housing prices in the short run, but do have an important contribution in the long run with contributions at around 20%. The total contribution of loan demand and supply shocks is between 40% and 50% for all horizons.

Interestingly, shocks from within the housing market have only a marginal impact on deviations of the real housing price from its long-run equilibrium with contributions at less than 10% at all horizons. This result suggests that the dominant shocks affecting the housing market are external with major contributions from the loan and money markets. There is also some contributions from the goods market through aggregate demand shocks with contributions to the volatility of $e_{1,t}$ at just under 20% in the first year, decreasing to slightly over 10% in the long run.

Table 3
Variance decompositions of the loan-to-output ratio (d_t) and the housing price disequilibrium error $(e_{1,t})$, for selected forecast horizons. Expressed as a percentage of the total forecast variability at each horizon, using data from 1985Q1 to 2020Q4.

Variable	Horizon	Shock					
	(Years)	Loan Supply	Loan Demand	Housing Market	Money Market	Aggregate Supply	Aggregate Demand
d_t	1	9.11	51.67	3.58	3.57	11.74	20.34
	2	14.89	46.26	3.96	4.03	11.75	19.10
	3	18.85	42.25	3.99	4.78	11.87	18.26
	4	21.80	39.49	3.91	4.71	11.85	18.25
	5	23.62	37.83	3.76	4.48	11.74	18.58
	10	24.86	36.03	3.57	4.63	11.32	19.58
$e_{1,t}$	1	1.00	47.77	3.13	28.89	1.59	17.62
	2	1.65	43.25	5.04	35.16	2.17	12.73
	3	5.17	38.53	7.44	35.91	2.81	10.15
	4	9.67	34.47	8.67	34.66	3.42	9.10
	5	13.85	31.44	8.94	32.86	3.94	8.95
	10	21.90	26.95	7.80	27.34	4.77	11.24

3.4. Understanding past movements in housing loans and prices

We next consider historical decompositions based on the estimated model, allowing us to investigate the role of different shocks on the time paths of the variables. Since this study focuses on the drivers of

loan expansion and housing price disequilibrium cycles, we concentrate on the historical decompositions of the loan-to-output ratio and the deviation of housing prices from their long-run equilibrium level. The Finnish case provides an interesting opportunity to investigate the contributions of different shocks over several episodes of rapidly rising, or declining, housing prices and mortgage debt.

3.4.1. Loan-to-output ratio

The impulse responses in Figs. 2 and 3, combined with the variance decompositions in Table 3, indicate that both loan supply and demand shocks significantly influence housing debt. It is interesting to investigate the role of these shocks in previous time periods. This provides information on for example, to what extent housing loan cycles originate from loan supply versus loan demand shocks in different market circumstances.

Fig. 5 gives the historical decomposition of the loan-to-output ratio growth rate Δd_t, with respect to a baseline projection (bars) in terms of the contributions of the shocks (continuous line). The financial liberalization in the mid to late 1980s is followed by a boom–bust cycle in the Finnish economy. The abolishment of credit controls also leads to a cycle in the loan-to-output ratio, where the loan market shocks expectedly drive the cycle. Both loan supply and demand shocks substantially contribute to the notable increases in the ratio during late 1980s, and adverse loan supply shocks in particular explain the negative movements in d_t during the 1990s. Aggregate demand shocks diminish the increase in d_t in the late 1980s boom phase, as real output substantially increases.

In the 2000s before the GFC, loan supply shocks have an important role in the rapid growth of d_t. The positive influence of aggregate demand shocks on d_t is due to these shocks having a negative influence on output, thus increasing the loan-to-output ratio. For the same reason, aggregate demand shocks explain a major share of the significant increase in d_t during the GFC. There is little influence from housing market shocks on movements in d_t, though housing shocks appear to have somewhat affected the loan cycle until mid 1990s.

Importantly, while the variance decompositions emphasize the role of loan demand shocks, the historical decompositions reveal that it is the loan supply shocks in particular that drive the loan cycles from mid 1980s until the GFC. The emergence of the GFC does not result in a substantial negative shock in loan supply, supposedly thanks to the Finnish banking sector being in good shape and having not taken large risks in contrast with numerous banks in other countries. The historical decomposition suggests that, with the exception of the late 1980s, the role of loan demand shocks operate more in the short run, without any clear observable patterns driving the d_t cycles.

From 2010 onwards there are no prominent cycles in d_t as occurred previously. Based on the historical decomposition, shocks in the aggregate supply and demand as well as the loan market shocks each contribute to the slow growth in d_t. The negative influence of loan supply shocks on d_t is as expected given the tightening of bank regulation after the GFC. Shocks from the money market have a minor role on the time path of d_t, as these shocks tend to influence both loan stock and output in the same direction.

3.4.2. Housing price disequilibrium

During our sample period the deviations of housing prices from their long-run equilibrium levels are divided into two periods. The first is from 1985 to the late 1990s, where there are large swings in housing prices, also relative to their long-run equilibrium values. The second period is from the late 1990s onwards where the amplitudes of the swings are much milder. Investigating the drivers of the prominent price cycle in the early sample period is particularly interesting, as such cycles can be extremely harmful for the whole economy.

While housing price shocks themselves have an important role in the cycle, especially in the boom period, Fig. 6 shows that loan supply and demand shocks both contribute significantly to the boom and bust phases in housing prices in the 1980s and 1990s, with loan demand shocks having a particularly strong influence. During the boom period, this likely relates to households' loan constraints substantially loosening because of increases in permitted loan maturities and in required LTVs that allowed households to demand more loans. During the bust phase banks tightened housing loan requirements, also due to significant increases in the number of defaulting housing loans, further increasing the housing price fall. The large increases in the money market rate are another major driver of housing prices dropping notably below their long-run fundamental level.

For the 2000 to 2020 period, the shocks tend to work in opposite directions with shocks to loan supply, housing markets and aggregate supply contributing to cyclical movements with longer durations, while the contributions of the remaining shocks tending to result in cycles with shorter durations. The short drop in housing prices relative to their long-run level during the GFC is due to adverse money and loan demand shocks. In Finland, housing prices decrease much less than in most developed countries during the GFC. One reason is that housing prices were well aligned with fundamentals before the GFC. Likely due to this, housing market shocks did not have adverse housing price effects. Moreover, as the banking sector was in good shape, the loan supply shocks did not influence housing prices negatively, as can be seen in Fig. 6. Note also that the drop in housing disequilibrium is diminished by a simultaneous decrease in GDP.

While the historical decomposition presented in Fig. 5 shows that there is only little influence from housing market shocks on movements in d_t, the historical decompositions of $e_{1,t}$ in Fig. 6 provide evidence of loan market shocks playing a major role in housing price cycles. Indeed, the historical decompositions emphasize the role of loan market shocks, rather than housing market shocks, behind both housing loan and price cycles. This is consistent with previous empirical evidence from both microeconometric analyses and macroeconometric models based on which housing price movements are more likely to respond to loan supply expansion rather than to cause such expansion (Mian and Sufi, 2018). The historical decompositions are also in agreement with the predictions of the housing related financial accelerator theory as housing market shocks nevertheless affect housing loan volume, although the influence is relatively minor.

4. Robustness and sensitivity experiments

This section summarizes five robustness and sensitivity experiments applied to the baseline model of Section 2. For each experiment the impulse responses reported in the online Appendix are found to be qualitatively similar to those of the baseline model, thereby providing evidence that the key empirical findings and implications are not altered by any of the robustness experiments.

(i) Long-run Restrictions

The empirical results presented in Fig. 2 show that loan supply shocks display no statistically significant effects on output in the short run or intermediate run, and by construction neither in the long run. To determine whether this lack of significance arises from the imposition of the adopted long-run restriction, an alternative identification strategy is considered by imposing a short-run restriction instead whereby loan supply shocks $\epsilon_{2,t}$, have no contemporaneous effect on $e_{1,t}$. The adoption of this restriction enables $\hat{v}_{3,t}$ to act as an instrument to identify $\epsilon_{2,t}$, which in turn, enables the identification of $\epsilon_{1,t}$ with $\epsilon_{2,t}$ as the alternative instrument. Figure D.1 of the online Appendix shows that the results are robust to this change in the identifying restrictions as loan supply shocks still have no statistically significant effect on output over all time horizons.

(ii) Conditioning for GFC and COVID-19 Shocks

The GFC and COVID-19 pandemic caused shocks in the Finnish economy that resulted in outlier residuals in 2009Q1 and 2020Q2,

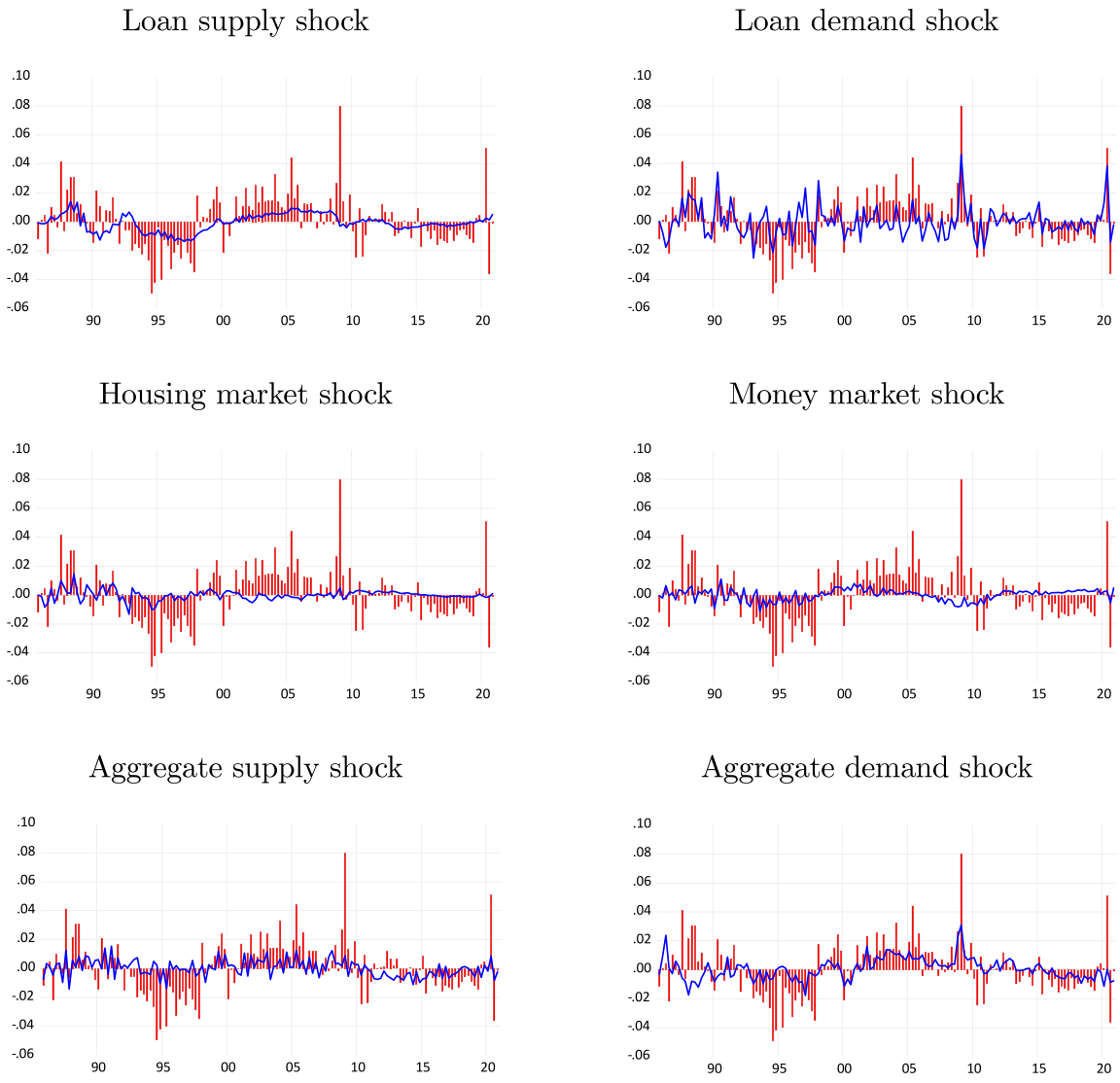


Fig. 5. Historical decomposition of the loan-to-output ratio growth rate (bars), in terms of the contributions of the shocks (continuous line), 1985Q1 to 2020Q4.

respectively. We investigate the robustness of the empirical findings to controlling for these shocks by including two indicator variables in the model. The first indicator variable takes the value of 1 in 2009Q1 and is zero otherwise, while the second dummy variable equals 1 in 2020Q2 and is zero in all other periods. Figure D.2 of the online Appendix reveals no notable differences between the impulse responses of the baseline model and the extended model capturing the outlier observations during GFC and the pandemic. There are some small changes in the variance decompositions with loan demand shocks having a relatively smaller role in the loan-to-output ratio path, 25% vs. 36% in the long run, whereas money and aggregate demand shocks have slightly greater influence in the loan-to-output ratio developments. There is also a relatively smaller contribution of loan supply shocks on housing price disequilibrium movements, but a greater role from money shocks than in the baseline model.

(iii) Quantitative Easing and Negative Nominal Rates

Inspection of Fig. 1 shows that Finland experienced negative nominal money market rates between 2016 and 2020 from quantitative easing policies in the Euro area. To identify the potential effects of negative rates on the efficacy of monetary policy and on the market dynamics in general, two extensions of the base model are investigated. The first extension is the inclusion of an indicator variable taking the value of 1 from 2016Q2 to 2020Q4, during the negative nominal rate period, and zero otherwise. The second extension combines the shadow rate constructed by Wu and Xia (2016, 2017, 2020) with the short-term money market rate from 2005Q3 onwards. Figure D.3 in Appendix D gives impulse responses from loan supply and demand shocks, on the loan-to-output ratio and the real loan rate, as well as on the housing price disequilibrium. Either extension produces qualitatively similar impulse responses. In the case of the first extension the indicator variable for the negative rate period is also statistically insignificant in all estimated structural equations.

(iv) Including Housing Co-op Loans in the Loan Stock

The definition of the loan stock is expanded to include loans of housing cooperatives (co-ops). By 2020Q4 the co-op loan to housing loan ratio is nearly 20% in Finland. These loans can have the effect of raising the overall indebtedness of households in the economy by relaxing households' loan constraints. While this is expected to increase housing demand, the use of co-op loans in housing construction affects the supply side as well by easing the developers' financial constraints.

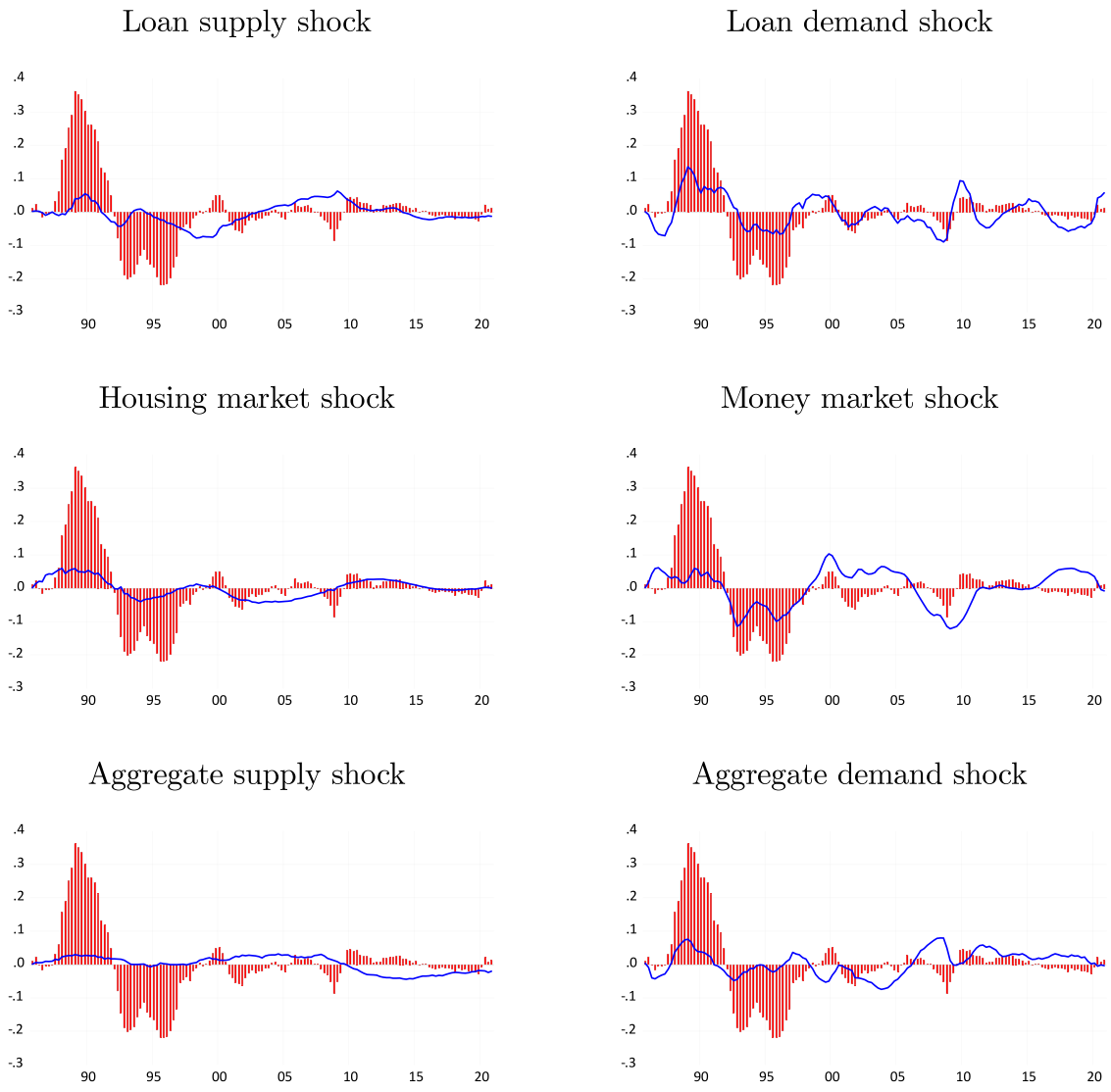


Fig. 6. Historical decomposition of the deviation between actual and long-run equilibrium housing prices (bars), in terms of the contributions of shocks (continuous line), 1985Q1 to 2020Q4.

Figure D.4 of the online Appendix shows no qualitative change to the impulse responses from the expanded loan stock definition.[18] However, the variance decompositions show that the role of loan market shocks with respect to the loan-to-output ratio movements is even greater in this experiment, with loan supply and demand shocks together explaining approximately 70%, compared to 60% in the baseline model, regardless of the time horizon. The higher relative importance of loan market developments comes from loan supply shocks in particular, which account for 32% (vs. 25% in the baseline model) of the variance decomposition at the 10-year horizon. The role of loan supply shocks also is greater for housing price disequilibrium developments than in the baseline investigation. These results suggest that the housing co-op loan developments have somewhat diminished the role of shocks in traditional housing loan supply behind household loan expansion and housing price dynamics, as the loan supply effects appear to partially take place indirectly via housing co-op loans.

(v) 5-variate Model

A key focus of the paper is on comparing the relative influences of loan supply and loan demand shocks rather than investigating the role of money shocks. Motivated by Gambetti and Musso (2017), a 5-variate model is estimated where the money shock is not separately identified by excluding the nominal short-term interest rate. The identifying restrictions in the 5-variate model are the same as in the baseline model, except for the restrictions related to the money rate. As the number of short-run restrictions can be decreased by one for the just-identified 5-variate model, the approach is to allow the housing price shock to have an immediate effect on the loan-to-output ratio. A comparison of impulse responses from loan supply and demand shocks presented in Figure D.5 of the online Appendix reveal qualitatively

[18] Official data on housing co-op loans from 1995Q1 onwards is provided by the Bank of Finland. For the earlier period 1985–1994, values are computed by assuming that the co-op loan-to-housing loan ratio remains constant at 5.77%, which is the observed value in 1995Q1. Given the stability of the ratio during 1995–2012, this should be a reasonable approximation for our purposes.

similar results for the baseline and 5-variate models regarding the loan and housing market reactions. There are also no large differences in the variance decompositions between the sets of models, except for the substantially greater share of housing market shocks in explaining the $e_{1,t}$ variance. Importantly, the implications regarding loan supply and demand shocks' influences are not notably altered.

5. Russian war of aggression and related shocks

The Russian war of aggression in Ukraine that started in 2022Q1 has affected Finland in many important ways. Similar to other European countries, Fig. 1 showed that Finland faced a dramatic and rapid rise in the inflation rate and a consequent tightening of monetary policy in the Euro area that led to a fast and large jump in the nominal money market and loan rates. Substantial adverse influences on the Finnish economy have also taken place due to the historically notable role of imports to and exports from Russia. Moreover, the perceived riskiness of Finland may have increased, and overall the adverse shocks may have negatively affected sentiment and expectations in the country.[19] Indeed, real output declined over 2% in Finland from early 2022 to 2024Q2. These developments have potentially had negative effects on housing demand and on loan supply and demand, hence affecting housing price and loan-to-output ratio time paths. Therefore, it is interesting to investigate the developments in the Finnish market during 2021–2024, including also a pre-war period to consider the potential influences of expectations about the (then still) potential forthcoming war of aggression. We examine the role of different shocks on housing price disequilibrium and loan-to-output ratio out-of-sample. This is achieved by investigating the historical decompositions based on the parameter estimates from the baseline SVECM, so not allowing the large shocks during 2021–24 to influence the parameters.

Figs. 7 and 8 respectively show the historical decompositions for the housing loan-to-output ratio d_t, and the housing price equilibrium error $e_{1,t}$, during 2021Q1-2024Q2. Both the variables are almost exactly at their baseline projection in 2021Q1, immediately after which the loan-to-output ratio diverges downwards, with the housing price disequilibrium starting to diverge one year later. Based on the historical decompositions, loan demand shocks have a prominent influence on the negative d_t and $e_{1,t}$ developments during the investigated period. This is particularly prominent in the case of $e_{1,t}$.

To understand the significant role of loan demand shocks from 2021 onwards, it is important to recall the nature of this shock. A loan demand shock has the same sign on both the loan rate and stock. These shocks can originate from innovations in economic expectations and changes in liquidity constraints, for instance. Since 2021Q1 there are simultaneous negative innovations in the loan-to-output ratio and real loan rate – reflecting negative loan demand shocks by definition – and the real rate remains negative during 2021Q1-2022Q2. Because of the monetary policy reaction to the inflation rate hike, the nominal loan rate experiences a rapid and large increase from early 2022 to late 2023, causing a dramatic rise in the housing loan expenses faced by borrowers. The consequent increase in loan payments-to-income ratios substantially tightens households' liquidity constraints, hence leading to lower loan withdrawals, imposing further negative shocks on loan demand. As expected, such tightening of liquidity constraints appears to have had significant adverse impact on housing demand and thereby on housing prices. For loan demand shocks, negative sentiment developments also may play a role. It is reasonable to assume that due to Finland's geographic location, an adverse influence of the war of aggression on the expectations, or sentiment, is stronger in Finland than in countries located further away from Russia. Indeed, consumer confidence quickly drops to a record low in 2022, after being close to a record high just before.

Also money shocks have a major role in the recent notable decline in housing prices, with housing prices operating over 20% below their long-run fundamental level in 2024Q2. The drastic drop in the real money rate, due to the inflation rate jump, can explain the positive influence of the money shock on $e_{1,t}$ in 2022, as the real money rate decrease represents an expansionary money shock. The European Central Bank reacted strongly to the Euro area wide inflation hike with some lag, the inflation rate decreased, and since 2023Q3 the real rate was clearly positive already. This constituted a contractionary money shock which in turn, had an adverse influence on housing price developments since mid-2023.

Housing price shocks themselves do not explain any of the dramatic drop in $e_{1,t}$, suggesting that the housing price decrease is purely a consequence of exogenous shocks on the housing market. In contrast, housing market shocks have a positive impact towards the end of the period. This is likely because of the housing supply side response to the adverse shocks in the economy: housing starts dramatically decreased, and eventually the number of newly developed dwellings dropped substantially.

Negative loan demand shocks also have a notable role in the decrease of the loan-to-output ratio until late 2022, with the proposed explanation being the same as that with respect to housing price developments. Loan supply shocks play some role: our analysis suggests that in contrast with loan demand, loan supply increases during 2021–24, thereby somewhat reducing the drops in d_t and $e_{1,t}$. Hence, it appears that from the banking sector's viewpoint the riskiness of the Finnish market has not increased since early 2021 – perceived higher risks would likely cause higher loan margins, i.e. negative loan supply shocks. The joint contribution of shocks in the aggregate economy on the loan-to-output ratio is negative throughout the studied period, with the exception of two quarters in 2021. In contrast with housing price developments, the historical decompositions do not show evidence of any notable influence from money shocks on d_t.

In sum, this exercise emphasizes the role of the interplay between inflation, and nominal and real interest rates, despite the war of aggression causing many kinds of shocks in the economy – not least in the Finnish economy. The historical decompositions suggest that both nominal and real rates, and hence inflation, are of great importance for the loan and housing markets, at least over the relatively short run. Intuitively, the nominal loan rate, too, is influential due to its effects on liquidity constraints and sentiment.

6. Conclusions

This study provides a new approach to modelling the interaction between housing and loan markets. An important feature of the estimated model is that it enables the identification of loan supply and demand shocks separately, and therefore distinguishing between the effects of these shocks. This is of importance, since in theory credit cycles could be driven by either credit supply or demand shocks as Mian et al. (2017) point out. In comparison to previous empirical modelling work, as all shocks of the model are identified the estimation approach allows for the past movements in the housing loan-to-output ratio and housing prices to be decomposed in terms of the full set of shocks.

The empirical analysis is based on quarterly data for Finland from 1985 to 2024. The Finnish market makes an interesting case study due to considerable cycles and innovations in the credit market during the sample period. The empirical results show that both loan supply and demand shocks can lead to significant housing loan expansion over the short and mid term, and can therefore notably affect financial stability. The variance decompositions and historical decompositions indicate that both shocks have had a major role in increasing the housing loan-to-output ratio in Finland, whereas housing price shocks are found to have little effect on this ratio. The loan supply shocks in

[19] Increase in the perceived riskiness of Finland may have been diminished by Finland becoming a member in NATO in 2023Q2.

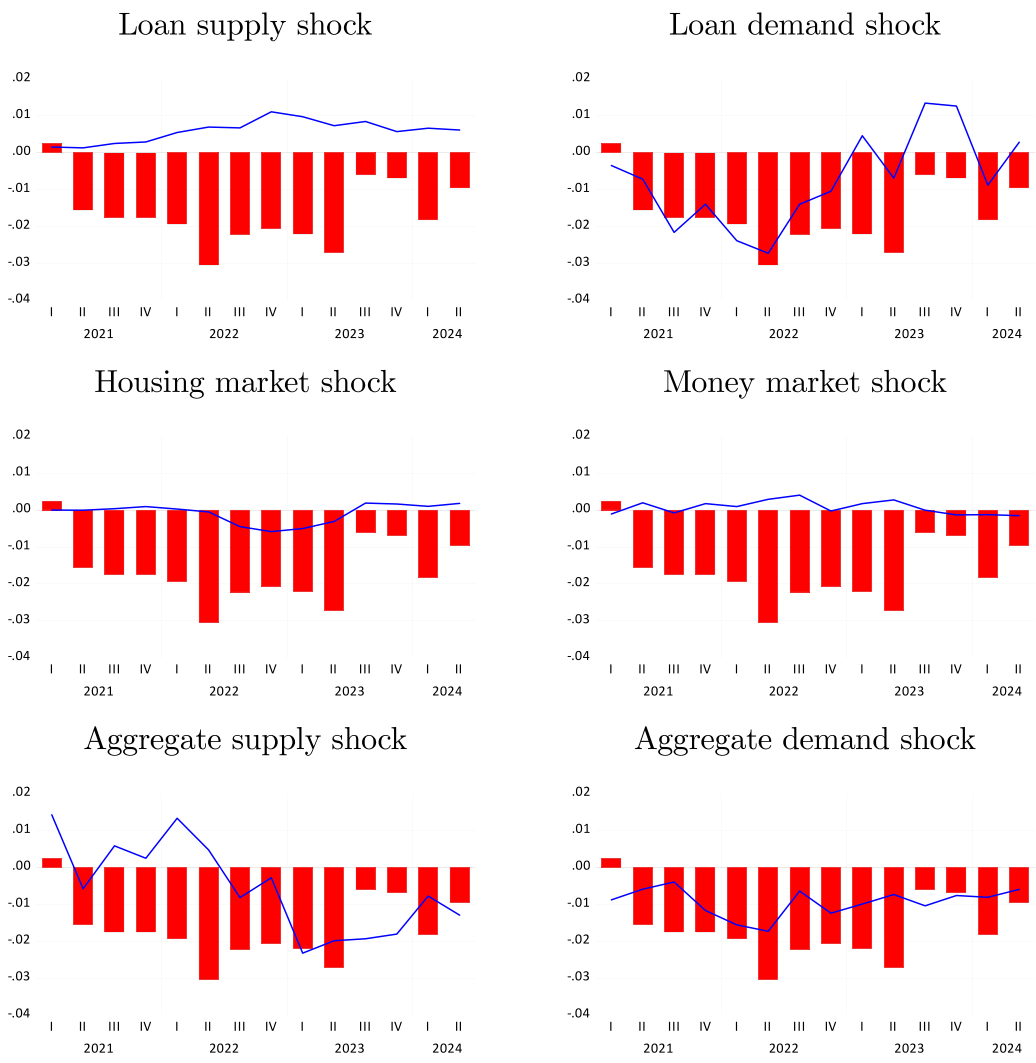


Fig. 7. Out-of-sample historical decomposition of the loan-to-output ratio growth rate (bars), in terms of the contributions of the shocks (continuous line), 2021Q1 to 2024Q2.

particular play an important role in the loan expansion in the early 2000s prior to the GFC, whereas loan supply and demand innovations jointly drive the dramatic loan cycle of the late 1980s and early 1990s. The corresponding boom–bust cycle in housing prices is also driven by housing price and money market shocks, in addition to the loan market innovations. All of these shocks influence housing price developments since the mid 1990s as well.

An important practical use of the model is understanding the effects of the Russian War of aggression on the Finnish market. Our out-of-sample historical decompositions for the war period point to the role of shocks stemming from the interplay between inflation, and nominal and real interest rates having a key role in the recent notable decreases in Finnish housing prices and loan-to-output ratio. Given that the Finnish economy has suffered more severely from the war of aggression than most European countries, due to Finland sharing a border of over 1300 kilometres with Russia, the role of this interplay likely has been even greater in Europe in general.

There are basically two broad possible ways to see the interaction between loans and more generally credit, and housing prices (Guerreri and Uhlig, 2016): (i) The house price boom–bust generates the credit boom-bust; (ii) The credit boom–bust generates the house price boom-bust. Our empirical evidence points to housing price movements being a response to loan market innovations rather than a cause of loan expansion. The practical implication is that it is indeed the loan market rather than the housing market directly that should be in focus in policy-makers reaction functions. Another important implication which adds to the existing literature is that both loan supply and demand developments act as channels of substantial macroprudential policy importance. That is, it is both the regulations affecting the loan margins, such as alterations in required bank capital, and policies influencing households' loan constraints, through e.g. LTVs and loan maturities, that should be considered by policy makers when aiming to influence loan expansion and housing price developments. An important methodological message stemming from the proposed approach is that the SVECM framework with identification based on long-run and short-run restrictions together with restrictions stemming from cointegration, potentially represents an important methodology to jointly identify loan supply and demand shocks from the data for other countries than Finland as well.

The main focus of the paper is on the joint modelling of shocks to demand and supply in loan markets, and how these shocks interact with the housing market within a prototype macroeconometric SVAR. In doing so we abstract from other potential channels linking monetary policy with key variables in the model. One channel emphasized by Moran and Queralto (2018) links monetary policy with output through its effect on labour productivity. This suggests that an important area



Fig. 8. Out-of-sample historical decomposition of the deviation between actual and long-run equilibrium housing prices (bars), in terms of the contributions of the shocks (continuous line), 2021Q1 to 2024Q2.

of research is to expand the present framework by extending the set of variables to include employment along the lines of the technology shocks in the SVAR model of Galí (1999).

CRediT authorship contribution statement

Elias Oikarinen: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Vance L. Martin:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

We have no conflict of interest.

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Appendix A. Data sources

The variables and their sources are contained in Table A.1. The housing price index is based on all secondary-market transactions of non-subsidized apartment units, i.e. units that can be bought and sold at market prices without any restrictions. Over 80% of all dwellings in Finland belong to the non-subsidized sector. In Finland, housing loans are recourse loans, and the purchased dwellings work as collateral for the loans.

Appendix B. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jfs.2026.101581.

Table A.1
Variable definitions, sources and adjustments.

Variable	Source	Adjustments
Real output, log (y_t)	Statistics Finland	Real GDP, seasonally adjusted by data provider using the Tramo/Seats method, normalized to 100 in 1985Q1
Inflation rate, log (π_t)	Statistics Finland	Quarterly difference of logged CPI, where CPI is seasonally adjusted using the Tramo/Seats method in EViews, annualized
Housing loan stock to output ratio, log (d_t)	Bank of Finland	Real housing loan stock divided by real GDP, seasonally adjusted using the Tramo/Seats method, where the real loan stock and real output are both normalized to 100 in 1985Q1
Nominal interest rate on housing loans (r_t)	Bank of Finland	Mean of loan contracts, annualized
Nominal money market rate (m_t)	Bank of Finland	12 month Helibor rate (1985–1999) and the 12 month Euribor rate (1999–2020), annualized
Real housing price index, log (h_t)	Statistics Finland	Seasonally adjusted by data provider using the Tramo/Seats method

Data availability

Data will be made available on request.

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