A Macro-Financial Theory of Hungary's CSOK

by

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Abstract

This thesis examines the effect of a recently introduced Hungarian public policy, the Family Housing Support Program (the so-called CSOK) on the Hungarian credit and housing market. Using a DSGE model similar to Forlati and Lambertini (2011), it focuses on the interaction between the two actors in this economy, lenders and borrowers, and estimates the effect of CSOK on key housing market variables, while compares these results to a theoretical setting in which CSOK has not been initiated. By doing so, this model predicts the reaction of the Hungarian credit and housing market to exogenous shocks with and without this policy change. The main findings show that CSOK amplifies the reactions of the housing market variables, thus when the mortgage market becomes riskier, house prices fall deeper, borrowers decrease their housing stock and consumption, while a larger share of borrowers lose their houses because they default on their mortgages. These results have a crucial policy implication: given that CSOK makes the Hungarian credit and housing market more volatile, a potential global crisis would leave the Hungarian markets in a more vulnerable situation.

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1 Introduction

In the western world, many countries suffer from the problem of an aging society. In 2015, the Hungarian government (FIFESZ) introduced a considerable housing allowance package with the aim of solving this social and economic issue. This policy is called Family Housing Support Program (CSOK), where CSOK stands for an abbreviation formed from the initial letters of the Hungarian name of the policy: Családi Otthonteremtési Kedvezmény. This program aims to encourage young couples to bring more children into the world with different forms of family housing allowances. It offers a non-refundable subsidization that can be used for a) building or purchasing a newly built dwelling or b) renovating or purchasing a second-hand apartment. There are different thresholds to the amount of subsidy depending on number of children. Categories and elements of the CSOK policy are presented in Table 1.1.

Children	New dwelling		Old dwelling		Subsidized Loans
	Allowance (Million HUF)	Minimum Size (m^2)	Allowance (Million HUF)	Minimum Size (m^2)	(Million HUF)
1	0.6	Apartment:40, House:70	0.6	Apartment:40	0
2	2.6	Apartment:50, House:80	1.43	Apartment:50	10
3	10	Apartment:60, House:90	2.2	Apartment:60	15
4	10	Apartment:60, House:90	2.75	Apartment:70	15

Source: kormany.hu
Table 1.1: Summary of CSOK

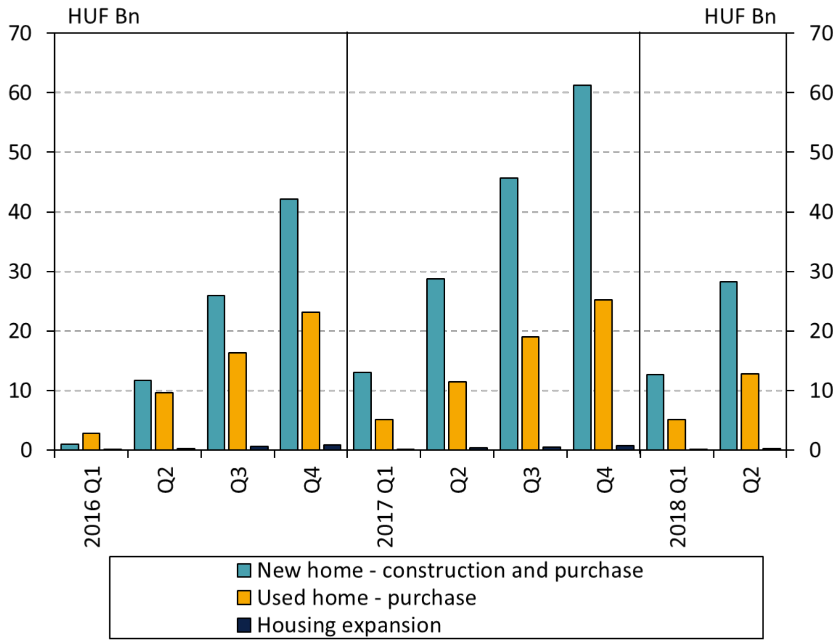
Every Hungarian couple who are either married or living together and planning to have a family are eligible for the grants. The exact amount given depends on the number of children and the size of the dwelling. A family with three or more children may be eligible to receive up to 10 million HUF for a newly built home, a family with two children may be eligible to receive 2.6 million HUF, while one-child family can apply for 600 thousand HUF. In case of purchasing old homes: a family with four children are eligible for 2.75million HUF; 2.2 million HUF for a family with three children; and so on. Married couples who have or plan on having three or more children may be eligible for a subsidized loan up to 15 million HUF at a fixed, 3 percent interest rate. Additionally, these couples can receive a value-added tax refund up to 5 million HUF on costs of building a home, and the VAT tax rate on newly built homes is reduced to 5% from 27% too, but these grants are not considered in this thesis, only the CSOK-related subsidies and subsidized loans.

The maximum amount of subsidy, 10 million HUF (approx. 34 400 USD) is a considerable subsidization given a second-hand apartment cost 11.64 million HUF in the country, and 17.39 million HUF in Budapest, a new apartment cost 17.9 million HUF in the country, and 20.4 million HUF in Budapest on average in 2015, the year CSOK was introduced[1]. Since then, dwelling prices have surged, especially in Budapest where there was a 22.9% nominal increase in house prices in 2018[2].

CSOK became quite a successful program in terms of the number of requests. Up until August 2018, OTP Bank had issued over 31000 contracts worth 96 billion HUF, the second largest distributor, Takarék Csoport, about 15000 contracts worth around 45 billion HUF while the third largest contributor K&H Bank covered 6300 contracts worth 16 billion HUF

[1]Source: KSH

[2]Housing Market Report, May 2019.



Source: MNB

Figure 1.1: Cumulative volume of contracts in the Family Housing Support Program by purpose

[3]. Figure 1.1 shows the cumulative volume of CSOK contracts by purpose. As can be seen, most of the contracts were signed for purchasing a new or used home, still, the increased demand suggests that CSOK has likely increased house prices.

In the existing literature, there are many models analysing the credit market in a dynamic general equilibrium framework. The two most influential papers are by Bernanke, Gertler, and Gilchrist (1999) and by Kiyotaki and Moore (1997). These two models form the basis of a whole field in the macro-financial literature. Kiyotaki and Moore (1997) made two important assumptions: (1) there is an imperfectly-working credit market, where loan repayment cannot be enforced, and (2) assets are no longer just a factor of production, but also serve as collateral to the loan. They showed that financial frictions amplify negative

[3]Source: MTI (Magyar Távirati Iroda).

shocks generating a deeper recession. Bernanke et al. (1999) created a tractable DSGE model which can quantitatively estimate the real effect of credit market frictions on the economy. The key assumption they made is that lenders need to pay a monitoring cost to resolve the principal-agent problem. In their model – in equilibrium – some borrowers default and loose their houses. Mortgage interest rate is larger than the risk-free interest rate, so there is an external finance premium.

After the 2008 global financial crisis, one of the most influential papers on housing market was by Iacoviello and Neri (2010). They studied housing market shocks and spillovers on the wider economy using a DSGE model estimated with Bayesian methods. This model features four important elements: 1) a multi-sector economy with housing and non-housing goods; 2) financial frictions in the household sector; 3) nominal rigidities; and 4) rich set of shocks that allow us to bring the model closer to the data. Their results match the data in that (1) they found both house prices and housing investment to be strongly procyclical and sensitive to monetary shocks; and (2) slower technological progress and the fixed amount of land accounts for the steady rise in house prices over the examined period. They also found that housing demand shocks and housing technology shocks can account for approximately 50% of the volatility in house prices and housing investment.

Based on the work of Iacoviello and Neri (2010) and Bernanke et al. (1999), Forlati and Lambertini (2011) built a multi-sector DSGE model with two kinds of households (borrowers and lenders) and two goods (non-durable consumption goods and housing stock). Lenders give one-period loans to borrowers at a state-contingent interest rate, and borrowers are exposed to idiosyncratic shocks, after which they can either pay back the loan to lenders or default. This endogenous default option is the proxy for financial frictions on the credit market. What makes this paper stand out is that they introduced idiosyncratic shocks with an AR(1) process standard deviation, hence the distribution of idiosyncratic shocks changes over each period, reflecting well the risky nature of the markets. Lambertini, Nuguer, and Uysal (2017) applied this model to US housing data with some extensions (e.g. shocks to intertemporal preferences, shocks to housing preferences and habit formation in non-durable consumption has been introduced). They successfully fitted the model to the mortgage market during the 2008-2009 global financial crisis with mortgage risk shock and negative housing demand shock. They used this model to evaluate a policy, which suggests to reduce the mortgages on the brink of default and hence stabilize the mortgage market.

Surveying the vast literature analysing the credit market in a dynamic general equilibrium framework, I concluded that there are limited DSGE models focusing on the effect of a public policy similar to CSOK as it is difficult to generalise the assumptions and specifications of these DSGE models given the highly context specific nature of each and every policy. This thesis contributes to the literature by introducing a model, specific to the Hungarian CSOK, constructed mostly from the work of (Forlati & Lambertini, 2011)and (Lambertini et al., 2017).

Since there is not enough data to evaluate whether this program has indeed increased childbirth, I rather focus on whether this policy generated an increase in house prices and mortgage loans. I use a DSGE model for qualitative analysis of the relation between CSOK and house prices and credit market risk. The aim is to show that CSOK has a considerable impact on the credit market and on the housing market.

I examine the credit and housing market in a very similar modelling framework as Forlati and Lambertini (2011) and Lambertini et al. (2017) with little extension and some simplifications. First, I introduce CSOK to the model as a money transfer between lenders and borrowers: lenders pay taxes after their loans to borrowers, and borrowers are paid state allowances from this tax revenue by the government. This is aimed to model one of the main goals of CSOK policy: to help the poorer families to get their own homes with the support of the government. Second, since the aim of this thesis is to examine the housing and credit market relation with the presence of government allowances, I simplify the models of Forlati and Lambertini (2011) and Lambertini et al. (2017) by the whole monetary policy, Calvo sticky prices and intermediate production sector blocks. I also assume that the housing stock of the economy to be constant over time, hence – unlike Forlati and Lambertini (2011) – in my model specification there are only non-durable goods producers in the market. Also, there is no construction sector in my model.

The main findings of this paper suggest that the sheer presence of such state allowances amplifies the reaction of key housing market variables when the mortgage market becomes riskier: (1) house prices fall deeper; (2) borrowers decrease their housing stock and consumption more compared to a situation in which they would have not been subject to this policy change; and (3) a larger share of borrowers lose their houses because they default on their mortgages. This result sends a critical message today, as some predict that we may be headed to another crisis in the coming years.

In the second section I explain all assumptions and equations in the model, in the third section I present the steady state calibration of the model with and without the policy, in the fourth section I present the output of the estimated model and in the last section I conclude.

2 The Model

The starting point of the model is Forlati and Lambertini (2011)'s two-sectoral endogenous default model with patient and impatient households who consume non-durable goods and housing services. Patient households give loans to impatient ones at a state-contingent interest rate. Each member in a household experiences an idiosyncratic shock after which they either pay back their loans or default. There is no commitment from the borrower's side to pay back. There are some modified assumptions in my model; contrary to Forlati and Lambertini (2011), agents work only in the non-durable sector and the housing stock level is constant over time.

2.1 Households

The population is a continuum of households distributed over [0,1], from which a fraction Ψ of households are identical borrowers with discount factor β, and fraction $1-\Psi$ households are identical lenders with discount factor $\gamma > \beta$.

2.1.1 Borrowers

Borrowers have a lifetime utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t z_t [ln(C_t - \epsilon C_{t-1}) + j_t ln H_t]$$

where C_t is the consumption of non-durables and H_t is the consumption of housing services. β is the discount factor of the borrower, z_t and j_t are shocks to intertemporal and housing preferences, ϵ is habit formation parameter. Borrowers have the following budget constraint:

$$P_{C,t}C_t + P_{H,t}H_t + [1 - F_t(\bar{\omega_t})](1 + R_{Z,t})L_{t-1} = L_t + sL_t + w_{C,t} + (1-\delta)[1 - G_t(\bar{\omega_t})]P_{H,t}H_{t-1}$$

They take loans from lenders L_t and get allowance sL_t from the government on their loans, which represents CSOK in this model. Only their housing stock serves as collateral – borrowers do not bear responsibilities personally. Borrowers also work in non-durable goods production and get wage $w_{c,t}$ per hour. Similarly to Forlati and Lambertini (2011), I assume that every loan is issued for only one period. Every household member is subject to an idiosyncratic shock to their housing stock, which is denoted by ω_{t+1}. If $\omega_{t+1}(1 -$

$\delta)P_{H,t+1}H_t > (1 + R_{Z,t+1})L_t$, then the household member is able to pay back the mortgage with interest. The threshold value of the idiosyncratic shock is $\bar{\omega}_t$, where the borrower is willing to pay back the mortgage with interest:

$$\bar{\omega}_{t+1}(1-\delta)P_{H,t+1}H_t = (1 + R_{Z,t+1})L_t$$

The state contingent interest rate, $R_{Z,t+1}$ is determined after the realization of shocks. The random variable $\bar{\omega}^i_{t+1}$ can only be observed by the borrower, the lender has to pay a monitoring cost μ to observe it and seize the collateral. This is an incentive for the borrowers to reveal their idiosyncratic shocks truthfully[1].

$[1 - F_t(\bar{\omega_t})]$ fraction of households do not default on their mortgages , where $F_t(\bar{\omega_t})$ is the CDF of $\bar{\omega_t}$; they own $(1-\delta)[1 - G_t(\bar{\omega_t})]P_{H,t}H_{t-1}$ housing stock at time t. They spend these assets on consumption of non-durables and housing services and repayment of their mortgages to lenders with interest, if they are able to do so. As in Forlati and Lambertini (2011), there are many members in a household who decide on total housing stock H_t of the household, and assign equal resources to all members to buy housing stock H^i_t so that $\int_i H^i_t di = H_t$.

There is another constraint in borrower's optimization, which is the participation constraint of the lender. Following Bernanke et al. (1999) via Forlati and Lambertini (2011), lenders agree to give one-period loans to borrowers at a pre-determined rate of return $1 + R_{L,t}$ at time t, hence they are only willing to provide loans if the following condition is satisfied:

$$(1 + R_{L,t})L_t = [\Gamma_{t+1}(\bar{\omega}_{t+1}) - \mu G_{t+1}(\bar{\omega}_{t+1})](1-\delta)p_{H,t+1}H_t{}^2$$

[1]For more detail, see Townsend (1979)

[2]Please find the derivation of this equation in Forlati and Lambertini (2011).

Γ and G functions are defined following Forlati and Lambertini (2011):

$$G_t(\bar{\omega}_t) = \int_0^{\bar{\omega}_t} \omega_t f_t(\omega) d\omega$$

$$\Gamma_t(\bar{\omega}_t) = \omega_t \int_{\bar{\omega}_t}^{\infty} f_t(\omega) d\omega + G_t(\bar{\omega}_t)$$

G is the expected value of the idiosyncratic shock conditional on that it is smaller than the threshold level, while Γ is the expected share of housing value gross of monitoring costs that goes to lenders.

Borrowers maximize their utility with respect to consumption, housing stock, loans and the endogenous default threshold, $\bar{\omega}_{t+1}$. See the first order conditions in the Appendix.

2.1.2 Lenders

Lenders have a lifetime utility function similar to borrowers, but with a larger discount factor γ:

$$U = E_0 \sum_{t=0}^{\infty} \gamma^t z_t [ln(C'_t - \epsilon C'_{t-1}) + j_t ln H'_t]$$

Their budget constraint is defined in the following:

$$C'_t + I'_t + p_{H,t} H'_t + L'_t + T_t = (1-\delta) p_{H,t} H'_{t-1} + w_{C,t} + (1 + R_{L,t-1}) L'_{t-1} + r^k_t K'_{t-1} + \Pi_{H,t}$$

where C'_t is the consumption of non-durables, H'_t is the housing stock of the lender, $p_{H,t}$ is the relative price of housing stock to non-durable goods, L'_t is the loan provided to borrowers at time t and T_t is a lumpsum tax that is used to finance CSOK allowances. Similarly to the assumptions of the borrowers, lenders work in non-durables production too for the same hourly wage, $w_{C,t}$. Another extension of this model for Forlati and Lambertini (2011) is that lenders own the capital used in production, which they lend to the firms at rate r^k_t. Lenders also own the profits of housing sector production, which is the rebuilding of depreciated housing stock. The capital accumulation equation is defined the in following way based on Lambertini et al. (2017):

$$K'_t = (1 - \delta_k)K'_{t-1} + I'_t$$

where δ_k is the depreciation rate of capital. The profits from housing sector production is:

$$(1 - \Psi)\Pi_{H,t} = p_{H,t}\delta(\Psi H_t + (1 - \Psi)H'_t)$$

Lenders maximize their utility with respect to C'_t, H'_t, L'_t and K'_t. See first order conditions in the Appendix.

2.2 Firms

There are many firms in this model working in a perfect competition setting with the same Cobb-Douglas production function:

$$F(K'_{t-1}) = A^c_t((1 - \Psi)K'_{t-1})^\alpha N_t^{1-\alpha}$$

For simplicity, I assume $N_t = 1$. Firms buy capital from lenders and use it to produce non-durable goods. Due to perfect competition, they take input prices as given, and maximize their profits with respect to capital. See first order condition and zero profit condition in Appendix.

2.3 Equilibrium

In equilibrium on the non-durables market, borrowers and lenders consume the produced non-durable goods exactly:

$$F(K'_{t-1}) = Y_t^C = \Psi C_t + (1-\Psi)C'_t + (1-\Psi)I'_t$$

Total loans provided by the lenders must equal total loans of borrowers:

$$\Psi L_t = (1-\Psi)L'_t$$

In equilibrium, lenders pay as much tax as allowances distributed to borrowers:

$$T_t = sL_t$$

And as I have already established, housing stock is assumed constant over time, normalised to 1:

$$\Psi H_t + (1-\Psi)H'_t = 1$$

2.4 Exogenous shocks

Each household member is exposed to idiosyncratic shocks. As assumed in Forlati and Lambertini (2011), these shocks are independent and identically distributed across all members of the same household with a lognormal distribution, for which the parameters were chosen such that the expected value of the shock in a household is 1:

$$ln\omega_t \sim Normal(-\frac{\sigma_{w,t}^2}{2}, \sigma_{w,t}^2)$$

$$E_t(\omega_{t+1}) = 1$$

Given that housing investment is risky, the standard deviation of the idiosyncratic shock is also an AR(1) process with an i.i.d.$(0, \sigma^2_{\sigma_w})$ distributed error term:

$$ln\frac{\sigma_{w,t}}{\sigma_w} = \rho_\sigma ln\frac{\sigma_{w,t-1}}{\sigma_w} + \epsilon_{\sigma_{w,t}}$$

There are 3 more exogenous shocks to the model: a TFP shock to non-durable goods production A^c_t, an intertemporal preference shock z_t and a preference shock to housing services j_t:

$$lnA^c_t = \rho_A lnA^c_{t-1} + \epsilon^C_t$$

$$lnz_t = \rho_z lnz_{t-1} + \epsilon^z_t$$

$$lnj_t = \rho_j lnj_{t-1} + \epsilon^j_t$$

All ϵ shocks are i.i.d. with mean zero and σ^2_A, σ^2_z and σ^2_j variances respectively and ρ_A, ρ_z and $\rho_j \in (0,1)$.

3 Steady state calibration

Turning to the steady state calibration, Table 3.1 presents the benchmark calibration with the values and the associated descriptions of parameters. I chose $\beta = 0.85$ and $\gamma = 0.87$ discount factor values, from which the latter pins down the steady state interest rate R_L. I followed Lambertini et al. (2017) in that lenders provide capital in the production sector, thus I set the rate of depreciation of capital equal to 0.025 accordingly. Therefore the rate of return to capital can be calculated: $r^k_{SS} = \frac{1}{\gamma} + \delta_k - 1$. I chose the steady state value of the standard deviation of idiosyncratic shock to be equal to 0.2, with the aim of ensuring that the Loan-to-Value ratio is close to the true 60.9%[1] average LTV ratio between 2005Q1-2018Q2 and that the default rate is close to 2%. Finally, all functions of $\bar{\omega}$ and σ_w can be calculated at the steady state: Γ, G and their partial derivatives.

I chose α to be equal to 0.33 in line with the standards in the macroeconomic literature and I used a 1% quaterly rate of depreciation of housing stock, δ. I calculated s, the proportion of subsidy in mortgage loans, by taking the proportion of CSOK-related loans in total housing loans and multiplied it with the average share of subsidy in a CSOK related loan. I took the proportion of CSOK related loans given by MNB in its latest Housing Market Report in November 2018 (see Appendix Figure 5.1). The data is given from 2016Q1 to 2018Q2, and I took the average share of CSOK-related loans to the total loans over this period, that is, 15%. The share of government subsidy in the CSOK-related loans is 52% on average[2]. Hence, 7.5% of total mortgage loans value is financed by the government.

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[1]Source: Housing Market Report, MNB, November 2018.

[2]Based on data by MNB and the Hungarian Ministry of Finance, 345 billion HUF CSOK loans have been taken up to 2017 Q4, from which the government paid 180 billion HUF in 66 thousand contracts. Simply taking an extrapolation to the 404 billion HUF loans up to 2018 Q2, I calculated that approximately 77 thousand contracts have been signed with a value of 210 billion HUF. Since the Ministry of Finance has no publicly available dataset to my best knowledge, I relied on the reports provided on their webpage. That is approximately 52% of the CSOK related loans have been financed by the government. In a later report made by the Ministry of Human Resources in April 26 2019, it was revealed that so far 100 thousand families have applied for CSOK for whom the government paid 300 billion HUF. This report further ensured that approximately 52% of loans are financed by the government subsidy. Source: (*Total amount of CSOK contracts so far*, n.d.).

Parameter	Value	Description
α	0.33	Share of capital in production of non-durables
β	0.85	Discount factor of the Borrower
γ	0.87	Discount factor of the Lender
δ	0.01	Rate of depreciation of housing
δ_k	0.025	Rate of depreciation of capital
μ	0.114	Monitoring cost
Ψ	0.5	Fraction of Borrowers in the population
s	0.075	CSOK-to-loan ratio
σ_w	0.2	Standard deviation of idiosyncratic shocks
μ_w	-0.02	First moment of idiosyncratic shocks

Table 3.1: Benchmark calibration

I chose the habit formation parameter to be equal to 0.7, which is the average parameter value among macro-DSGE models based on the meta-analysis of Havranek, Rusnak, and Sokolova (2017). I assumed there are equal amount of borrower and lender households in the economy. Based on data provided by Dancsik et al. (2015), it takes 11.4% of the collateral's value for the liquidation proceedings; hence I set the monitoring cost to be equal to 11.4% in this model.

The steady state values of the main variables are presented in Table 3.2 for two scenarios: (1) when there is CSOK in the model and (2) when there is not. Clearly, the presence of CSOK is favourable for borrower households, their consumption and housing demand increase, naturally with an increased amount of loans. Since borrowers can get $(1+s)L_t$ amount of loans, where $s = 7.5\%$, and they only need to pay L_t back, housing investment becomes an attractive business. The expected return on loans by the lender household only depends on the discount factor of the lender, which is assumed to be the same in both scenario, 3.09%, which is much smaller than the subsidy on the loans, s. Hence, the mortgage market flourish, this, though, has come at a cost: mortgage interest rate R_Z has to increase, i.e. the credit market is riskier when CSOK is present in the economy.

Variable	Policy	No Policy
Consumption of Borrowers [3]	30.06	29.58
Housing Demand of Borrowers [4]	34.08	26.88
Loans	1.3718	0.8617
External Finance Premium	1.73	0.32
Default Rate (%)	7.90	1.58
Loan-to-Value ratio (%)	72.81	63.61
Leverage Ratio [5]	59.93	48.44
Threshold level $\bar{\omega}$	0.74	0.64

Table 3.2: Steady states

4 Estimation of the model

To estimate this model, I used the codes and guidance of the handbook of the Bank of England, with the title of Applied Bayesian Econometrics for central bankers. I estimated the model using Bayesian econometrics with data between 1995Q1-2018Q3. I used three

3 $\frac{\Psi C_{SS}}{\Psi C_{SS}+(1-\Psi)C'_{SS}}$

4 $\frac{\Psi H_{SS}}{\Psi H_{SS}+(1-\Psi)H'_{SS}}$

5 $\frac{L_{SS}}{L_{SS}+w_c^{SS}}$

observable variables: Total household final consumption, House prices and Capital Investment. Data are drawn from the March 2019 Inflationary Report for all three variables[1]. I used HP-filter with the usual $\lambda = 1600$ with the aim of eliminating any trends in the data sets.

I linearized the equations describing the equilibrium around the steady state and cast them into state-space form:

$$\Gamma_0 x_t = \Gamma_1 x_{t-1} + \Psi_0 \epsilon_t + \Pi \eta_t$$

where x_t denotes the vector of endogenous variables, ϵ_t is the vector of 'model based shocks' $(A_t^C, z_t, j_t, \sigma_{w,t})$ and η_t is the vector of error terms for the variables in Expectation operator. This vector-equation can be reformulated into the following equation:

$$x_t = F x_{t-1} + e_t$$

where e_t error term has the variance-covariance matrix: $Q = G'G$. I used Chris Sims' algorithm for calculating the F and G matrices from the former coefficient matrices.

Then I used Kalman-filter to obtain the likelihood function. For parameters that could not be set priorly, those are the distribution parameters of shocks in the model, I assumed prior distributions, see Table 4.1.

[1]Real Household Final Consumption Expenditure – H_C; House Price Index – P_{PROP} divided by Consumer Price Index – CPI, Capital Investment – I.

Parameter	Prior	Mean	Variance	Posterior	Mean	Variance
ρ_A	Beta	0.7	0.05	Beta	0.7538	0.0019
ρ_j	Beta	0.5	0.05	Beta	0.8024	0.0016
ρ_z	Beta	0.7	0.05	Beta	0.6109	0.0228
ρ_{σ_w}	Beta	0.5	0.05	Beta	0.8317	0.0014
σ_A	Inverse Gamma	0.01	0.00005	Inverse Gamma	0.0028	0.0000
σ_j	Inverse Gamma	0.08	0.001	Inverse Gamma	0.0599	0.0001
σ_z	Inverse Gamma	0.04	0.0001	Inverse Gamma	0.0231	0.0000
σ_{σ_w}	Inverse Gamma	0.5	0.005	Inverse Gamma	0.3380	0.0008

Table 4.1: Prior and posterior distributions of hyperparameters

First, I maximized the loglikelihood with respect to the hyperparameters, see the likelihood peeks in Appendix Figure 5.4. Then I used Metropolis-Hastings algorithm to determine the posterior distribution of the hyperparameters, see the prior and posterior distributions on Figure 4.1. I generated 35 000 draws from the posterior around the parameter vector that maximizes the loglikelihood, from which I discarded 20 000 draws based on the toolkit provided by the Bank of England. I plotted the distribution of these draws with the help of Kernel densities.

On Figure 4.1, apart from the prior and posterior distributions, I present the mean values of prior and posterior distributions with a dotted line with the same colors, and the parameter vector that maximized the loglikelihood function with a cyan blue color. The mean of the distribution may not be on the mode because of the asymmetric nature of these distributions. When the posterior mean and the ML parameter vector are close to each other, it means that the prior distribution was updated with the data. When the posterior mean is closer to the prior mean it means that the data contains limited information for estimating that parameter. This might occur when, for example the likelihood function is relatively flat with respect to this parameter.

The prior distributions seem to have limited effect on the AR parameters of the hosuing preference shock and the standard deviation of idiosyncratic shocks, i.e the data contains useful information on these parameters. Furthermore, the posteriors of all the standard deviation of shocks seem to be mostly determined by the data. However, after several simulations I found that the posterior of the AR coefficient of the TFP shock ρ_A and the AR parameter of the intertemporal shock z_t pretty much follows their prior distributions, which means that the data contains limited information about these parameters.

When a posterior has many modes, it can happen because the mode of the prior distribution is too far away from the mode of the likelihood. This happens exactly with σ_z, when its posterior is disturbed by the prior. Figure 4.1 also suggests that the likelihood is somewhat flat in the ρ_z parameter, since the posterior mode is much lower than the prior mode. [2] Overall, the posterior distribution of ρ_j, ρ_{σ_w} and all the posteriors of standard deviation hyperparameters are convincing, and I suggest the reader to handle results connected to ρ_A and ρ_z with caution.

Since this model is a very simple DSGE model, it cannot be used for numerical predictions. However, it is applicable to show probable movements of variables, both with and without the housing allowance policy, CSOK. A great way to show this is using Impulse Response Functions to the estimated model.

Mortgage Risk shock : In my opinion, one of the most exciting features of this basic model is the changing distribution of idiosyncratic shocks, that represents the riskiness of the mortgage market. The difference between the moments of the distribution after a positive mortgage risk shock hits the model is that the mean is lower and the standard

[2] I am aware that this is not an optimal situation, but due to time constraint I was not able to improve these figures.

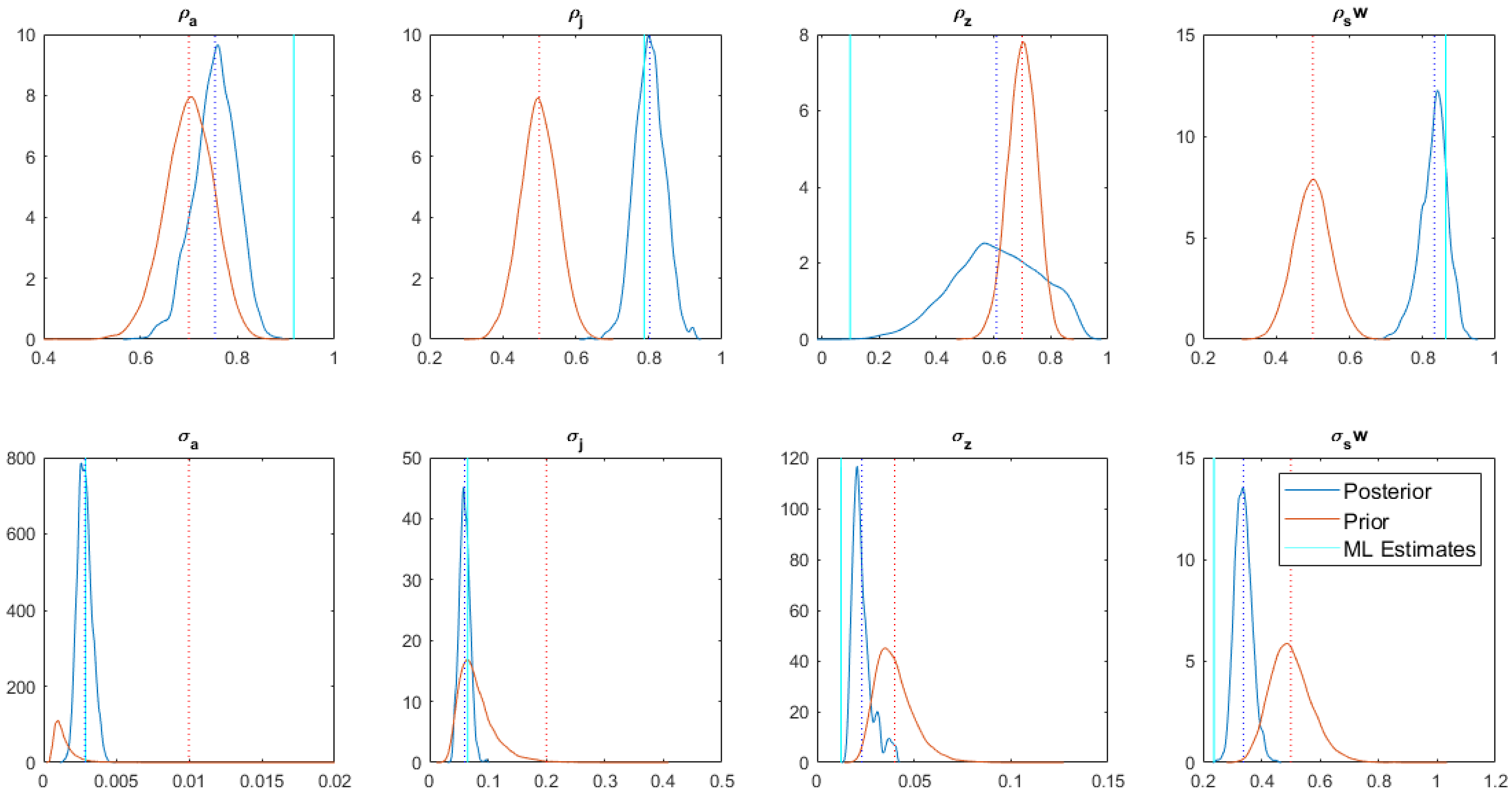


Figure 4.1: Prior and Posterior distributions

deviation is larger. For a lognormal distribution this means that the tails are fatter and for the same threshold level, borrowers are more likely to default[3]. When the mortgage market becomes riskier, the results are very different in the two scenarios as shown in Figure 4.2. In the No Policy case, the results match that of Lambertini et al. (2017): the default rate increases, together with the state-contingent interest rate, $R_{Z,t}$. Borrowers' financial conditions significantly worsen: more borrowers lose their houses when they default, while non-defaulting borrowers pay a higher interest rate. Hence, housing investment is no longer a great business, demand falls, as well as house prices. Borrowers are now willing to take less loans, hence LTV ratio decreases. Since non-defaulting borrowers pay higher interest on their loans, their budget constraint becomes stricter, hence demand for non-durable goods also falls. Fall in demand causes capital investment to fall in the non-durable production sector. Lenders lose value of their housing stock, more borrowers default and cannot pay the loan back with interest and capital investment also falls in the production: lenders budget constraint becomes tighter and their consumption falls. As it is usual for a DSGE model, after a few periods, every variable is converging back to its steady state value, the fastest of which is capital investment.

Under Policy, borrowers take up more loans when the financial conditions are good, thus when conditions worsen the decrease in house prices and loans are significantly larger. Lenders can smooth their consumption, so when house prices fall, they can exploit this opportunity to invest more in housing stock. Many borrowers have to decrease their consumption – due to their worse financial situation – to such extent that aggregate consumption falls sharply below that of under No Policy. Due to stricter budget constraint of borrowers and lenders allocating their sources to housing stock investment, demand for non-durable goods fall and thus capital investment too. Larger default rate and mortgage

[3]See Appendix Figure 11 in Forlati and Lambertini (2011)

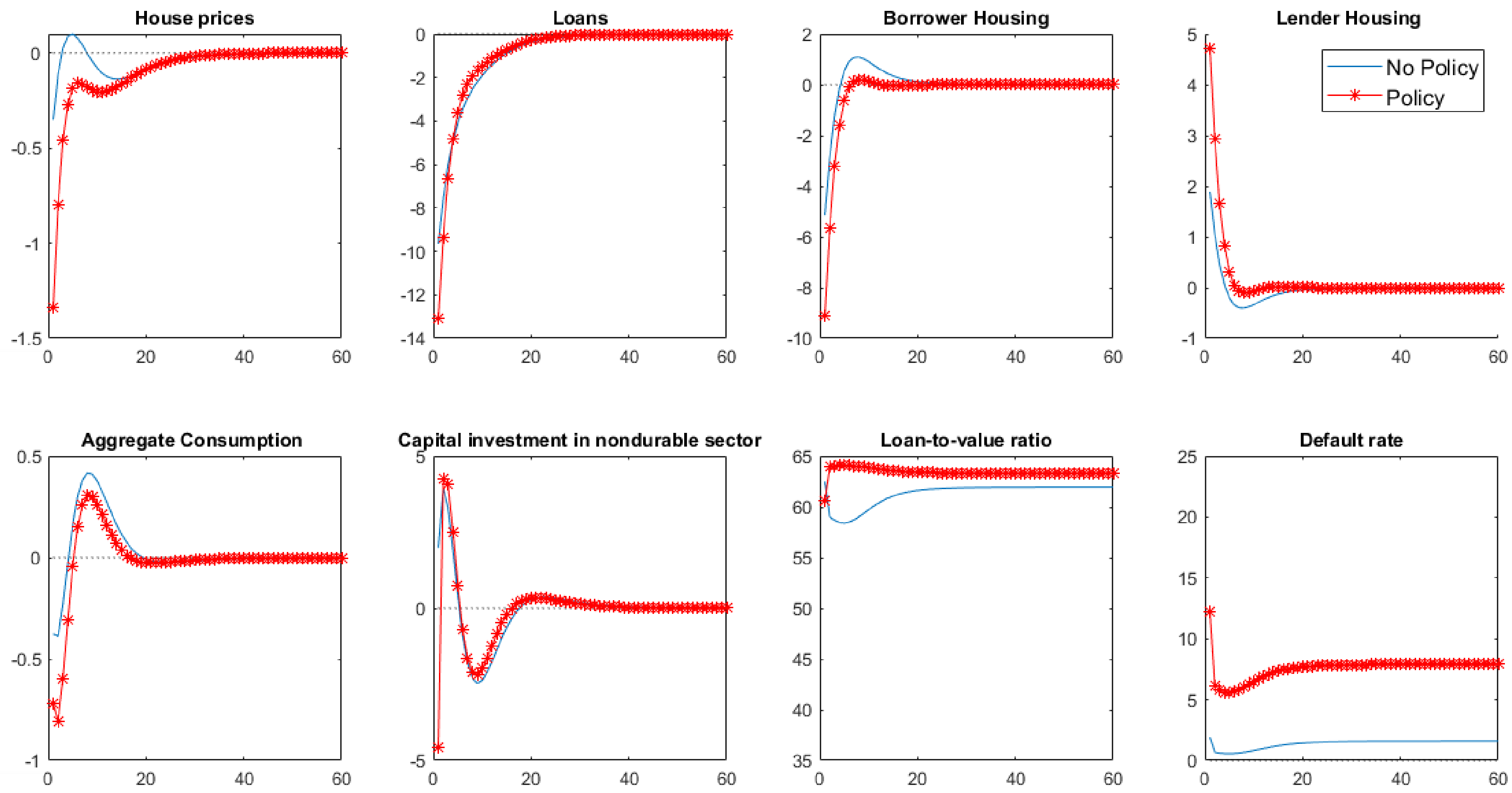


Figure 4.2: IRF to a positive unit of Mortgage Risk shock

interest rate causes a deeper fall in loans than house value, hence Loan-to-Value ratio decreases on impact.

Overall it seems that CSOK has caused a more volatile change after a Mortgage Risk shock compared to the No Policy scenario,i.e. it was an amplifier. Now, the question is: Is this amplification noteworthy? As I have shown, the rate of CSOK subsidy in loans s is equal to 7.5%. However, the change in the amount of loans taken is -2.5 under No Policy and 3 under Policy. If the difference would only be accounted to the CSOK rate, the direct fall under Policy should have been around 2.7, since CSOK only brings a (1+s) multiplier before the variable L_{t+1}. So, it seems that when CSOK is present, borrowers jump into more loans in a boom period, and house prices rise even more than the rate of the change, 7.5% would have indicated. This result can be associated to reality, where we observed a larger willingness to take subsidized loans and buy new houses, as if people who would not necessarily jump into such investment now do so, because CSOK seems to be a once in a lifetime opportunity. We now arrived to the first warning about this policy: simply CSOK allowance cannot cover the price of a new house, people need to take mortgages from commercial banks to cover the difference. As more and more people pile up their loans, the economy becomes exposed to a higher credit market risk. And, when the mortgage market becomes riskier, prices fall, mortgage interest rates rise, and thus begins a larger fallback to a recession than without the policy.

TFP shock : The impact of a TFP shock is often associated with expansions and recessions. Today, we are experiencing an expansionary period, where housing investment and consumption are booming, wages are increasing, people are able to save and make big plans, for which they take up loans. As Figure 4.3 shows, borrowers and lenders both increase their consumption after a positive TFP shock, amount of loans increases as well as house prices and wages. Since I introduced TFP shock to non-durable consumption – housing stock is assumed to be constant over time – a positive shock to non-durables reflects in changing behaviours: agents rather turn to consumption than housing investment, especially lenders, who even decrease their housing stock when prices are high and exploit the high rate of return on capital and high wages in the non-durable sector.

The difference between the Policy and No Policy scenarios is that when CSOK is present, borrowers can increase their consumption even more than before, while lenders can only increase their consumption by a little less. This is the pure redistribution effect of CSOK. The two scenarios produced very similar results which can be attributed to the fact that the data did not bear much information on the TFP shock, so I was not able to estimate its hyperparameters correctly, but the posterior relies very much on the prior distribution I specified. So it is positive that these business cycle movements on Figure 4.3 are almost identical to the ones in Forlati and Lambertini (2011) and Lambertini et al. (2017), however, with the wrongly estimated parameters in hand, CSOK seem to not make much difference. This result needs to be taken with caution.

Housing Preference shock : A positive shock to Housing Preferences – or a housing demand shock – increases house prices and loans under both scenarios. Borrowers increase their housing stock, while lenders are able to smooth their consumption, and hence sell their housing stock at this higher price. The decrease in lender's housing stock is too little to change the sign in aggregate terms: housing stock increases. These movements match the IRFs of Lambertini et al. (2017) and Forlati and Lambertini (2011). Under the Policy scenario though, the results are a little different. CSOK serves again as an amplifier: borrowers can increase their housing stock and consumption by a larger amount, hence loans and house prices increase due to increased housing demand.

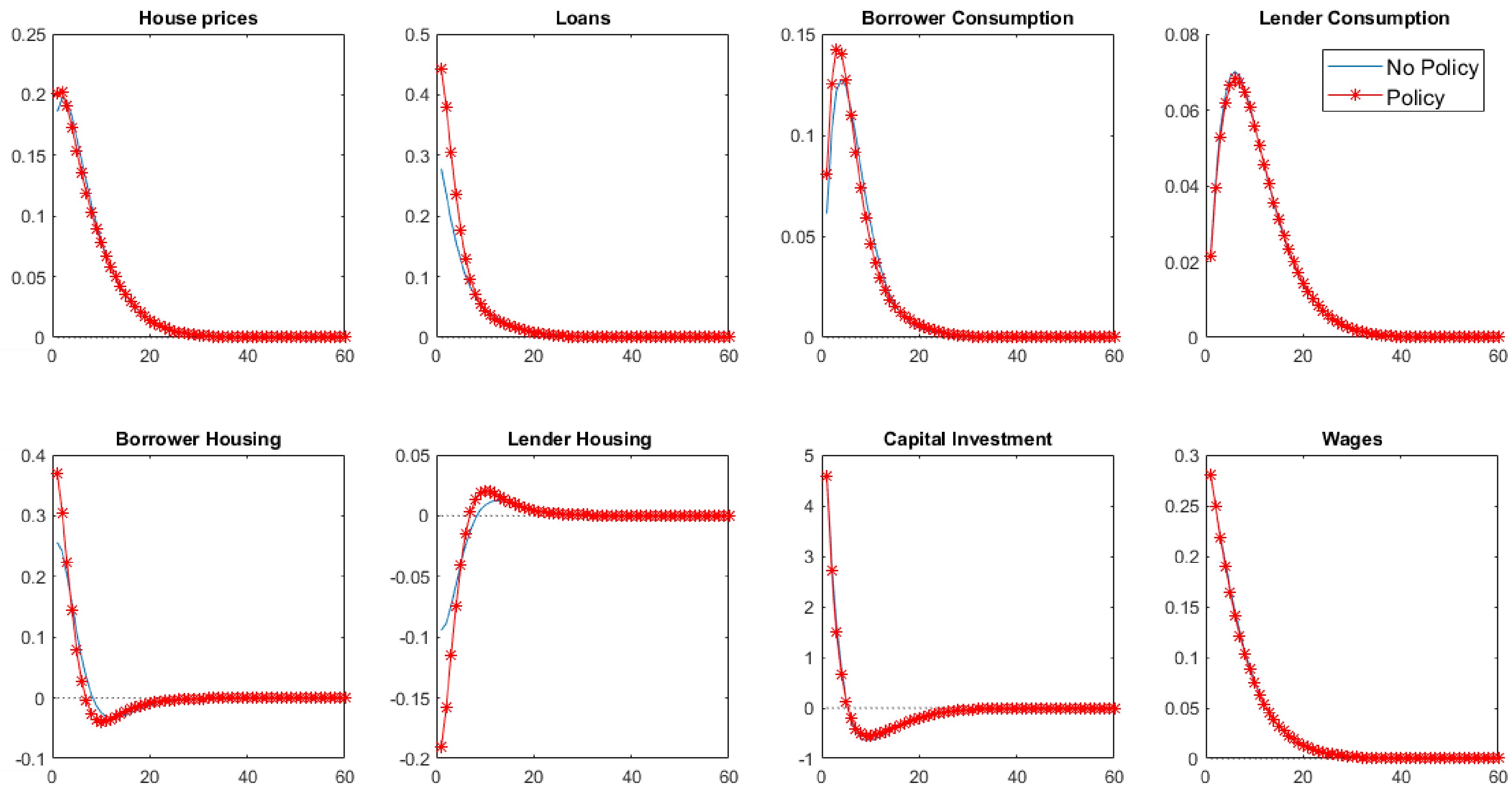


Figure 4.3: IRF to a positive unit of TFP shock

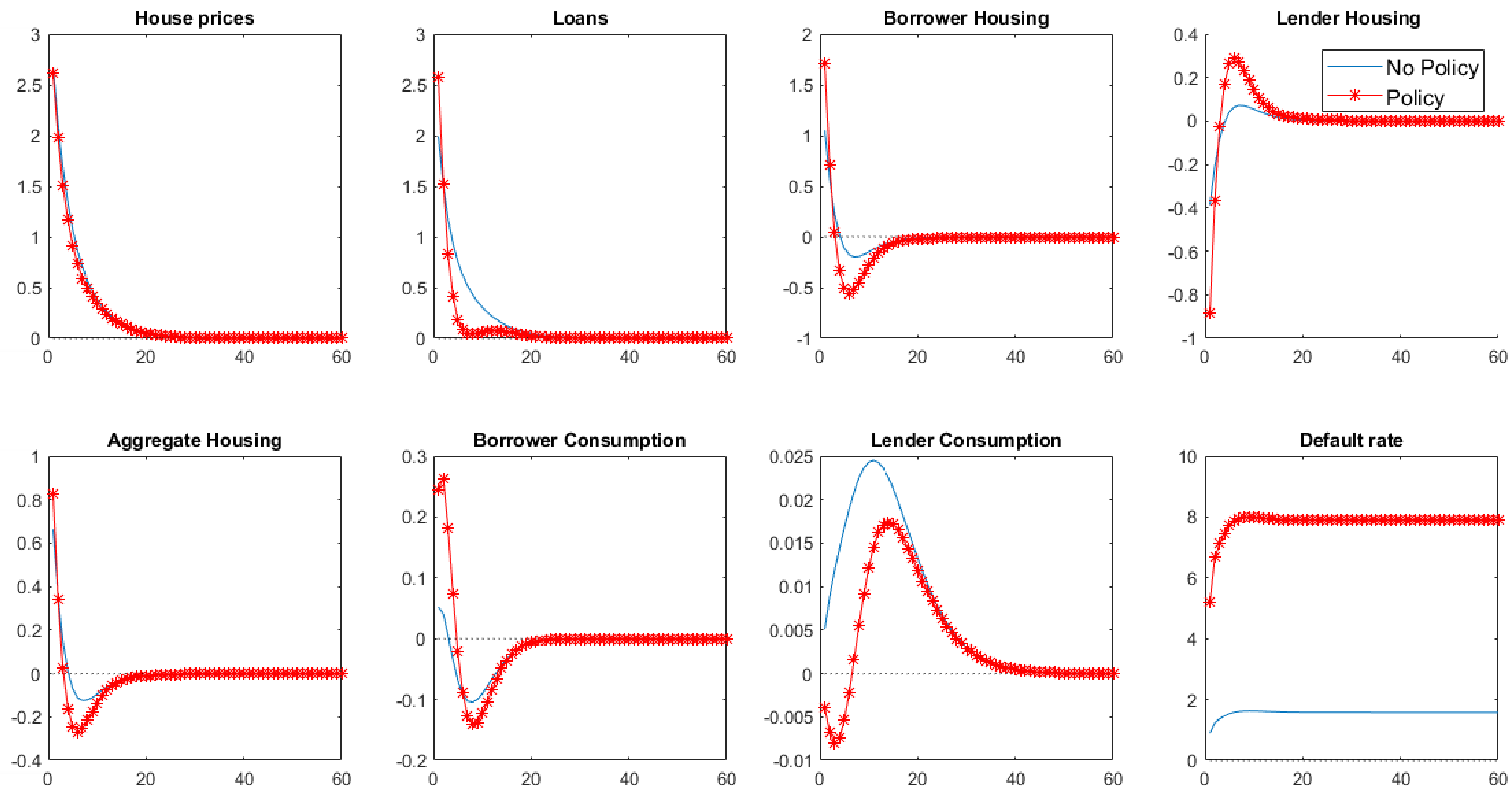


Figure 4.4: IRF to a positive unit of shock to Housing Preferences

5 Conclusion

The main objective of this thesis was to acquire some understating about the effect of a Hungarian public policy introduced in 2015, the so-called CSOK on the Hungarian credit and housing market. Due to limited availability of data, I used a DSGE model based on the assumptions of the Forlati and Lambertini (2011)'s two-sectoral endogenous default model and applied a Bayesian estimation strategy to estimate it with data. Bayesian methods are highly sensitive to the specification of the prior distribution, therefore I used several specifications of prior distributions and thus discovered that the findings are stable and robust across various specifications.

To better understand the effect of CSOK on the Hungarian economy in general and on the credit and housing market in particular, I compared the effect of CSOK on lenders and borrowers to a hypothetical scenario in which CSOK has not been initiated. More precisely, I introduced a mortgage risk shock to the model to test the effect of a sudden increase in mortgage risk on the housing market with and without CSOK. The main empirical findings imply that CSOK amplifies the reactions of the housing market variables, thus increasing housing market fragility and making not just the housing and credit market but the whole economic system more volatile.

These results have a crucial policy implication. Given that CSOK makes the Hungarian credit and housing market more volatile, it makes the country's economy more exposed to the negative effects of an exogenous housing market crisis. Hence – to name one example – a more thorough and strict evaluation of borrower's financial situation is needed to decrease the risk exposure of the mortgage market.

This paper can serve as an inspiration for future researches in two ways. First, a more elaborate and better estimated model would show a more comprehensive picture of the effects of CSOK. Second, few years later, when data is available for long enough period, a thorough econometric research will be possible and then the predictions of this model could be matched to those of the econometric model.

Appendix

Model Equations:

First Order Conditions of Borrower: $\frac{\partial L}{\partial C_t}, \frac{\partial L}{\partial H_t}, \frac{\partial L}{\partial l_t}, \frac{\partial L}{\partial \bar{\omega_{t+1}}}$

$$\frac{z_t}{C_t - \epsilon C_{t-1}} = \lambda_t^{BC1}$$

$$\frac{z_t j_t}{H_t} - \lambda_t^{BC} p_{H,t} + \lambda_{t+1}^{BC} \beta (1-\delta)(1-\mu G_{t+1}(\bar{\omega_{t+1}})) p_{H,t+1} + \lambda_t^{PC} [\Gamma_{t+1}(\bar{\omega_{t+1}}) - \mu G_{t+1}(\bar{\omega_{t+1}})](1-\delta) p_{H,t+1} = 0$$

$$\lambda_t^{BC}(1+s) = \lambda_{t+1}^{BC} \beta (1 + R_{L,t}) + \lambda_t^{PC}(1 + R_{L,t})$$

$$\lambda_t^{PC} = \lambda_{t+1}^{BC} \beta \frac{\mu G_{t+1}(\bar{\omega_{t+1}})}{\Gamma_{t+1}(\bar{\omega_{t+1}}) - \mu G_{t+1}(\bar{\omega_{t+1}})}$$

Budget Constraint of Borrower:

$$C_t + p_{H,t} H_t + (1 + R_{L,t-1}) l_{t-1} = l_t (1+s) + w_{C,t} + (1-\delta)[1 - G_t(\bar{\omega}_t)] P_{H,t} H_{t-1}$$

Participation Constraint of the Lender:

$$(1 + R_{L,t}) l_t = [\Gamma_{t+1}(\bar{\omega}_{t+1}) - \mu G_{t+1}(\bar{\omega}_{t+1})](1-\delta) p_{H,t+1} \Pi_{C,t+1} H_t$$

[1] I made the assumption that borrowers treat their previous period's consumption exogenous, so that FOCs become much simple. The intuition behind it is that habits are defined not by own level of consumption but by average level (which is equal to individual consumption within each group, since borrower and saver are representative of their groups).

First Order Conditions of Lender: $\frac{\partial L}{\partial C'_t}, \frac{\partial L}{\partial H'_t}, \frac{\partial L}{\partial L'_t}, \frac{\partial L}{\partial K'_t}$

$$\frac{z_t}{C'_t - \epsilon C'_{t-1}} = \alpha_t$$ [2]

$$\frac{z_t j_t}{H'_t} - \alpha_t p_{H,t} + (1-\delta) p_{H,t+1} \alpha_{t+1} \gamma = 0$$

$$\alpha_t = (1 + R_{L,t}) \alpha_{t+1} \gamma$$

$$\alpha_t = (1 - \delta_k + r^k_{t+1}) \alpha_{t+1} \gamma$$

Budget Constraint of the Lender:

$$C'_t + I'_t + p_{H,t} H'_t + l'_t + T_t = (1-\delta) p_{H,t} H'_{t-1} + w_{C,t} + (1 + R_{L,t-1}) l'_{t+1} + r^k_t K'_{t-1}$$

Capital formation equation:

$$I'_t = K'_t - (1-\delta_k) K'_{t-1}$$

First Order Condition and Zero Profit Condition of Firms:

$$r^k_t = \alpha A^C_t {K'_{t-1}}'^{(}\alpha - 1)$$

$$w_{C,t} = (1-\alpha) A^C_t {K'_{t-1}}'^{\alpha}$$

Loan Market Equilibrium:

$$\Psi l_t = (1 - \Psi) l'_t$$

[2] I made the assumption that savers treat their previous period's consumption exogenous, so that FOCs become much simple. The intuition behind it is that habits are defined not by own level of consumption but by average level (which is equal to individual consumption within each group, since borrower and saver are representative of their groups).

House Market Equilibrium:

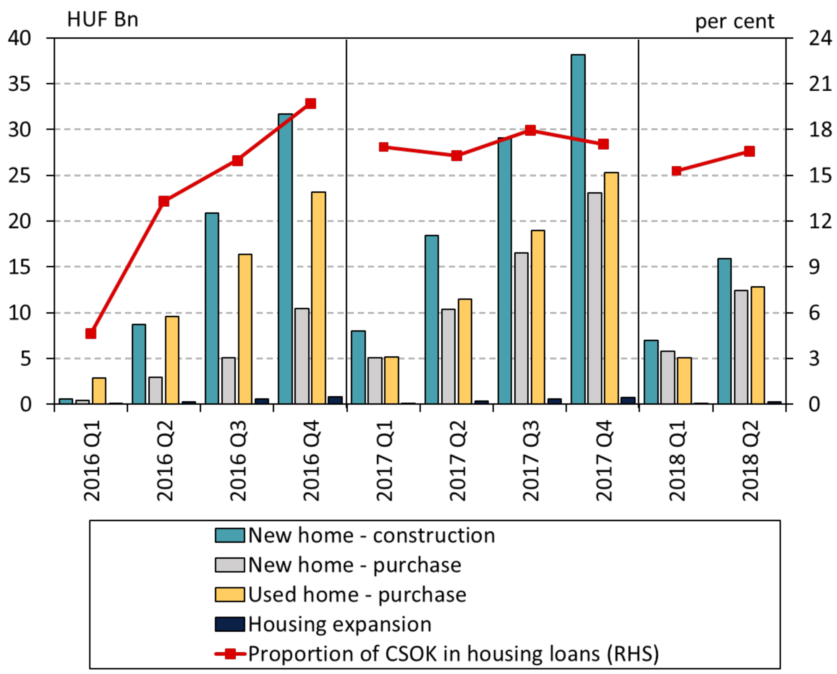
$$\Psi H_t = (1 - \Psi) H_t'$$

Tax = CSOK subsidy in equilibrium:

$$T_t = sl_t$$

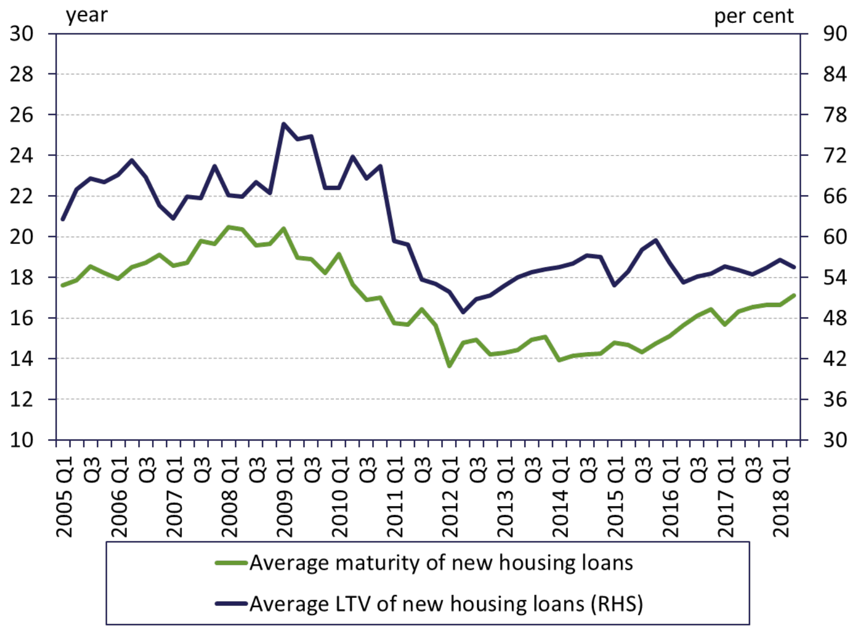
There are 14 equations and 14 variables in this model after the shadow prices are substituted out. Steady states can be determined from these equations uniquely.

FIGURES FOR CALIBRATION:



Source: MNB

Figure 5.1: CSOK loans



Source: MNB

Figure 5.2: Average LTV ratios on new loans

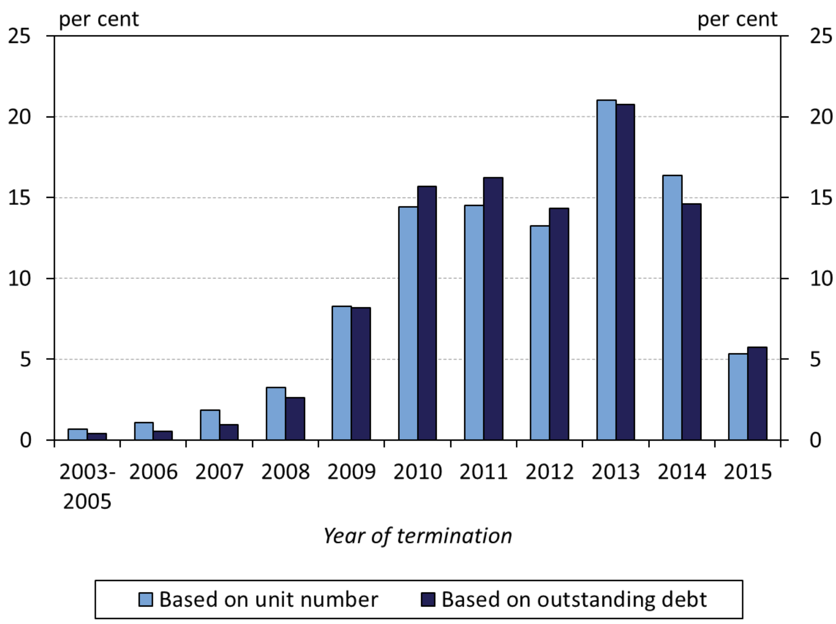


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Figure 5.3: Distribution of terminated mortgage contracts by year of termination

Figures for Estimation:

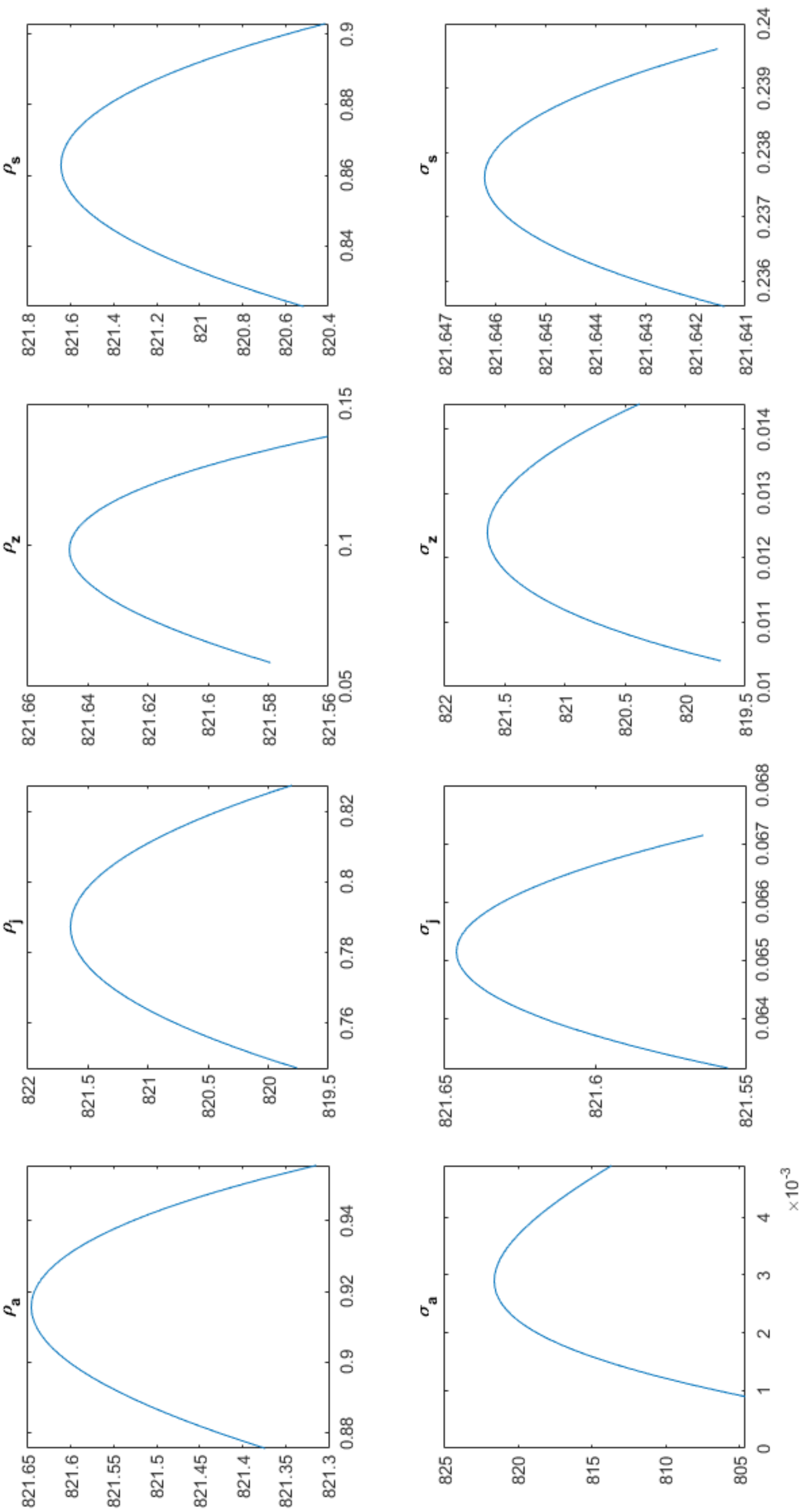

Figure 5.4: Loglikelihood peaks

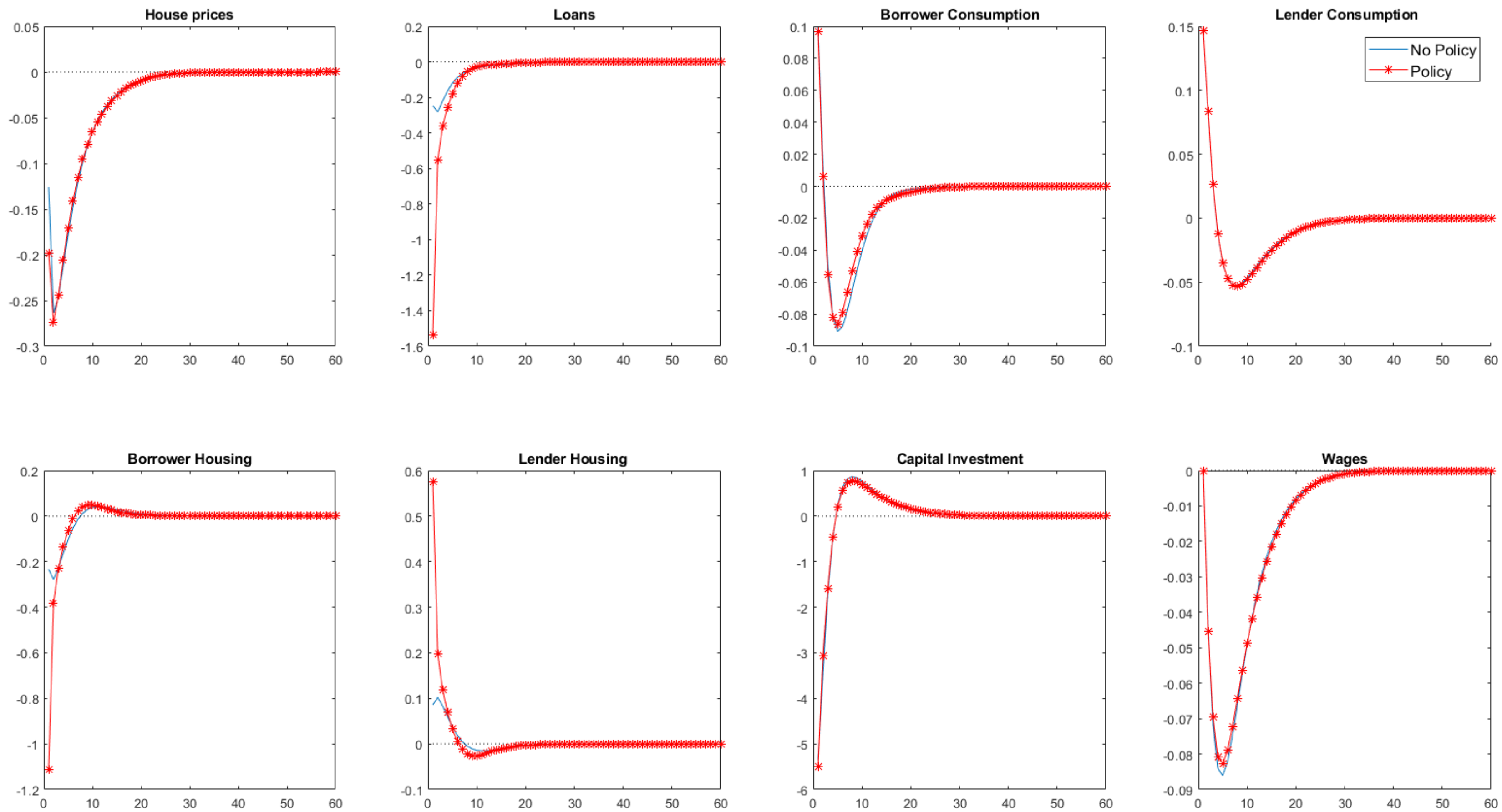

Figure 5.5: IRF to a positive unit shock to Intertemporal Preferences

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