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ASSET PRICES AND FINANCIAL FRICTIONS IN MONETARY TRANSMISSION: THE CASE OF LATVIA

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ABBREVIATIONS

AR – autoregression
CES – constant elasticity of substitution
CPI – consumer price index
DSGE – dynamic stochastic general equilibrium
EU – European Union
GDP – gross domestic product
PPP – purchasing power parity
SDR – Special Drawing Rights
UIP – uncovered interest rate parity

ABSTRACT

The purpose of this paper is to quantify the role of financial frictions in Latvia's monetary transmission. Our model extends M. Iacoviello (9) framework along three dimensions. First, we introduce open-economy features by allowing imports of foreign consumer goods and borrowing from abroad. Second, we relax the assumption of fixed housing stock, allowing for investment. Finally, we assume a risk premium on foreign borrowing, which depends on net foreign asset position. We estimate the model by Bayesian approach and compare impulse responses to shocks under various scenarios. In addition to the baseline scenario, we explore the importance of tighter borrowing constraints and higher foreign risk premium elasticity in the model dynamics. Our findings show that tighter credit constraints weaken the transmission of shocks to housing demand and consumption. In the case of foreign interest rate and risk premium shocks, higher risk premium elasticity lessens the effect of monetary transmission on the domestic economy through higher cost of external funds.

Keywords: financial frictions, monetary transmission, asset prices, DSGE model, Bayesian approach

JEL classification: C11, E32, E44, E52, R21

INTRODUCTION

The recent history of housing prices' boom and bust cycle has amplified interest in the role of housing for transmission mechanism, drawing particular focus on the overall risk assessment of the housing sector in broader macro economy. Papers by N. Kiyotaki and J. Moore (11) and M. Iacoviello (9) provided the basis for further research in the field of collateralised debt and macroeconomic fluctuations (see, e.g. B. Bernanke et al. (3), J. R. Campbell and Z. Hercowitz (5), M. Iacoviello and S. Neri (10)). There are also a growing number of researches on DSGE models with housing collateral by central banks (I. Christensen et al. (6), K. Walentin and P. Sellin (13), A. Gerali et al. (8), A. Calza et. al. (4), and M. Rubio (12)).

The purpose of this paper is to quantify the role of financial frictions in monetary transmission for the Latvian economy. Despite a rather short recent history of the Latvian housing market and related mortgage lending, the market has experienced a sharp housing stock growth, rocketing prices after accession to the European Union in 2004, and a huge housing price drop after the second quarter of 2007 (–70% in the period between the first quarter of 2007 and the third quarter of 2009), followed by a deep economic recession. While, compared with the other European countries, the share of households with mortgage loans in Latvia is rather small (around 18% in 2009), the effect of shrinking collateral value on the economy through both balance sheet and wealth transmission channels is believed to be pronouncedly negative. The questions we are addressing herein, therefore, are: 1) the potential effect of more restrictive bank credit policy, i.e. a lower loan-to-value assumption, and 2) worsening investors' expectations regarding solvency of the Latvian economy, i.e. a higher risk premium applied by foreign investors to external debt holdings.

In order to address these issues, we develop and estimate a DSGE model with borrowing constraints. Following M. Iacoviello (9), we assume borrowing constraints both at household and firm levels and ex-ante heterogeneity in household discount factors (constrained and unconstrained households). Our model extends M. Iacoviello's model along 3 dimensions. First, we introduce open-economy features into this closed economy framework to make the model better characterise the Latvian economy. This extension allows for foreign savers to supply funds to the domestic economy, thus affecting the response of interest rates and asset prices to shocks. Second, we relax the assumption of a fixed housing stock, allowing for investment in structures. Third, following M. Adolfson et al. (1), we assume that there is such a premium on foreign bond holdings that depends on the aggregate net foreign asset position of domestic households. These features complement the model with realistic elements that are likely to be crucial when assessing the importance of financial frictions for such open economy as Latvia's. We estimate the model with the Latvian data using Bayesian approach.

To gauge the role of borrowing constraints and foreign risk premium in the model dynamics, we construct impulse responses for the estimated (baseline) model and two altered specifications: 1) a model with a tighter borrowing constraint on impatient households, and 2) a model with a larger foreign risk premium elasticity to net foreign asset position.

We find that in the case of tighter credit constraints (lower loan-to-value ratio) the transmission of shocks is less pronounced; overall, the scenario restrains borrowing, housing demand and consumption of credit constrained households but does not have any pronounced effect on total output.

The main implication of higher risk premium elasticity is the restricting effect of various shocks on foreign borrowing. In the case of foreign interest rate and risk premium shocks, higher risk premium elasticity lessens the effect of monetary transmission on the domestic economy through higher cost of external funds. In the case of constrained households' positive credit shock, the impulse responses under higher risk premium elasticity and baseline scenarios are very similar due to their negligible effect on the domestic interest rate.

Compared with other shocks, the terms of trade shock has the most permanent impact on domestic loans, consumption, housing demand, prices, and investment, all of which return to the initial path in 3–4 years due to persistence in the domestic interest rate. The effect of foreign interest rate and risk premium shocks on constrained household loans, housing prices and investment fades away in 1.5 years.

We present the details of model framework in Section 2. Section 3 outlines the estimation strategy and gives an overview of the data. Section 4 describes impulse responses of the key macro variables to exogenous shocks. We also conduct some experiments to highlight the importance of financial frictions in the model dynamics. The final section concludes.

1. MODEL SETUP

There are three types of agents in the economy: the entrepreneurs, the so called "patient" consumers, and the "impatient" consumers. Consumers, patient and impatient, consume housing as well as non-durable consumer goods. To raise the funds to buy goods, they supply labour to entrepreneurs, who combine labour with their own stock of housing (which, in a production context, can be thought of as business structures such as factories or offices). The entrepreneurs and impatient consumers differ from the patient consumers in that they discount the future at a faster rate than patient agents. Given the opportunity to do so, the patient agents will be net lenders in the economy, while the entrepreneurs and impatient agents figure as net borrowers. In our model, to prevent borrowing from growing without limit, the entrepreneurs and impatient consumers face a credit constraint which is a fixed proportion of the expected future value of their housing. In M. Iacoviello's original model, entrepreneurs supplied their output competitively to imperfectly competitive retailers, who transformed the homogeneous intermediate goods into various brands and faced Calvo-style price rigidity, allowing for a Phillips curve. To introduce the open-economy features into our model, we make the structure of final goods production more complicated following I. Christensen et al. (6). In this framework, domestic entrepreneurs sell their output to domestic brand firms, which mark it up; meanwhile, intermediate-good-importing firms produce imported brands and mark them up. The domestic and imported brands are then combined by perfectly competitive retailers into a final good.

Unlike M. Iacoviello's model, we also permit the production of new housing, i.e. housing investment. In the current version of the model, we assume for simplicity that the housing producers are competitive firms (also owned by patient agents) using final goods to produce new units of housing.

The world economy is modelled as a continuum of small open economies represented by the unit interval. The performance of each economy does not have any impact on the rest of the world. Economies face imperfectly correlated productivity shocks while sharing identical preferences, technology, and market structure.

Variables with $i \in [0, 1]$ subscript refer to economy i as one of the continuum of economies constituting the world economy. Variables denoted by * stand for the world economy as a whole.

1.1 Patient Households

Patient agents gain utility from their consumption of non-durables C_t' and housing services proportional to their housing holdings H_t'. They also lose utility from labour effort N_t'. Patient agents raise funds in several ways. They sell their labour in a competitive labour market earning wage W_t', and make profit F_t from their ownership of imperfectly competitive brand-label firms (the nature of which will be described below). They can also borrow funds from two sources. In each period, as in M. Iacoviello (9), they borrow sum B_t' from other agents in the local economy at the local nominal interest rate R_t, or rather (as patient agents are the lenders in our economy) lend amount $(-B'_t)$. In this model, they can also borrow sum B^*_t from foreign lenders at an appropriate interest rate $R^*_t\zeta_t$, where R^*_t is foreign interest rate and ζ_t is risk premium specific to the local economy, related to its debt burden in a fashion that will be discussed below. Patient agents use the raised funds to pay off debts (domestic and foreign), buy consumer goods, and invest in housing. A representative patient household maximises its utility given by

$$E_0\sum_{t=0}^{\infty}(\beta')^t\left(\frac{(C'_t/A_t)^{1-\sigma}}{1-\sigma}+\frac{(H'_t)^{1-\delta}}{1-\delta}-\frac{(N'_t)^{1+\varphi}}{1+\varphi}\right) \qquad [1]$$

where $0<\beta'<1$ is discount factor, σ is risk aversion parameter, δ is weight on housing in the patient agent's utility function, φ is slope of the patient agent's labour supply function, and A_t is non-stationary world-wide technology shock. The presence of A_t in equation [1] implies that households derive utility from effective consumption relative to the level of technology, and guarantees that the model has a balanced growth path along with hours worked. C'_t is consumption, which is a part of composite domestic consumption index C_t defined as

$$C_t\equiv\left[(1-\alpha)^{\frac{1}{\eta}}(C_{H,t})^{\frac{\eta-1}{\eta}}+\alpha^{\frac{1}{\eta}}(C_{F,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \qquad [2]$$

where $C_{H,t}$ is index of consumption of domestic goods, $C_{F,t}$ is index of imported goods, $\alpha\in[0,\ 1]$ measures the degree of openness defined as a share of imported goods in the final domestic goods basket, whereas $\eta>0$ denotes substitutability between domestic and foreign goods from the standpoint of domestic consumer.

The household maximises its utility defined in equation [1] subject to a budget constraint

$$P_tC'_t+G_t(H'_t-(1-\delta^H)H'_{t-1})+Q_t(\zeta_{t-1}R^*_{t-1}B^*_{t-1}-B^*_t)\le W'_tN'_t-R_{t-1}B'_{t-1}+B'_t+T'_t+F_t \qquad [3]$$

where P_t stands for CPI, G_t is nominal housing price, δ^H is housing depreciation rate, Q_t is nominal exchange rate (domestic currency per unit of foreign currency), and T'_t denotes lump-sum transfers (taxes).

The solution of utility maximisation problem in log-linearised terms gives the expression for optimal labour supply:

$$\tilde{w}'_t=\sigma\tilde{c}'_t+\varphi n'_t \qquad [4]$$

where lowercase letters stand for deviation from steady state, whereas tilde denotes stationarised variables. In order to stationarise, the real variables[1] are scaled by technology and the nominal ones[2] – by technology and price.

The optimal choice of housing holdings in log-linear form is given by

1 Output, consumption, investment, exports and imports.
2 Wages, housing price and loans.

$$\tilde{c}_t' = \beta'(1-\delta^H)E_t\{\tilde{c}_{t+1}'\} + \frac{1}{\sigma}\left(\tilde{g}_t - \beta'(1-\delta^H)E_t\{\tilde{g}_{t+1}\} + \left(1-\beta'(1-\delta^H)\right)\delta h_t'\right) \quad [5].$$

The optimal domestic lending choice implies

$$\tilde{c}_t' = E_t\tilde{c}_{t+1}' - \frac{1}{\sigma}\left(r_t - E_t\pi_{t+1}\right) + \frac{1}{\sigma}E_t\Delta a_{t+1} \quad [6]$$

where $E_t\pi_{t+1} = E_t p_{t+1} - p_t$ and Δa_t is change in technology to be described below.

The choice between domestic and foreign bond holdings balances into an arbitrage condition pinning down expected exchange rate changes (i.e. uncovered interest rate parity (UIP) condition). To ensure a well-defined steady state in the model, we assume that there is a premium on foreign bond holdings ζ_t, which depends on the aggregate net foreign asset position of domestic households (according to, e.g. M. Adolfson et al. (1)). Log-linearised risk premium is given by

$$\varsigma_t = \varsigma_b \tilde{b}_t^* + \varepsilon_t^\zeta \quad [7]$$

where $\tilde{b}_t^*$ is log deviation of net foreign asset position and ε_t^ζ is shock to risk premium.

The UIP condition follows by combining the demand for foreign funds with the optimal domestic lending choice:

$$r_t - r_t^* = E_t\{\Delta q_{t+1}\} + \varsigma_t = E_t\{\Delta q_{t+1}\} + \varsigma_b \tilde{b}_t^* + \varepsilon_t^\zeta \quad [8]$$

where Δq_t is nominal exchange rate changes.

Finally, to linearise the budget constraint of equation [3], we first have to derive labour demand; hence it is left for the entrepreneurs' problem.

1.2 Impatient Households

Impatient households, similar to patient agents, gain utility from their consumption of non-durables C_t'', housing holding H_t'', while losing utility from labour effort N_t''. Impatient households can raise funds either by selling their labour in a competitive labour market, earning wages W_t'', or by borrowing funds B_t'' from patient agents using their housing stock as collateral. The maximum amount the impatient agents can borrow is a fraction $m'' < 1$ of the discounted future value of their housing stock, allowing for depreciation. Unlike the patient households, the impatient ones cannot borrow from abroad. They use funds to pay off debt, buy non-durables, and invest in housing.

The representative impatient household maximises its utility

$$E_0\sum_{t=0}^{\infty}(\beta'')^t\left(\frac{(C_t''/A_t)^{1-\sigma}}{1-\sigma} + \frac{(H_t'')^{1-\delta}}{1-\delta} - \frac{(N_t'')^{1+\varphi}}{1+\varphi}\right) \quad [9]$$

subject to the budget constraint

$$P_t C_t'' + G_t (H_t'' - (1-\delta^H) H_{t-1}'') + R_{t-1} B_{t-1}'' \leq B_t'' + W_t'' N_t'' + T_t'' \qquad [10],$$

and the borrowing constraint

$$B_t'' \leq m'' E_t \left(\frac{G_{t+1}(1-\delta^H) H_t''}{R_t} \right) \qquad [11]$$

where T_t'' denotes lump-sum transfers (taxes).

The solution of household utility maximisation problem with respect to consumption C'' and borrowing B_t'' yields a shadow price of the flow of funds constraint and a shadow price of the borrowing constraint. Substituting for the respective shadow prices in the equation for optimal choice of housing and log-linearising yields

$$\tilde{c}_t'' = \frac{s'}{(1-s'')} E_t \tilde{c}_{t+1}'' + \frac{1}{\sigma(1-s'')} \left[\tilde{g}_t - (s'+s'') E_t \tilde{g}_{t+1} - s'' E_t \Delta a_{t+1} - s'' E_t \pi_{t+1} + s'' r_t + (1-s''-s') \delta h_t'' \right] \qquad [12]$$

where $s' \equiv \beta''(1-m'')(1-\delta^H)$, $s'' \equiv m''\beta'(1-\delta^H)$, and $E_t \pi_{t+1} = E_t p_{t+1} - p_t$.

The optimal labour supply in log-linear form is given by

$$\tilde{w}_t'' = \sigma \tilde{c}_t'' + \varphi n_t'' \qquad [13].$$

As in the patient households' case, linearisation of the budget constraint is left for the entrepreneurs' problem.

The log-linear borrowing constraint of equation [11] is

$$\tilde{b}_t'' = \tilde{g}_{t+1} + h_t'' + \pi_{t+1} + \Delta a_{t+1} - r_t \qquad [14].$$

1.3 Entrepreneurs

There is a continuum of entrepreneurs in the economy, each is denoted by j_H on the unit interval (where subscript H stands for domestic economy), i.e. $j_H \in [0, 1]$. Entrepreneurs gain utility only from consumer goods. In each period t, they can raise funds in two ways. One way is producing domestic intermediate input $Y_{H,t}^{\text{int}}(j_H)$, using their housing stock $H_t^E(j_H)$, labour supplied by the patient agents $N_t'(j_H)$ and impatient agents $N_t''(j_H)$, and selling it at competitive price ψ_t, i.e. at domestic marginal cost. Another way is borrowing from the patient agents amount $B_t(j_H)$ using their housing capital as collateral. Specifically, the maximum amount entrepreneurs can borrow is a fraction $m<1$ of the discounted future value of their housing stock. With the funds raised, entrepreneurs pay their wage bills and repay past loans at a nominal interest rate R_t. They also buy consumption goods $C_t^E(j_H)$ and invest in housing (paying G_t per unit). Dropping j_H for notation convenience, the entrepreneurs attempt to maximise their utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(C_t^E / A_t)^{1-\sigma}}{1-\sigma} \right) \qquad [15]$$

subject to a budget constraint

$$P_t C_t^E + G_t (H_t^E - (1-\delta^H) H_{t-1}^E) + R_{t-1} B_{t-1} + W_t' N_t' + W_t'' N_t'' \leq Y_{H,t}^{\text{int}} \psi_t + B_t \qquad [16],$$

a production function constraint

$$Y_{H,t}^{\text{int}} = A_t \left(H_{t-1}^E\right)^{\nu} \left(N_t'\right)^{\kappa(1-\nu)} \left(N_t''\right)^{(1-\kappa)(1-\nu)} \qquad [17],$$

and a borrowing constraint

$$B_t \leq m E_t \left(\frac{G_{t+1}(1-\delta^H) H_t^E}{R_t} \right) \qquad [18]$$

where A_t is level of technology and $a_t \equiv \log A_t$ is described by the AR(1) process $a_t = \rho_a a_{t-1} + \varepsilon_t^a$, $\beta < 1$ is entrepreneurial discount factor, while κ measures the share of wage bill going to patient households.

The optimal choice of housing in log-linear terms yields

$$\tilde{c}_t^E = E_t \tilde{c}_{t+1}^E + \frac{1}{\sigma(1-p'')} \left[\tilde{g}_t - (p'+p'') E_t \tilde{g}_{t+1} - p'' E_t (\Delta a_{t+1} + \pi_{t+1} - r_t) - \left(1 - p' - p''\right) E_t (\hat{\tilde{\psi}}_{t+1} + \tilde{y}_{H,t+1}^{\text{int}} - h_t^E) \right] \qquad [19]$$

where $\hat{\tilde{\psi}}_t$ stands for deviation of real (log) marginal cost from its steady state, $p' \equiv \beta(1-m)(1-\delta^H)$, and $p'' \equiv m\beta'(1-\delta^H)$.

To linearise the production function, we first combine labour supply and demand, and substitute for the respective N_t' and N_t'' into equation [17] to obtain

$$\tilde{y}_{H,t}^{\text{int}} = \left(\frac{1+\varphi}{\varphi+\nu} \right) \nu h_{t-1}^E + \left(\frac{1-\nu}{\varphi+\nu} \right) \hat{\tilde{\psi}}_t - \frac{\sigma\left(\kappa(1-\nu)\tilde{c}_t' + (1-\kappa)(1-\nu)\tilde{c}_t''\right)}{\varphi+\nu} \qquad [20].$$

1.4 Wholesale Firms

Domestic brands. The producers of domestic brands buy domestic intermediate input $Y_{H,t}^{\text{int}}$ from the entrepreneurs at price ψ_t and transform it, using linear technology, into $Y_{H,t}(j_H)$. Thus, $Y_{H,t}$ is a CES composite of individual "brands" of domestically made inputs, each brand being produced by imperfectly competitive domestic firm $j_H \in [0, 1]$. Specifically,

$$Y_{H,t} \equiv \left(\int_0^1 Y_{H,t}(j_H)^{\frac{\varepsilon-1}{\varepsilon}} dj_H \right)^{\frac{\varepsilon}{\varepsilon-1}} \qquad [21],$$

implying that the price index of domestically produced goods is defined as

$$P_{H,t} \equiv \left(\int_0^1 P_{H,t}(j_H)^{1-\varepsilon} dj_H \right)^{\frac{1}{1-\varepsilon}} \qquad [22].$$

The makers of domestic brands maximise

$$P_{H,t}\left(\int_0^1 Y_{H,t}(j_H)^{\frac{\varepsilon-1}{\varepsilon}} dj_H\right)^{\frac{\varepsilon}{\varepsilon-1}} - \int_0^1 P_{H,t}(j_H)Y_{H,t}(j_H)dj_H \to \max.$$

This yields a demand curve for each good

$$Y_{H,t}(j_H) = \left(\frac{P_{H,t}(j_H)}{P_{H,t}}\right)^{-\varepsilon} Y_{H,t} \qquad [23].$$

Each firm faces Calvo price rigidity, thus, at each period, fraction $1 - \theta$ of firms reset their prices, whereas the remaining fraction θ keep their prices unchanged. In this way, θ represents price stickiness. Assuming that all the firms resetting prices will choose the same price $\overline{P}_{H,t}$, the aggregate price level takes the following form:

$$P_{H,t} = \left[\theta(P_{H,t-1})^{1-\varepsilon} + (1-\theta)(\overline{P}_{H,t})^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \qquad [24]$$

or in log-linear terms

$$\pi_{H,t} = (1-\theta)(\overline{p}_{H,t} - p_{H,t-1}) \qquad [25].$$

Imported brands. There is also a continuum of firms $j_i \in [0, 1]$, which import a homogeneous intermediate foreign good to produce another differentiated good $Y_{i,t}(j_i)$. Thus, $Y_{i,t}$ is CES composite of individual "brands" of imported inputs, each brand being produced by imperfectly competitive foreign country's i firm $j_i \in [0, 1]$. The solution of imported brand makers' problem yields total expenditure on goods imported from country i defined as $P_{i,t}Y_{i,t}$.

1.5 Retailers

Retailers combine domestic brands of intermediate goods $Y_{H,t}$ and imported intermediate goods $Y_{F,t}$ to form a final good Y_t. They operate in a perfectly competitive market using the following CES production function:

$$Y_t = \left[(1-\alpha)^{\frac{1}{\eta}} Y_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} Y_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \qquad [26].$$

Cost minimisation entails the following demand curves for $Y_{H,t}$ and $Y_{F,t}$:

$$Y_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} Y_t \qquad [27],$$

$$Y_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} Y_t \qquad [28].$$

Plugging equations [27] and [28] into equation [26] yields equation for the CPI:

$$P_t \equiv \left[(1-\alpha)(P_{H,t})^{1-\eta} + \alpha(P_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}} \quad [29].$$

1.6 Identities between Inflation, Exchange Rates and Terms of Trade

Further, several identities linking inflation, exchange rates and terms of trade are defined. Bilateral terms of trade between country *i* and the domestic economy are given by

$$S_{i,t} = \frac{P_{i,t}}{P_{H,t}}.$$

Consequently, the effective terms of trade are defined as

$$S_t \equiv \frac{P_{F,t}}{P_{H,t}} = \left(\int_0^1 S_{i,t}^{1-\gamma} di\right)^{\frac{1}{1-\gamma}}.$$

Log-linearisation of CPI equation [29] gives

$$p_t \equiv (1-\alpha)p_{H,t} + \alpha p_{F,t} = p_{H,t} + \alpha s_t \quad [30],$$

implying that domestic inflation and CPI inflation are related in the form

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \quad [31].$$

It can be shown that under the assumption that relative PPP holds, the relationship linking CPI inflation, foreign inflation, exchange rate, and terms of trade obeys

$$\pi_t = \Delta q_t - (1-\alpha)\Delta s_t + \pi_t^* \quad [32].$$

1.7 Housing Producers

Housing production firms take final goods, transform them into housing using linear technology, and sell the housing at price G_t. It is assumed that housing producers invest in housing to replace depreciation, thus housing investment I_t^H is given in the following stationary form:

$$\tilde{I}_t^H = \tilde{G}_t \delta^H H_{t-1} \quad [33]$$

or in log-linearised form

$$\tilde{i}_t^H = \tilde{g}_t + h_{t-1} \quad [34].$$

1.8 Domestic Interest Rates

In contrast to the conventional Taylor rule, which defines the reaction function of policy rate, in this specification the policy rate is implicitly captured by domestic mortgage rate r_t

$$r_t = \rho_R r_{t-1} + (1-\rho_R)[\psi_1 \pi_t + \psi_2 \tilde{y}_t + \psi_3 \Delta q_t] + \varepsilon_t^R \quad [35]$$

where ψ_1, ψ_2, $\psi_3 \geq 0$, and ε_t^R stands for an exogenous domestic interest rate shock. The effect on domestic rate in equation [35] comes from several sources. First, it is affected by the central bank's reaction to movements in CPI, as well as output and exchange rate deviations from the target levels. Second, as the focus is on the asset channel and role of credit constraints, we use mortgage rate data for r_t in the estimation. Due to the prevalence of loans in euro in the domestic loan portfolio, the main contribution to r_t is accounted for by the euro mortgage rate and is expected to reflect high persistence in ρ_R. Third, r_t should also capture the bank risk premium, which thereby affects the economy through the lending channel.

1.9 Market Clearing Conditions

Domestic output $\widetilde{Y}_t$ can be consumed domestically, invested or exported

$$\widetilde{Y}_t = \widetilde{C}'_t + \widetilde{C}''_t + \widetilde{C}_t^E + \widetilde{I}_t^H + \widetilde{Y}_{H,t}^F - \widetilde{Y}_{F,t} \qquad [36]$$

where $\widetilde{Y}_{H,t}^F$ stands for stationary domestic exports and $\widetilde{Y}_{F,t}$ for domestic imports. Making use of the definition of openness α, which captures the share of imports in domestic output, equation [36] can be rewritten in log-linear form as

$$\widetilde{Y}\widetilde{y}_t = \frac{1}{1+\alpha}\left(\widetilde{C}'\widetilde{c}'_t + \widetilde{C}''\widetilde{c}''_t + \widetilde{C}^E\widetilde{c}_t^E + \widetilde{I}^H\widetilde{i}_t^H + \widetilde{Y}_H^F\widetilde{y}_{H,t}^F\right) \qquad [37].$$

Meanwhile, the economy-wide housing supply H_t equals the demand by entrepreneurs H_t^E, patient households H'_t, and impatient households H''_t

$$Hh_t = H^E h_t^E + H'h'_t + H''h''_t \qquad [38].$$

The domestic loan market condition implies that the total borrowed funds are equal to the funds lent out by patient households:

$$\widetilde{B}\widetilde{b}_t + \widetilde{B}''\widetilde{b}_t'' = -\widetilde{B}'\widetilde{b}_t' \qquad [39].$$

Finally, the trade balance equals net saving of the domestic economy, so that

$$\frac{P_{H,t}}{P_t}\widetilde{Y}_{H,t}^F - \frac{P_{F,t}}{P_t}\alpha\widetilde{Y}_t = Q_t\zeta_{t-1}R_{t-1}^*\widetilde{B}_{t-1}^*\frac{P_{t-1}A_{t-1}}{P_tA_t} - Q_t\widetilde{B}_t^*.$$

Log-linearising and using the terms of trade and CPI equations gives:

$$\frac{P_H}{P}\widetilde{Y}_H^F(\widetilde{y}_{H,t}^F - \alpha s_t) - \frac{P_F}{P}\alpha\widetilde{Y}((1-\alpha)s_t + \widetilde{y}_t)$$

$$= Q\zeta R^*\widetilde{B}^*(q_t + \varsigma_{t-1} + r_{t-1}^* + \widetilde{b}_{t-1}^* - \pi_t - \Delta a_t) - Q\widetilde{B}^*(q_t + \widetilde{b}_t^*) \qquad [40].$$

1.10 Complete Log-linearised Model

Finally, we provide a brief overview of the key final log-linearised equations of the model which we will use for estimation

Patient households

$$\tilde{c}'_t = \beta'(1-\delta^H)E_t\{\tilde{c}'_{t+1}\} + \frac{1}{\sigma}\left(\tilde{g}_t - \beta'(1-\delta^H)E_t\{\tilde{g}_{t+1}\} + \left(1-\beta'(1-\delta^H)\right)\delta h'_t\right) \quad [41],$$

$$\frac{\tilde{C}'}{\tilde{Y}}\tilde{c}'_t + \frac{\tilde{G}H'}{\tilde{Y}}\left(h'_t - (1-\delta^H)h'_{t-1} + \delta^H\tilde{g}_t\right) + \frac{Q\tilde{B}^*}{\tilde{Y}}\left(q_t\left(\frac{1}{\beta'}-1\right) + \frac{1}{\beta'}\tilde{b}^*_{t-1} - \tilde{b}^*_t + \frac{1}{\beta'}\left(\varsigma_{t-1} + r^*_{t-1} - \pi_t - \Delta a_t\right)\right)$$
$$+\frac{\tilde{B}'}{\tilde{Y}}\frac{1}{\beta'}(r_{t-1} + \tilde{b}'_{t-1} - \beta'\tilde{b}'_t - \pi_t - \Delta a_t) = \kappa(1-\nu)\tilde{\psi}(\tilde{y}_t + \hat{\tilde{\psi}}_t) \quad [42],$$

$$\tilde{c}'_t = E_t\tilde{c}'_{t+1} - \frac{1}{\sigma}\left(r_t - E_t\pi_{t+1}\right) + \frac{1}{\sigma}E_t\Delta a_{t+1} \quad [43],$$

$$r_t - r^*_t = E_t\{\Delta q_{t+1}\} + \varsigma_t = E_t\{\Delta q_{t+1}\} + \varsigma_b\tilde{b}^*_t + \varepsilon^\zeta_t \quad [44],$$

$$\varsigma_t = \varsigma_b\tilde{b}^*_t + \varepsilon^\zeta_t \quad [45].$$

Impatient households

$$\tilde{c}''_t = \frac{s'}{(1-s'')}E_t\tilde{c}''_{t+1} + \frac{1}{\sigma(1-s'')}\left[\tilde{g}_t - (s'+s'')E_t\tilde{g}_{t+1} - s''E_t\Delta a_{t+1} - s''E_t\pi_{t+1} + s''r_t + \left(1-s''-s'\right)\delta h''_t\right] \quad [46],$$

$$\frac{\tilde{C}''}{\tilde{Y}}\tilde{c}''_t + \frac{\tilde{G}H''}{\tilde{Y}}\left(h''_t - (1-\delta^H)h''_{t-1} + \delta^H\tilde{g}_t\right) + \frac{\tilde{B}''}{\tilde{Y}}\frac{1}{\beta'}(r_{t-1} + \tilde{b}''_{t-1} - \beta'\tilde{b}''_t - \pi_t - \Delta a_t) = (1-\kappa)(1-\nu)\tilde{\psi}(\tilde{y}_t + \hat{\tilde{\psi}}_t) \quad [47],$$

$$\tilde{b}''_t = \tilde{g}_{t+1} + h''_t + \pi_{t+1} + \Delta a_{t+1} - r_t + \varepsilon^{b''}_t \quad [48].$$

Entrepreneurs

$$\tilde{c}^E_t = E_t\tilde{c}^E_{t+1} + \frac{1}{\sigma(1-p'')}\left[\tilde{g}_t - (p'+p'')E_t\tilde{g}_{t+1} - p''E_t(\Delta a_{t+1} + \pi_{t+1} - r_t) - \left(1-p'-p''\right)E_t(\hat{\tilde{\psi}}_{t+1} + \tilde{y}_{t+1} - h^E_t)\right] \quad [49],$$

$$\tilde{y}_t = \left(\frac{1+\varphi}{\varphi+\nu}\right)\nu h^E_{t-1} + \left(\frac{1-\nu}{\varphi+\nu}\right)\hat{\tilde{\psi}}_t - \frac{\sigma\left(\kappa(1-\nu)\tilde{c}'_t + (1-\kappa)(1-\nu)\tilde{c}''_t\right)}{\varphi+\nu} \quad [50],$$

$$\tilde{b}_t = \tilde{g}_{t+1} + h^E_t + \pi_{t+1} + \Delta a_{t+1} - r_t + \varepsilon^b_t \quad [51],$$

$$\tilde{\psi}\nu(\tilde{y}_t + \hat{\tilde{\psi}}_t) = \frac{\tilde{C}^E}{\tilde{Y}}\tilde{c}^E_t + \frac{\tilde{G}H^E}{\tilde{Y}}\left(h^E_t - (1-\delta^H)h^E_{t-1} + \delta^H\tilde{g}_t\right) + \frac{\tilde{B}}{\tilde{Y}}\frac{1}{\beta'}(r_{t-1} + \tilde{b}_{t-1} - \beta'\tilde{b}_t - \pi_t - \Delta a_t) \quad [52].$$

Housing investment

$$\tilde{i}_t = h_{t-1} + \tilde{g}_t + \varepsilon^i_t \quad [53].$$

Inflation

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \alpha\beta E_t\{\Delta s_{t+1}\} + \alpha\Delta s_t + \frac{(1-\theta)(1-\beta\theta)}{\theta}(\hat{\tilde{\psi}}_t + \alpha s_t) \quad [54].$$

Domestic interest rates

$$r_t = \rho_R r_{t-1} + (1-\rho_R)[\psi_1\pi_t + \psi_2\tilde{y}_t + \psi_3\Delta q_t] + \varepsilon^R_t \quad [55].$$

Market clearing conditions

$$\widetilde{y}_t = \frac{1}{1+\alpha}\left(\frac{\widetilde{C}'}{\widetilde{Y}}\widetilde{c}_t' + \frac{\widetilde{C}''}{\widetilde{Y}}\widetilde{c}_t'' + \frac{\widetilde{C}^E}{\widetilde{Y}}\widetilde{c}_t^E + \frac{\widetilde{I}^H}{\widetilde{Y}}\widetilde{i}_t^H + \frac{\widetilde{Y}_H^F}{\widetilde{Y}}\widetilde{y}_{H,t}^F\right) \quad [56],$$

$$\frac{GH}{\widetilde{Y}}h_t = \frac{GH^E}{\widetilde{Y}}h_t^E + \frac{GH'}{\widetilde{Y}}h_t' + \frac{GH''}{\widetilde{Y}}h_t'' + \varepsilon_t^h \quad [57],$$

$$\frac{\widetilde{B}}{\widetilde{Y}}\widetilde{b}_t + \frac{\widetilde{B}''}{\widetilde{Y}}\widetilde{b}_t'' = -\frac{\widetilde{B}'}{\widetilde{Y}}\widetilde{b}_t' \quad [58],$$

$$\frac{P_H}{P}\frac{\widetilde{Y}_H^F}{\widetilde{Y}}(\widetilde{y}_{H,t}^F - \alpha s_t) - \frac{P_F}{P}\alpha((1-\alpha)s_t + \widetilde{y}_t) = \frac{Q\widetilde{B}^*}{\widetilde{Y}}\frac{1}{\beta'}(q_t + \varsigma_{t-1} + r_{t-1}^* + \widetilde{b}_{t-1}^* - \pi_t - \Delta a_t) - \frac{Q\widetilde{B}^*}{\widetilde{Y}}(q_t + \widetilde{b}_t^*) \quad [59].$$

Law of one price

$$\pi_t = \Delta q_t - (1-\alpha)\Delta s_t + \pi_t^* \quad [60].$$

Shock processes

$$s_t = \rho_s s_{t-1} + \varepsilon_t^s \quad [61],$$

$$\Delta a_t = \rho_a \Delta a_{t-1} + \varepsilon_t^a \quad [62],$$

$$r_t^* = \rho_{r^*} r_{t-1}^* + \varepsilon_t^{r^*} \quad [63],$$

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_t^{\pi^*} \quad [64].$$

Exclusion of technology trend from observed data

$$gy\_obs_t = \Delta a_t + \widetilde{y}_t - \widetilde{y}_{t-1} \quad [65],$$

$$gg\_obs_t = \Delta a_t + \widetilde{g}_t - \widetilde{g}_{t-1} + \pi_t \quad [66],$$

$$gb'\_obs_t = \Delta a_t + \pi_t + \widetilde{b}_t' - \widetilde{b}_{t-1}' \quad [67],$$

$$gi\_obs_t = \Delta a_t + \widetilde{i}_t - \widetilde{i}_{t-1} \quad [68]$$

where

$$s' \equiv \beta''(1-m'')(1-\delta^H) \quad [69],$$

$$s'' \equiv m''\beta'(1-\delta^H) \quad [70],$$

$$p' \equiv \beta(1-m)(1-\delta^H) \quad [71],$$

$$p'' \equiv m\beta'(1-\delta^H) \quad [72].$$

Equation [41] represents housing demand of patient households where the expected consumption change is positively related to the expected change in housing prices. Budget constraint of patient households is captured by equation [42], implying that the sum of consumption expenses, costs of housing purchase, and interest payments for funds borrowed abroad should be equal to the income from domestic loan interest payments and wage earnings. Equation [43] reflects inter-temporal consumption where current consumption is positively related to the expected technology growth and negatively to the real domestic interest rate.[3]

The UIP condition in equation [44] shows that the changes in the exchange rate and risk premium account for a difference between the domestic and foreign interest rates. Risk premium in equation [45] depends on net foreign asset position: the more foreign funds are borrowed by the economy, the higher the risk premium reflecting investors' expectations about solvency of the domestic economy is.

Equation [46] presents the impatient households' housing demand, implying that the expected consumption change is positively related to the expected change in housing prices and productivity. Since the impatient households can borrow an amount which does not exceed a definite share of housing value, the demand for housing also depends on the domestic real interest rate. Budget constraint equation [47] for impatient households states that expenses for consumption, purchase of housing, and interest payments for domestically borrowed funds are equal to wage earnings (to get rid of wages and labour in the model, we equated labour supply and demand conditions; therefore wage earnings appear implicitly in the constraint via the production function). Equation [48] is impatient households' borrowing constraint implying that the amount borrowed is capped by a certain share of discounted future value of housing.

Equation [49] is entrepreneurial housing demand. An expected consumption change is related to expected output, expected change in housing prices and productivity positively and to the real domestic interest rate – negatively. Production function [50] shows that the output produced depends on the volume of entrepreneurial housing and shares of labour of patient and impatient households. Wage expenses are derived from household consumption and marginal costs of production. Entrepreneurial borrowing constraint equation [51] states that the amount of borrowed funds cannot exceed a certain share of the real future discounted value of entrepreneurial property. The budget constraint equation [52] shows that the sum of expenses for entrepreneurial consumption, housing purchase, and interest payments is equal to the value of output produced.

Housing investment equation [53] states that housing producers invest in housing to replace depreciation such that the total housing stock is constant.

The open economy New Keynesian Phillips curve in equation [54] defines CPI inflation as a function of inflation expectations, present and expected changes in terms of trade as well as real marginal costs. The terms of trade term in the Phillips curve equation shows that a part of total consumption is imports, whereas the effect of marginal costs on inflation depends on the deep parameters – price stickiness and entrepreneurial discount factor.

Equation [55] implies that the effect on domestic rate comes both from the central bank's reaction to movements in CPI, output and exchange rate deviations from the target levels and via foreign rate in UIP in equation [44].

[3] Here and hereinafter in the text, the domestic interest rate is a weighted average mortgage rate of impatient households and entrepreneurs, where the main contribution refers to the euro mortgage rate.

The market clearing condition in equation [56] states that domestic output aggregates domestic consumption of households and entrepreneurs, investment and net exports. Housing market equilibrium defined by equation ([57] implies that total housing supply is equal to housing demand of households and entrepreneurs. Domestic loan market equilibrium equation [58] shows that borrowed funds of impatient households and entrepreneurs are equal to loans supplied by patient households.

Equation [59] reflects external equilibrium implying that trade balance is equal to net savings of the domestic economy.

The law of one price in equation [60] links CPI to foreign inflation and changes in the exchange rate and terms of trade.

In equations [61]–[64], we add exogenous shocks to first order autoregression processes of terms of trade, technology growth, foreign interest rate and foreign inflation.

Equations [65]–[68] define the observed time series for output, housing price, domestic mortgage loans, and housing investment, respectively, with the corresponding model counterparts. The technology trend is defined in output equation [65] stating that the output growth is entirely determined by technological progress. Housing price, borrowing and investment time series are de-trended before estimation.

Expressions [69]–[72] are notational simplifications.

2. EMPIRICAL ESTIMATES

2.1 Data Description

Quarterly observations on real output growth, nominal domestic interest rates, nominal foreign interest rates, consumer price index, terms of trade, real housing price growth, nominal exchange rate, borrowing growth and growth in housing investment are used in this empirical analysis. All data are at quarterly frequencies for the period from the first quarter of 1999 to the second quarter of 2009. Year 1999 is chosen as the starting point of the series due to availability of housing price statistics.

Output growth is calculated as log-differences of seasonally adjusted real GDP series. Nominal domestic interest rate is mortgage rate, and nominal foreign interest rate is 3 month EURIBOR. Inflation is defined as CPI log-differences. Terms of trade are log-differences of import to export price index ratios. For exchange rate series, we take the average of commercial banks' bid and ask rates of the lats to SDR up to December 2004 and of the lats to EUR afterwards. Deviations of exchange rates from the SDR and EUR parity levels in the respective periods are calculated as log-differences of exchange rate and parity levels.

Real housing price growth series is a log-difference of real housing prices. Real investment growth is a log-difference of seasonally adjusted series for non-financial investment in residential buildings and other buildings and structures. Nominal borrowing growth is a log-difference of mortgage loans granted to entrepreneurs and households.

2.2 Calibrated Parameters

There are several calibrated parameters in the model: discount factors β, β', β'', risk aversion parameter σ, weight on housing in the household's utility function δ, slope of household's labour supply function φ, housing depreciation rate δ^H, openness α, and frictionless markup Λ.

The calibrated parameter values are shown in Table 1. We set the discount factor of patient agents β' to 0.952, implying a steady-state annual interest rate R of 5%. The discount factor β of entrepreneurs is set to 0.943 implying an average 6% annual interest rate. The impatient agents' discount factor β'' is fixed at 0.925, which corresponds to an average 8.16% annual interest rate for household housing loans over the period. The depreciation rate for housing δ^H is set to 0.05. The parameter describing disutility from work φ is set to 2, following L. J. Christiano et al. (2007). We assume the frictionless markup to be 1.04. The risk aversion parameter σ is set to 1, which corresponds to log utility function and ensures the model solution. The openness parameter is set to 0.5 which corresponds to the average value over the estimation period.

When solving for the steady state, we check compatibility of the chosen parameter values with the steady state big ratios used in the model.

Table 1
Calibrated parameters

Description	Parameter	Value
Patient households discount factor	β'	0.952
Impatient households discount factor	β''	0.925
Entrepreneurial discount factor	β	0.943
Risk aversion	σ	1
Weight on housing services in the utility function	δ	1
Labour supply aversion	φ	2
Housing depreciation rate	δ^H	0.05
Openness	α	0.50
Frictionless markup	Λ	1.043

2.3 Choice of Priors

Table 2 provides information about the priors for Latvia. Prior distributions are assumed to be independent. The prior for technology process ρ_a and priors for policy rule parameters ψ_1, ψ_2, ψ_3 are Bayesian estimates for Latvia obtained in the previous studies of the Bank of Latvia (V. Ajevskis, K. Vītola (2)). To choose smoothing parameters for domestic and foreign interest rates, terms of trade, and foreign inflation, we run AR(1) to time series of the respective variables. The prior for Calvo price stickiness θ is set to 0.4 implying an average duration of price stickiness of 1.7 quarters. Initial values of v and κ are set to align with the steady state big ratios. We assume a prior value of 0.2 for elasticity of foreign risk premium ς_b and 0.5 for loan-to-value of entrepreneurs and constrained agents (m, m'' respectively).

The priors of individual shocks are very intuitive; therefore, we allow for a wide distribution of shock values.

3. RESULTS

3.1 Posterior Estimates

The Bayesian posterior estimates of structural parameters for Latvia are reported in Table 2. In addition to 90% posterior probability intervals, we report posterior means as point estimates.[4]

The posterior coefficient for the probability of fixed price appears lower than its prior mean, implying that entrepreneurs change their prices every 1.2 quarters, which is in line with inflation dynamics observed over the estimation period. The housing factor share takes a value of 0.3, thus 70% of output is determined by labour input. The estimate of wage share of patient households κ is 0.53 implying a share of labour income to credit constrained agents of about 0.47. Elasticity of foreign risk premium is lower than the prior mean, indicating that investors attach less significance to domestic economy's external debt in setting their risk premium. We observe lower persistence in the domestic interest rate compared to the foreign rate. The posterior for terms of trade shows higher persistence than the prior value, while the estimate for technology appears lower compared to the prior mean. The posteriors of policy rule inflation and output coefficients are similar to the results of V. Ajevskis and K. Vītola (2), while the estimate for ψ_3 confirms the fixed exchange rate policy pursued by the Bank of Latvia. Most posteriors are highly concentrated around their posterior mean values. This implies that overall the data are informative, and the parameter estimates are close to their true values.

Table 2

Prior distributions and posterior estimation results for Latvia

Description	Parameter	Prior distribution			Posterior distribution		
		Distribution	Mean	Standard deviation	Mean	90% interval	
1	2	3	4	5	6	7	8
Domestic interest rate, inflation	ψ_1	Gamma	1.26	0.60	1.36	0.38	2.30
Domestic interest rate, output	ψ_2	Gamma	0.03	0.02	0.03	0.00	0.07
Domestic interest rate, exchange rate	ψ_3	Gamma	44.81	20	142	109	187
Loan-to-value, entrepreneurs	m	Beta	0.50	0.10	0.49	0.36	0.67
Loan-to-value, households	m''	Beta	0.50	0.10	0.50	0.35	0.66
Probability of fixed price	θ	Beta	0.40	0.20	0.19	0.02	0.34
Real estate share, production function	ν	Beta	0.20	0.10	0.30	0.07	0.51
Patient households' wage share, production function	κ	Beta	0.50	0.20	0.53	0.14	0.90
Risk premium elasticity	ς_b	Beta	0.20	0.10	0.03	0.01	0.04

[4] We construct the posteriors using the Metropolis–Hastings algorithm with a Markov chain 500 000 observations long, running 3 MH blocks. All estimation was conducted using Dynare 4, in Matlab R2008a.

1	2	3	4	5	6	7	8
AR, domestic interest rate	ρ_R	Beta	0.80	0.10	0.45	0.32	0.60
AR, technology	ρ_a	Beta	0.61	0.30	0.39	0.12	0.66
AR, terms of trade	ρ_s	Beta	0.78	0.09	0.86	0.74	0.97
AR, foreign inflation	$\rho_{\pi*}$	Beta	0.50	0.20	0.49	0.17	0.77
AR, foreign interest rate	ρ_{R*}	Beta	0.70	0.10	0.65	0.51	0.83
Standard deviation, technology shock	σ_a	InvGamma	1.72	0.80	0.46	0.41	0.52
Standard deviation, domestic interest rate shock	σ_R	InvGamma	1.95	1.00	0.81	0.62	1.02
Standard deviation, terms of trade shock	σ_s	InvGamma	2.12	1.00	0.57	0.50	0.64
Standard deviation, foreign interest rate shock	σ_{r*}	InvGamma	0.32	0.20	0.07	0.06	0.08
Standard deviation, risk premium shock	σ_ς	InvGamma	0.50	0.30	0.12	0.10	0.13
Standard deviation, impatient households' borrowing shock	$\sigma_{b''}$	InvGamma	0.50	0.30	0.31	0.19	0.50
Standard deviation, entrepreneurs' borrowing shock	σ_b	InvGamma	0.50	0.30	0.23	0.18	0.28
Standard deviation, housing stock shock	σ_h	InvGamma	0.50	0.30	2.34	1.91	2.79
Standard deviation, housing investment shock	σ_i	InvGamma	0.50	0.30	2.16	1.74	2.56
Standard deviation, foreign inflation shock	$\sigma_{\pi*}$	InvGamma	1.27	0.60	0.30	0.29	0.30

3.2 The Role of Borrowing Constraints and Foreign Risk Premium in Model Dynamics

To gauge the importance of individual shocks, we estimate impulse responses to one standard deviation large exogenous shocks. The impulse responses are generated for foreign interest rate, foreign risk premium, impatient households' mortgage, and terms of trade shocks for the estimated model (baseline) and the following altered models:

1) a model with tighter borrowing constraint for impatient households ($m'' = 0.35$), while keeping loan-to-value for entrepreneurs and risk premium elasticity unchanged ($m = 0.5$, $\varsigma_b = 0.026$);

2) a model with larger foreign risk premium elasticity ($\varsigma_b = 0.05$), implying that investors are more cautious in their expectations regarding solvency of the domestic economy.

The results for the baseline model are reported in Chart 1. Hereinafter, each shock is described in detail.

3.2.1 Foreign Interest Rate Shock

Foreign interest rate shock (ε^{r^*}) raises cost of foreign borrowing thus dampening foreign capital inflow and domestic lending. Due to euro dominance in the domestic loan portfolio, rising EURIBOR largely accounts for an increase in domestic mortgage rates. Lower lending through the credit channel dampens household and entrepreneurial consumption. Housing price drop decreases housing market profitability thus discouraging housing investment. The negative effect of foreign monetary shock on constrained households' loans, housing prices and investment persists for 1.5 years; as to entrepreneurial loans, consumption, and real estate demand, the effect endures for more than 3 years.

Tighter borrowing constraint (first scenario) weakens the transmission of foreign monetary shock to constrained households' consumption, mortgage loans, and initially to demand for housing.

Higher risk premium elasticity (second scenario) lessens the effect of monetary transmission on the domestic economy. An increase in total cost of financing (interest rate plus risk premium) makes it harder for patient households to borrow from abroad, thereby decreasing the amount of loans available for entrepreneurs and credit constrained households. A lesser amount of available loans implies a smaller effect from foreign monetary shock on housing prices and investment. The effect on housing demand is smaller for all three agents of the economy compared to the baseline case.

3.2.2 Foreign Risk Premium Shock

A direct shock to the risk premium implies that foreign investors are less willing to take risk and thus apply a higher risk premium to their loans.

The effect of risk premium shock (ε^{ζ}) is similar to foreign interest rate shock: it raises the price of foreign debt service and results in higher domestic mortgage rates, thereby discouraging domestic private sector crediting. Due to a lower mortgage demand, housing prices and housing investment decline. This, in turn, results in lower household and entrepreneurial consumption through credit and wealth channels. Less borrowing and the declining housing prices also lead to redistribution of housing demand by decreasing the entrepreneurial and constrained households' share and increasing the unconstrained households' housing demand.

The main result of including risk premium frictions is a credit crunch effect. Foreign investors, now less confident in the local economy, start to call in loans. To pay off foreign creditors, the patient agents, i.e. the lenders in the economy, call in debts from firms and impatient agents. Debt levels fall, and the demand for investment in housing weakens further.

Shock patterns for all three scenarios are very similar: the rise of domestic mortgage rates decreases the demand for housing loans, housing prices, and housing investment. Lower housing wealth results in smaller consumption. The borrowing and housing demand difference between scenarios is similar to the one described for the foreign interest rate shock. In the tighter credit constraint scenario, the effect on mortgage loans and housing demand for impatient households is lower compared to the baseline case. In the case of higher risk premium elasticity, monetary transmission to domestic variables is less pronounced than in the baseline case.

3.2.3 Constrained Households' Borrowing Shock

Impatient households' positive credit shock ($\varepsilon^{b''}$) implies an increase in the total volume of loans, albeit at the expense of reduced entrepreneurial lending. More loans to constrained households drive consumption and housing demand, whereas less borrowing subdues real estate demand of entrepreneurs. Due to these counteracting effects, housing price changes are short-lived. Overall, the effect of credit shocks on domestic mortgage rates, housing prices, and investment fades away in a year.

Under lower production capacity (real estate input), the output, exports, and marginal costs decline. According to the external balance condition, the declining exports drive foreign borrowing, which results in higher risk premium.

The impulse responses for different scenarios show that the effect of tighter credit constraint scenario stands out from the other two. Since the effect of a positive credit shock is constrained by lower loan-to-value, entrepreneurial borrowing shrinks to a lesser extent vis-á-vis the baseline case. This explains a smaller shock effect on all variables compared to the baseline scenario.

The impulse responses under higher risk premium elasticity and baseline scenarios are very similar, since the effect of observed temporary credit supply shock on the domestic mortgage rate is negligible.

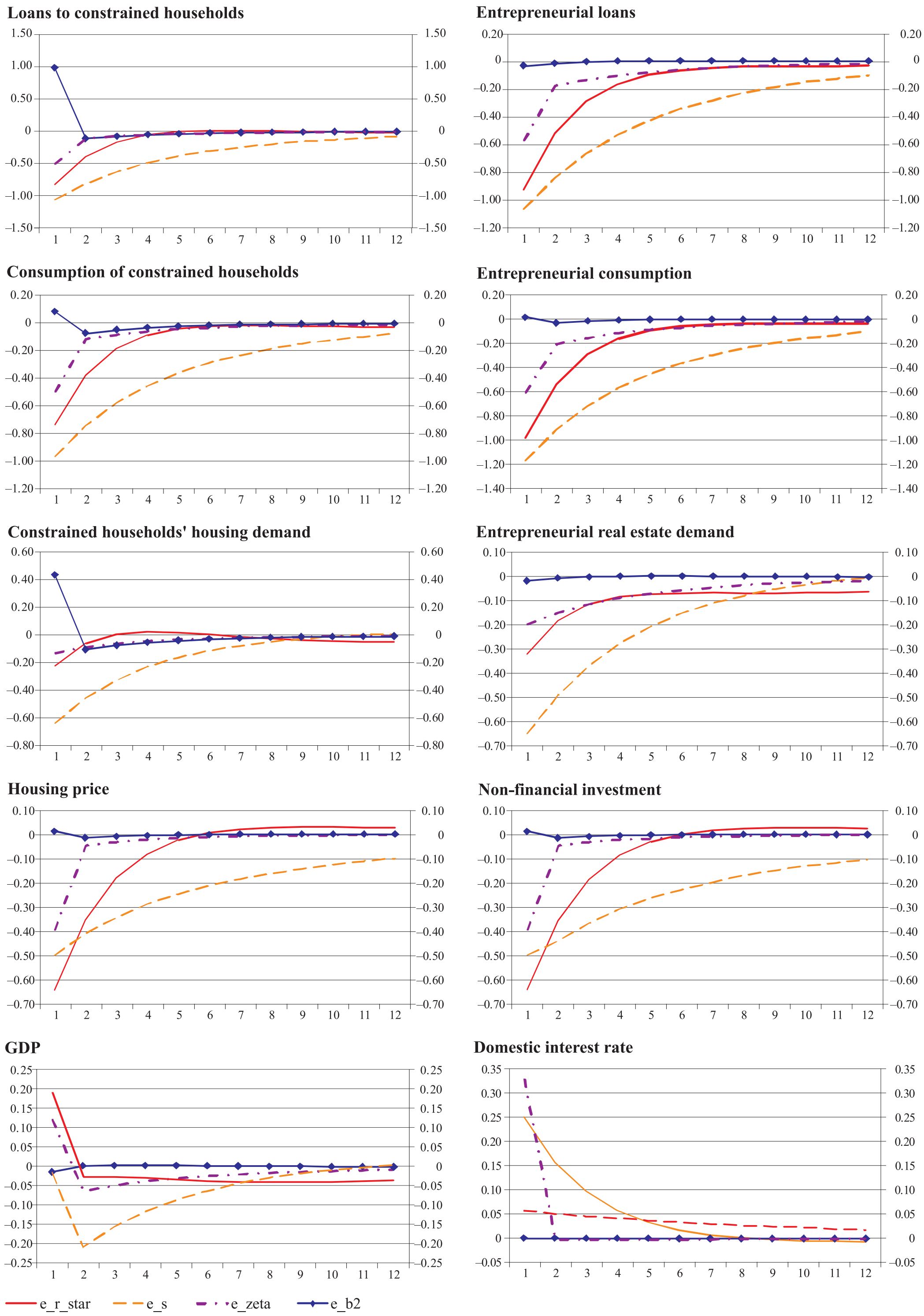
3.2.4 Terms of Trade Shock

A positive terms of trade shock (ε^{s}) implies a temporal increase in the import and export price ratio, which after two quarters translates into inflation. Inflation subdues consumption and thus the total output entailing a decrease in the domestic activity. Lower income dampens constrained households' and entrepreneurial demand for mortgage loans and housing, thus inducing a housing price decline. Falling prices discourage housing investment due to lower returns.

As prices decline, the unconstrained agents increase their demand for real estate by borrowing abroad, thus entailing a rise in risk premium. Given the exchange rate targeting, a higher risk premium tends to increase the domestic rate via UIP. Due to credit constraints, household and entrepreneurial consumption, housing demand, prices and investment return to the initial path in 3–4 years.

Chart 1

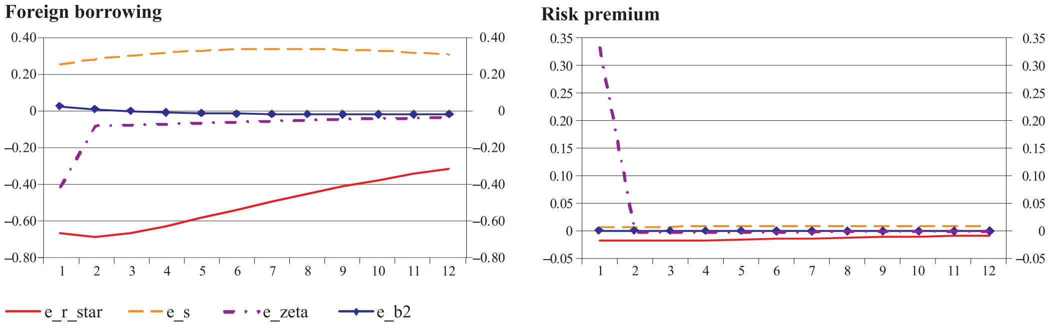
Impulse responses to shocks for estimated (baseline) model



Notes: e_r_star is the foreign interest rate shock (ε^{r*}); e_s – terms of trade shock (ε^{s}); e_zeta – risk premium shock (ε^{ζ}); e_b2 – impatient households' credit shock ($\varepsilon^{b''}$).

Chart 1 (cont.)

Impulse responses to shocks for estimated (baseline) model



Notes: e_r_star is the foreign interest rate shock (ε^{r^*}); e_s – terms of trade shock (ε^{s}); e_zeta – risk premium shock (ε^{ζ}); e_b2 – impatient households' credit shock ($\varepsilon^{b''}$).

CONCLUSIONS

In this paper we develop and estimate a small open economy DSGE model for Latvia using Bayesian approach. Our model extends M. Iacoviello (9) model along 3 dimensions. First, we introduce open-economy features into this closed economy framework to make the model a better characterisation of the Latvian economy. Second, we relax the assumption of a fixed housing stock, allowing for investment in structures. Third, we assume that there is premium on foreign loans which depends on the aggregate net foreign asset position of the domestic households.

Apparently, a model with entrepreneurial and household financial frictions responds to shocks differently compared to a framework that ignores them. The advantage of allowing for open economy features is the ability to examine the effects of external shocks on domestic indicators, while financial frictions track the power of these effects in monetary transmission. The inclusion of housing investment allows for considering the role of residential construction in the business cycle and its interaction with financial frictions.

We find that in the case of tighter credit constraints (lower loan-to-value ratio) the transmission of shocks is less pronounced; overall, the scenario restrains borrowing, housing demand and consumption of the credit constrained households but has no pronounced effect on the total output.

The main implication of higher risk premium elasticity is the restricting effect of various shocks on foreign borrowing. In the case of foreign interest rate and risk premium shocks, higher risk premium elasticity lessens the effect of monetary transmission on domestic economy through higher cost of external funds. In the case of constrained households' positive credit shock, the impulse responses under higher risk premium elasticity and baseline scenarios are very similar due to the negligible effect on the domestic mortgage rate.

The terms of trade shock compared to other shocks has the most permanent impact on domestic loans, consumption, housing demand, prices, and investment which return to the initial path in 3–4 years due to credit constraints. The effect of foreign interest rate and risk premium shocks on constrained household loans, housing prices and investment fades away in 1.5 years.

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