The Hungarian foreign currency loan bailout scheme in a New-Keynesian modeling framework

by

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Abstract

The objective of my thesis is to investigate the economic effects of the foreign currency loan bailout schemes implemented by the Hungarian government. These measures are studied in a New-Keynesian modeling framework, and they are introduced as exogenous shocks to the system. The applied structure is a small open economy model supplemented by a linked housing-borrowing part, where the seminal paper of Iacoviello (2005) is heavily utilized. The results underpin other economists' opinion: apart from the welfare distribution across saving and borrowing households, there is a temporary rise in consumption and output, but in the middle run both indicators take a negative turn, indicating an economic recession *ceteris paribus*. The paper can be extended by introducing hyperbolic preferences and a more realistic risk premium evolution process.

Table of Contents

Abstract ii

List of Tables iv

List of Figures vi

1 Introduction 1

2 The foreign currency loan issue in Hungary 3

2.1 Reasons behind the development of foreign currency lending 3

2.2 Harms of broad foreign currency lending 6

2.3 Foreign currency cending in Hungary and solution attempts 7

2.4 Evaluation of solution attempts 10

3 The model economy 12

3.1 Households 12

3.2 Banking sector 16

3.3 Production sector 17

3.4 Housing and capital sector 19

3.5 Foreign sector 21

3.6 Market equilibrium 22

3.7 Transmission mechanism 24

4 Simulations **25**

4.1 Steady state of the model 25

4.2 Calibration 26

4.3 Simulation results 28

5 Conclusion **34**

Bibliography **36**

A Appendix **39**

A.1 Derivation of the export demand equation 39

A.2 Equations characterizing the steady state 40

A.3 Loglinearized model 41

A.4 Calibrated parameter values 48

A.5 The exact steady state values 49

List of Tables

A.1 Calibrated parameter values 48
A.2 Steady state values after calibration 49

List of Figures

4.1 Foreign currency loan stock with cost shock 29
4.2 Foreign currency loan stock with cost and preference shocks 30
4.3 Foreign and domestic currency loans 31
4.4 Consumption and housing 32
4.5 Aggregate economic indicators 33

Chapter 1

Introduction

At the end of 2011 gross public debt in Hungary added up to 81% of the GDP, mostly financed by foreigners, while the households' GDP proportionate foreign currency loan stock reached 20% (Hudecz, 2012; OECD). This unambiguously fragile situation not only made the Hungarian economy extremely dependent on foreign processes, but also had constrained the potentials of fiscal and monetary policy. However, while the public debt issue remained mostly an economic problem, the growing installment costs of foreign currency loans imposed huge political risk on the government. For 2011 roughly 13% of the foreign currency loans were non-performing (more than 90 days default), and according to the Hungarian National Bank (MNB, 2011) 13% of the disposable income of households were spent on installment costs. It was beyond question that this issue was to be solved. Eventually, the Hungarian government implemented several measures to assist the highly indebted foreign currency loan holders.

In my thesis I examine the economic effects of the two main bailout schemes implemented from 2012: the early repayment and the exchange rate ceiling. In order to get *ceteris paribus* effect, the schemes are analyzed in a New-Keynesian modeling framework, where they are implemented as exogenous shocks to the system. That is, instead of testing hypotheses on fully empirical data, I use a model which can properly describe the Hungarian economy. The applied structure is a small open economy model supplemented by a linked housing-borrowing part, where the seminal paper of Iacoviello (2005) is heavily utilized. In order to capture foreign currency borrowing, two types of households are featured in the model: a lending patient one and a borrowing impatient one. Price rigidities are introduced by Calvo pricing, and the shocks are designed to describe both the conversion and the subsidy part of the schemes.

The findings of the thesis are in line with my prior hypotheses and other economists' opinion: although the programs provide some short-run advantages through loosening liquidity constraints and promoting consumption growth, they cause economic disturbances and recession in the middle run. Furthermore, they generate welfare redistribution from savers to borrowers, and bring about moral hazard in the long run, which can even threaten with an increasing currency loan stock.

The rest of the thesis is organized as follows: in order to provide a sound background to the analysis I explain the foreign currency loan issue in detail in Chapter 2, concentrating especially to the circumstances which granted the development of foreign currency lending in Hungary. Chapter 3 describes the model utilized in the thesis, and shows the transmission channels, through which the shocks can influence the economy. After calibrating the model for the Hungarian data, in Chapter 4 I present the impulse response functions and interpret them, and finally Chapter 5 contains the conclusions of the thesis.

Chapter 2

The foreign currency loan issue in Hungary

2.1 Reasons behind the development of foreign currency lending

According to the standard international finance theory there is no room for widely used foreign currency lending. This finding can be best explained by the law of uncovered interest parity, which states that the *expected* yield from a domestic and a foreign asset should be equal in equilibrium. That is, in order to satisfy the no-arbitrage condition, there cannot be any *systematic* deviation across the interest rates, taking into account possible future movements in the exchange rate (if any), thus the *expected* cost of borrowing should be equal, too. [1] If these conditions are fulfilled, the borrowers cannot have any incentive to *systematically* take loans denominated in foreign currency instead of the domestic one, especially considering the

[1] $(1+i) = \frac{E_t(S_{t+k})}{S_t}(1+i^*)$, where *i*: domestic interest rate, i^*: foreign interest rate, S_t: spot exchange rate at time *t*, $E_t(S_{t+k})$: expected future exchange rate *k* period later

possible risk from exchange rate volatility.

Often, borrowing in foreign currency happen. During the recent decades a number of emerging (mostly Latin-America and East-Asia) and transition economies met the phenomena of dollarization (Basso et al., 2007; Eichengreen and Hausmann, 1999), which basically refers to the situation when the agents cannot find enough (profitable) assets and/or (cheap) credits denominated in their domestic currency, and they decide to lend/borrow in a liquid and stable currency. Although the case of the emerging countries that experienced dollarization are quite different from that of the Central and Eastern European countries [2], the main underlying factors are often similar.

One possible argument is that these countries are typically in a catching-up period, and usage of foreign resources are inevitable to their real convergence. That is, they are scarce in capital and thus the marginal product of capital is high, as well as the *expected* productivity and income growth, which makes worth borrowing from abroad (and lending to them). However, this reasoning is also true for the cases when the foreign banks/investors bear the exchange rate risk (foreign direct investment, lending in domestic currency). The question is more why the debtors are willing to bear this risk over domestic liabilities.

A possible explanation is that the financial markets are relatively underdeveloped in these countries, and there were not enough long-term domestic credit sources available. That is, the households/firms have no choice but to bear the risk. Another incentive can stem from the loose fiscal policy and high indebtedness of the country. In this case the risk premium increases and the government's high credit demand can crowd out private agents from the credit market. Both effect can raise the interest rate on domestic sources making them more expensive. Likewise, foreign currency borrowing can be an insurance tool against high and

[2]The Latin American and East Asian countries possessed more underdeveloped financial sector than the CEE countries.

volatile domestic inflation (Yeyati and Ize, 1998).

Ignoring the exchange rate risk is a seemingly irrational behavior; however, the behavior can be explained. Firstly, people can expect that the exchange rate will remain stable in the future, which can originate from an explicit policy (eg. exchange rate band) or an expected implicit policy (eg. preventing a currency from over- or undervaluation). The latter can also be related to moral hazard, under which people who take out a foreign currency loan (FCL) expect a governmental bailout if the domestic currency becomes too weak. This belief is especially reasonable when there are many people who have or at least plan to borrow FCLs. Because a massive default can pose serious threats against social security and financial stability in the economy, it is is clearly an unacceptable situation for the government. Finally, there are two other aspects, which can help to explain the risk-taking attitude of these economic agents. One is that people tend to believe that the past evolution of exchange rates will stay stable in the future, too. Thus, a favorable trend can make them ignore exchange rate risk. Whereas in the second case they are aware of the risk, but they have liquidity problems, so they cannot afford to pay the originally higher interest rate of domestic loans.

All of the above conditions are important but none of them seems to be strong enough alone to cause a massive wave of foreign currency lending. Instead, most of the conditions must be fulfilled at the same time. This was the case in Hungary. In the mid-2000's the capital markets had opened and the country was expected to start converging to West-Europe. However, soon the productive investments had been replaced by debt-financed consumption (Hudecz, 2012) and the government debt began to grow. Meanwhile the inflation rate fluctuated between 2.5-8.6% (KSH), and the monetary policy tried to hold the exchange rates within a $\pm$ 15% band, where the forint was usually close to the strong margin. The latter not only implied a continuing long-run trend but also had an implicit guarantee that there can be at most 30% depreciation in the exchange rate. Moreover, although the government frequently reset the target date, Hungary was always expected to join the Eurozone within the following five years. Finally, with foreign currency lending having become massive, people strongly believed that the government will provide some bailout mechanism for them in case of emergency. Thus, it should be no surprise that by the end of 2011 65% of retail credits in Hungary were denominated in foreign currency.

2.2 Harms of broad foreign currency lending

Although a 65% FCL share indicator could be considered a sign of economic imbalance on its own, there are several specific reasons why broad foreign currency lending can pose a threat against the economy.[3] These issues can be divided into two group: the flow and the stock problem. The first one includes all possible harms caused by the high portion of FCLs across *newly issued* loans, while the second one refers to those damages, which stem from the high portion of FCLs across the *existing* debts.

The main expense of issuing FCLs in high proportion is that doing so brings down the effectiveness of the interest rate transmission channel of the monetary policy. Generally one of the main tools of the central bank is setting the nominal interest rate, through which it can influence the inflation rate and the cyclical movement of the output. However, with availability of FCLs with lower interest rate people are less willing to respond to such incentives. For instance, according to Brzoza-Brzezina et al. (2010) in Hungary after interest rate rise 55-60% of the decrease in domestic currency loan issuance are compensated by FCLs. Moreover, of course, a long-existing flow problem leads directly to a stock problem.

The high stock of FCLs also influences the effectiveness of monetary policy, but in this case

[3] Although foreign currency lending can have positive effects on the economy – see for instance Ranciere et al. (2010), who argue that "currency mismatch relaxes borrowing constraints, reduces interest rates and enhances growth across sets of firms that arguably are the most credit constrained" – here I concentrate exclusively on the possible harms, which makes a policy intervention necessary.

through the exchange rate transmission channel. Usually a devaluation of the domestic currency can induce higher demand for domestic products and thus boost the output. Nevertheless, it also raises the domestic value of FCL installments, which pulls back the domestic demand, causing a reduction in output, thus making monetary policy interventions less effective. Furthermore, if defaults were becoming more frequent due to higher installments, not only would lending have pulled back (having a negative effect on economic growth), but also financial stability would be endangered. Altogether, high stock of FCLs makes the whole domestic economy more exposed to foreign shocks (Beckmann et al., 2012).

2.3 Foreign currency cending in Hungary and solution attempts

As earlier mentioned, at the end of 2011 almost 65% of retail credits in Hungary were in the form of FCLs, which altogether added up to 20% of the GDP (Hudecz, 2012). The building-up of this huge FCL stock took only 4-6 years. FCLs appeared on the Hungarian credit market first in 2000, and borrowing in foreign currency became widespread around 2004-2005 when people started to substitute the state-subsidized housing loans with the cheaper FCLs due to the much stricter eligibility requirements (Vadas, 2007). By 2008 almost 100% of all newly issued mortgage loans and more than 80% of all newly issued loans had been denominated in foreign currency (MNB, 2009).

The forint suffered an unsurprisingly vast devaluation against the main currencies during the crisis[4], which resulted in one of the major crisis of the recent years. According to the estimation of the Hungarian National Bank in the middle of 2010 the installment costs of the

[4]From February 26, 2008 the exchange rate regime of Hungary has been changed into a floating one.

households added up to almost 5,5% of the GDP (MNB, 2010), and the installments of the Swiss frank denominated mortgage loans were on average 79% higher than in the take-out time[5] (Hudecz, 2012). Because banks could raise their interest rates unilaterally, which they did to cover their losses, the debtors were further burdened. Consequently many household could not repay their debts, and by the end of 2011 around 13% of the retail loan stock was non performing (Hudecz, 2012).

It was obvious that the government had to deal with the foreign currency loan problem. In first step they implemented some regulatory and macroprudential measures in order to control the flow problem of FCLs, which seem to have proved efficient in pulling back foreign currency lending close to zero (MNB, 2010); however, this would have likely happened without the government as well, since people became more concerned about the exchange rate risk (Hudecz, 2012). After the flow-problem of FCLs had ceased by 2010, the huge stock of FCLs remained the only – and far more complicated – issue. As Balás and Nagy (2010) and Hudecz (2012) pointed out, there is no real solution for this problem, except outgrowing it and letting the stock deteriorate, which clearly takes time. Nevertheless, the government tried to find a short-term solution, and implemented a couple of measurements. Although there has been other provisions (eviction moratorium, establishment of a national real estate operator, residential complex for extremely indebted families) as well, the most significant ones have been the *early repayment* and the *exchange rate ceiling* schemes.

Participation in both schemes has been voluntary (in contrast to for instance Argentina or Peru, where conversion of FCLs into domestic loans was made compulsory). The early repayment scheme guaranteed an opportunity for foreign currency debtors to repay their debt in a lump sum at a very favorable fixed exchange rate (180 HUF/CHF, 250 HUF/EUR, and 2

[5]Accordingly the FCL-to-GDP ratio increased to its 20% from a 16% level in 2008 purely to the forint devaluation.

HUF/JPY), either financed by savings or by new forint loans. The other framework offered a fixed exchange rate[6], through which the debtors could pay their monthly installments for at most 5 years. While the principal payment above the ceiling goes to a gathering account where it bears interest according to special rules, the interest payment above the ceiling is paid by the state and the banks equally. Above given spot rates (270 HUF/CHF, 340 HUF/EUR, and 3,3 HUF/JPY) all exchange rate differences are paid by the state. Moreover, 30% of the bank's losses arosen from the early repayment scheme were made deductible from the sectoral bank tax.

According to MNB (2012) 24.1% of the foreign currency loan stock were paid back in the early repayment scheme, along with a total cost of 370 billion forints, from which 111 billion forints has been financed directly by tax payers(Hudecz, 2012). The exact numbers of the exchange rate ceiling scheme will be available only at the end of 2017 when the program terminates, but according to preliminary calculations roughly 90-100% of the remaining non-defaulting households will participate, and it will levy 25-25 billion forints per year on the banks and the state (MNB, 2012). During the participation spell the installments are smaller by 25-30%[7]. Altogether these two schemes cost the banks roughly 400 billion, and the state 250 billion forints. The banks have financed their losses partly by passing it through on their customers, partly by accounting it as capital loss, while the state has financed its expenditure mostly through specific sectoral taxes. These taxes likely motivated the affected companies to postpone their investment, and also decreased their profits.

[6]Similar to the previous repayment scheme, except for the yen exchange rate: 2.5 HUF/JPY.

[7]This information is important for the simulation settings.

2.4 Evaluation of solution attempts

Many papers (Balás and Nagy, 2010; Holmár, 2012; Hudecz, 2012) argues that the FCL stock problem can never be solved in the short run; the aggregated open exchange rate position and the fiscal losses cannot be reduced, only redistributed across economic actors.

This feature was especially important for the early repayment scheme. In this case not only the size of the redistribution was huge (370 billion forints) but it also had an 'unhealthy' direction. Since paying back the loan in one amount was only possible if one had enough savings or at least had the financial capacity to take on new (and cheap enough) forint loan, participation in this program was possible only for the richer debtors, who likely suffered the least from their burden. As the assistance provided by the scheme was financed by those who either did not have foreign currency loans or were not able to participate in the program, it likely created a transfer from poorer to richer households. The exchange rate ceiling scheme is also causing a redistribution across households, but not so unequivocally towards the richer. Nevertheless, it obviously levies a cost on those who either were saving instead of borrowing or took ex-ante more expensive forint loans. Moreover, the *average* installments for the whole repayment period were still lower for the foreign currency loans than for the forint loans until the end of 2011, and for the euro loans even the *current* installments were below the level of forint loans (Hudecz, 2012). This effect can be exaggerated by the growing demand on the forint loan market originating from the foreign currency loan transformation. According to Holmár (2012) beside the above distributional issues there are other possible harms caused by these programs. The measures endanger the predictability and the legal stability, deteriorate the position of the government budget, decreases the loan issuance capability of the banking system and through the above channels can result in a fall of the potential growth.

The schemes can also provide positive effects for the economy, though. By the growing demand for domestic loans the monetary policy can become more effective, and by loosening the financial constraints for the highly indebted households, their demand and the economy stability can grow side by side. Moreover, if the redistribution of the burdens make the economy more stable, refinancing the debt becomes cheaper through the smaller risk premium. It is hard to decide which channels are stronger, and thus to evaluate the measures. Therefore, in the next chapter I develop a model economy where the resultant of the above effect can be examined by simulations.

Chapter 3

The model economy

The model used in this paper incorporates the features of the ones developed by Iacoviello (2005) and Gali and Monacelli (2002), and builds partly on the model conceived in Brzoza-Brzezina et al. (2014) as well. The seminal paper of Iacoviello (2005) set up a DSGE framework with housing and collateral credit constraint, which can provide a similar environment to that of in Hungary with introduction of both domestic and foreign currency denominated loans. At the same time the work of Gali and Monacelli (2002) serves as a starting point to a small open economy model with price rigidities.

3.1 Households

In the domestic economy there are two representative households (with equal weight in the population)a patient one with a higher discount factor and an impatient one, which is allowed to take on loan denominated in foreign currency. Both households gain utility from consumption (C_t) and housing stock (H_t), and supply labor (N_t) causing negative utility.

$$\max_{C_t,H_t,N_t} \quad E_0 \sum_{t=0}^{\infty} \beta^t [U(C_t) + jV(H_t) - Z(N_t)] \tag{3.1}$$

where $U(C_t) \equiv log(C_t)$; $V(H_t) \equiv log(H_t)$; $Z(N_t) \equiv \frac{{N_t}^{1+\varphi}}{1+\varphi}$ and j is the weight of utility stemming from housing. C_t is a composite consumption index defined by a constant elasticity of substitution (CES) function:

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} {C_{H,t}}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} {C_{F,t}}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{3.2}$$

where $C_{H,t}$ and $C_{F,t}$ are indicies of domestic and foreign consumption, respectively. Nonetheless, as a simplification $C_{F,t}$ is assumed to be a composite foreign good here, while $C_{H,t}$ is given by the following CES aggregator of the quantities consumed of each type of good:

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t}(i)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}} \tag{3.3}$$

The housing stock evolves according to the law of motion for housing:

$$H_t = (1-\delta_H)H_{t-1} + \Delta H_t \tag{3.4}$$

The budget constraint for the patient household is given by

$$\int_0^1 P_{H,t}(i)C_{H,t}(i)di + P_{F,t}C_{F,t} + Q_t\Delta H_t + D_t = (1-\tau_{R,t})R_{D,t-1}D_{t-1} + W_tN_t \tag{3.5}$$

for $t = 0, 1, 2...\infty$ with D_t standing for (domestic) deposit, $R_{D,t}$ for interest rate on deposit set by the monetary authority and $\tau_{R,t}$ for value added tax on interest. The expenditure minimization problem gives the optimal allocation between the differentiated domestic goods:

$$C_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon} C_{H,t} \tag{3.6}$$

$\forall i \in [0,1]$, with $P_{H,t} \equiv \left[\int_0^1 P_{H,t}(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$ being the price index for domestic goods. Similarly, the optimal allocation between domestic and foreign goods are given by

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t; \quad C_{F,t} = \alpha \left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{3.7}$$

where $P_t \equiv \left[(1-\alpha)P_{H,t}^{1-\eta} + \alpha P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}$ denotes the consumer price index of the domestic economy. Notice that, when the price indices for domestic and foreign goods are equal, α corresponds to the share of domestic consumption allocated to imported goods.

Accounting for the above optimality conditions and substituting (3.4) in, the budged constraint can be rewritten as

$$P_t C_t + Q_t[H_t - (1-\delta_H)H_{t-1}] + D_t = (1-\tau_{R,t})R_{D,t-1}D_{t-1} + W_t N_t \tag{3.8}$$

The remaining optimality conditions for the patient household are given by the labor supply equation (3.9), the Euler equation (3.11) and the housing equation (3.10):

$${N_t}^{\varphi} = \frac{W_t}{P_t C_t} \tag{3.9}$$

$$\frac{Q_t}{P_t C_t} = \frac{j}{H_t} + \beta(1-\delta_H)E_t\left\{\frac{Q_{t+1}}{P_{t+1}C_{t+1}}\right\} \tag{3.10}$$

$$\frac{1}{P_t C_t} = \beta E_t\left\{\frac{(1-\tau_{R,t+1})R_{D,t}}{P_{t+1}C_{t+1}}\right\} \tag{3.11}$$

The domestic impatient household has the same preferences towards consumption, housing and labor[1], but has a lower discount factor ($\beta' < \beta$), plus can take foreign currency loans ($B'_{F,t}$) and domestic ones, too.[2] So, the budget constraint is given by

$$\begin{aligned}\int_0^1 P_{H,t}(i)C'_{H,t}(i)di + P_{F,t}C'_{F,t} + Q_t\Delta H'_t + \varrho_{t-1}R_{F,t-1}X_t(2-S_t)B'_{F,t-1} + \\ + R_{H,t-1}B'_{H,t-1} = B'_t + W_tN'_t + \Pi_{B,t}\end{aligned} \tag{3.12}$$

where X_t stands for the exchange rate and S_t is a subsidy term from the government supporting foreign currency loan holders[3]. ϱ_t denotes a risk premium term depending on the relative deviation of the FCL portfolio from its steady state value[4]:

$$\varrho_t = 1 + \kappa\left(e^{\frac{(B'_{F,t}-B'_F)X_t}{Y_t}} - 1\right) \tag{3.13}$$

Finally[5] B'_t is the loan aggregate defined by the following CES function

$$B'_t \equiv \left[(1-\mu_t)^{\frac{1}{\phi}}B'^{\frac{\phi-1}{\phi}}_{H,t} + \mu_t^{\frac{1}{\phi}}(X_tB'_{F,t})^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}} \tag{3.14}$$

The CES function assures - similarly to the consumption indices - that the two loan types are not perfectly substitutable. The optimal allocation from the expenditure minimization problem is

$$B'_{H,t} = (1-\mu_t)\left(\frac{R_{H,t}}{R_t}\right)^{-\phi}B'_t; \quad B'_{F,t} = \mu_t\left(\frac{E\{X_{t+1}\}\varrho_tR_{F,t}}{R_t}\right)^{-\phi}B'_t \tag{3.15}$$

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[1]In this case denoted by C'_t, H'_t and N'_t.

[2]The different discount factors ensure that the patient household will save, while the impatient one will borrow.

[3]Trivially, $S_t = 1$ is equivalent to zero, while $S_t > 1$ to positive support.

[4]With steady state FCL stock it has no effect. κ measures the elasticity of risk premium wrt. foreign debt.

[5]The role of Π_B is discussed later.

where $R_t \equiv \left[(1-\mu_t)R_{H,t}^{1-\phi} + \mu_t(E\{X_{t+1}\}\varrho_t R_{F,t})^{1-\phi}\right]^{\frac{1}{1-\phi}}$ denotes the aggregate loan price index. Accounting for the above optimality conditions, the budged constraint can be rewritten as

$$\begin{aligned} P_t C'_t + Q_t[H'_t - (1-\delta_H)H'_{t-1}] + R_{t-1}B'_{t-1} - \varrho_{t-1}R_{F,t-1}X_t(S_t-1)B'_{F,t-1} \\ = B'_t + W_t N'_t + \Pi_{B,t} \end{aligned} \tag{3.16}$$

Moreover, the impatient household faces a collateral constraint

$$R_t B'_t \leq m Q_t H'_t \tag{3.17}$$

which holds with equality due to $\beta' < \beta$, and captures the fact that in case of default the creditor can sell the debtors house with some $(1-m)$ loss/transaction cost. The derived optimality conditions are somewhat similar to the ones of the patient household:

$$N_t'^{\varphi} = \frac{W_t}{P_t C'_t} \tag{3.18}$$

$$\frac{(R_t - m)Q_t}{R_t P_t C'_t} = \frac{j}{H'_t} + \beta' E\left\{\frac{(1-\delta_H)Q_{t+1} - mQ_t}{P_{t+1}C'_{t+1}}\right\} \tag{3.19}$$

3.2 Banking sector

While the supply of foreign currency loans is infinite on the given price (set by a foreign monetary authority with an exogenous process in the model), the domestic loan is supplied by a bank, which in turn collects deposit from the patient household. Since interest rate on deposit is set by the monetary authority, but the size of $B'_{H,t}$ has to be equal to D_t, the bank acts as a monopoly. This ensures that setting of the interest rate on $B'_{H,t}$ takes place with accounting for its demand. The objective function of the bank henceforth given by

$$\max_{R_{H,t},D_t} \quad \Pi_{B,t} = R_{H,t}B'_{H,t} - R_{D,t}D_t \tag{3.20}$$

subject to the resource constraint $B'_{H,t} = D_t$ and internalizing the demand equation (3.15). The resulting first-order condition gives the optimal price of the domestic currency loan:

$$R_{H,t} = \frac{\Phi}{\Phi - 1}R_{D,t} \tag{3.21}$$

Because the mark-up ($\frac{\Phi}{\Phi-1}$) on the marginal cost results in an implicit welfare-reduction for the impatient household, the profit of the bank ($\Pi_{B,t}$) is transferred back to offset this effect in the model.

3.3 Production sector

Domestic firms supply differentiated goods - the rate of differentiation is given by ϵ - and thus compete monopolistically in the goods market. Otherwise they are identical (their production functions are the same):

$$Y_t(i) = A_t K_{Y,t}(i)^{\nu} N_{Y,t}(i)^{1-\nu} \tag{3.22}$$

with $Y_t(i)$ standing for output of a firm, $K_t(i)$ for capital, and A_t denotes the productivity term, which follows an AR(1) process in its logarithm:

$$a_t = \rho_a a_{t-1} + \zeta_{a,t} \tag{3.23}$$

where $a_t \equiv log(A_t)$. Moreover $Y_t \equiv \left[\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}}$ represents an index for the aggregate output, analogous to the ones introduced for the households' consumption. [6]

Price stickiness is introduced into the model using Calvo pricing based on Calvo (1983). A firm can set its price with $(1-\theta)$ probability each period, and this probability is independent of the time elapsed since its last price resetting. Accordingly, the optimal price setting strategy of a firm is given by the following maximization problem[7]:

$$\max_{\bar{P}_t} \quad \sum_{k=0}^{\infty} \theta^k E_t\{\Omega_{t,t+k}(\bar{P}_t Y_{t+k} - \Psi(Y_{t+k}))\} \tag{3.24}$$

where $\Omega_{t,t+k} \equiv \beta^k \frac{C_t}{C_{t+k}} \frac{P_t}{P_{t+k}}$ is the stochastic discount factor and $\Psi(.)$ denotes the cost function, which takes the form of $\Psi(Y_t) \equiv \left(\frac{R_{K,t}}{\nu}\right)^{\nu} \left(\frac{W_t}{1-\nu}\right)^{1-\nu} \frac{Y_t}{A_t}$

With internalizing the demand equations coming from the households' optimization and the goods market equilibrium

$$Y_{t+k}(\bar{P}_t) = \left(\frac{\bar{P}_t}{P_{H,t+k}}\right)^{-\epsilon} (C_{H,t+k} + C'_{H,t+k} + C^*_{F,t+k}) \tag{3.25}$$

the first-order condition takes the form

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{\Omega_{t,t+k} Y_{t+k} \left(\bar{P}_t - \frac{\epsilon}{\epsilon-1} MC_{t+k}\right)\right\} \tag{3.26}$$

[6]Trivially, $\Pi_{F,t} = \int_0^1 [P_{H,t}(i)Y_t(i) - \Psi(Y_t(i))]\, di$ gives the per-period aggregate profit of the firms, with $\Psi(.)$ being the cost function. The firms are assumed to have foreign owners, thus, profit goes to abroad.

[7]Since all firms resetting prices in any given period will choose the same price (they are identical), the i subscript henceforth can be dropped here.

with MC_{t+k} being the marginal cost of the firm, and given by

$$MC_t \equiv \left(\frac{R_{K,t}}{\nu}\right)^{\nu} \left(\frac{W_t}{1-\nu}\right)^{1-\nu} \frac{1}{A_t} \tag{3.27}$$

After several transformations the usual log-linearized inflation equation is yielded:

$$\pi_{H,t} = \frac{(1-\theta)(1-\theta\beta)}{\theta}\hat{mc}_t + \beta E\{\pi_{H,t+1}\} \tag{3.28}$$

where $\pi_{H,t} = log(P_{H,t}) - log(P_{H,t-1})$ is the price inflation of domestic goods and $\hat{mc}_t$ denotes deviation of the real aggregated marginal cost (in this case being equivalent to the individual marginal cost) in logarithmic terms from its steady state rate ($\bar{mc} = log\left(\frac{\epsilon-1}{\epsilon}\right)$).

Furthermore, the optimal factor utilization of the firms is given by

$$N_{Y,t}(i) = \left(\frac{W_t}{R_{K,t}}\frac{\nu}{1-\nu}\right)^{1-\nu} \frac{Y_t}{A_t}; \quad K_{Y,t}(i) = \left(\frac{W_t}{R_{K,t}}\frac{\nu}{1-\nu}\right)^{-\nu} \frac{Y_t}{A_t} \tag{3.29}$$

3.4 Housing and capital sector

Housing stock is also produced with a Cobb-Douglas production function, but in contrast to the goods market, there is only one, perfectly competitive representative firm, which can set her price constantly. [8] As the maximization problem is given by

$$\max_{\Delta H_t^S, N_{H,t}, K_{H,t}} Q_t \Delta H_t^S - (W_t N_{H,t} + R_{K,t} K_{H,t}) \tag{3.30}$$

[8]This is an obvious simplification, but the inclusion of housing plays role only in the households' borrowing decision, so there is no need to make its production more sophisticated.

subject to the production function

$$\Delta H_t^S = A_t K_{H,t}^{\chi} N_{H,t}^{1-\chi} \tag{3.31}$$

the first order conditions take a form of

$$R_{K,t} = \chi Q_t A_t \left(\frac{N_{H,t}}{K_{H,t}}\right)^{1-\chi} \tag{3.32}$$

$$W_t = (1-\chi) Q_t A_t \left(\frac{N_{H,t}}{K_{H,t}}\right)^{-\chi} \tag{3.33}$$

In the model capital is provided by a separate sector (with one representative firm), which is owned by foreign actors and operates in a perfectly competitive environment. The maximization problem is given by

$$\max_{I_t} \quad \Pi_{K,t} = (1-\tau_{R,t}) R_{K,t} K_t - P_{F,t} I_t \tag{3.34}$$

where capital (K_t) and investment (I_t) are related through the law of motion for capital [9]:

$$K_t = (1-\delta_K) K_{t-1} + I_t^{\gamma} \tag{3.35}$$

As earlier, $P_{F,t}$ denotes the price of the foreign composite good, and the logic behind this model specification is the following. Foreign products are assumed to be transformable into capital with an $F(.) = I_t^{\gamma}$ production function, and thus $P_{F,t}$ occurs as some kind of opportunity cost.

[9]We can make the decision static without loss of intuition regarding evolution of capital and investment decisions.

The optimal investment decision is henceforth given by

$$I_t = \left[\gamma \frac{(1-\tau_{K,t})R_{K,t}}{P_{F,t}}\right]^{\frac{1}{1-\gamma}} \tag{3.36}$$

3.5 Foreign sector

Assuming a representative foreign household with identical decision problem to the patient domestic household's, the following *ad hoc* export demand equation can be introduced[10]:

$$C_t^*(i) = P_{F,t}^*(i)^{-\epsilon} C_t^* \quad \forall i \in [0,1] \tag{3.37}$$

where $P_{F,t}^*(i)$ is the price of good i denominated in foreign currency. Consequently, we can rewrite it in terms of the domestic price and the exchange rate as

$$C_t^*(i) = \left(\frac{P_{H,t}(i)}{X_t}\right)^{-\epsilon} C_t^* \quad \forall i \in [0,1] \tag{3.38}$$

In order to make the foreign prices ($P_{F,t}$, $R_{F,t}$) and aggregate demand (C_t^*) independent of domestic shocks, they are assumed to be determined by exogenous processes[11], where small letters denote logarithms, variables without t subscript denote steady state values[12]

$$P_{F,t} = (1-\rho_P)P_F + \rho_P p_{F,t-1} e^{\zeta_{P,t}} \tag{3.39}$$

[10]Assumptions and rough derivation of the export demand equation can be found in the Appendix A.1.

[11]Demand for goods and loans from the domestic households is negligible compared to the foreign sector, moreover, we are not interested in the process how prices are determined in the foreign economy, so I make them totally exogenous.

[12]Assuming similar preferences and decision problem for the abroad, $C^* = C_H$

$$R_{F,t} = (1-\rho_R)R_F + \rho_R R_{F,t-1} e^{\zeta_{R,t}} \tag{3.40}$$

$$C^*_{F,t} = (1-\rho_C)C^*_F + \rho_C C^*_{F,t-1} e^{\zeta_{C,t}} \tag{3.41}$$

The nominal exchange rate is given by the ratio of the the price indeces of the tradable goods $X_t \equiv \frac{P_{H,t}}{P_{F,t}}$ with the implicit assumption that FCLs has no direct impact on the exchange rate. The assumption is reasonable, since the additional foreign currency demand related to the provisions of the government is financed from the central bank's reserve. (The second round effects coming from for instance the change in risk premium are ignored for the purposes of the thesis.)

3.6 Market equilibrium

The market equilibrium in the domestic economy is determined by the following equations (from which the first one has already been used at the firms' pricing decision):

$$C_{H,t}(i) + C'_{H,t}(i) + C^*_t(i) = Y_t(i) \tag{3.42}$$

$$\Delta H_t + \Delta H'_t = \Delta H^S_t \tag{3.43}$$

$$\int_0^1 N_{Y,t}(i)di + N_{H,t} = N_t + N'_t \tag{3.44}$$

$$\int_0^1 K_{Y,t}(i)di + K_{H,t} = K_t \tag{3.45}$$

The subsidy for the foreign currency loan holders is financed from different sources, where ω_B denotes the ratio of subsidy cost levied directly on the banking sector, part of which can be passed through to costumers; ω_K denotes the ratio of subsidy cost levied on the foreign shareholders (e.g. through extra sectoral taxes), which can bias their investment decisions; and finally $(1 - \omega_B - \omega_K)$ is the ratio of subsidy cost levied again on foreign owners, but without any distortionary effect (levied on the firms' profit).

$$\omega_B(S_t - 1)\varrho_{t-1}R_{F,t-1}X_tB'_{F,t-1} = \tau_{R,t}R_{D,t-1}D_{t-1} \tag{3.46}$$

$$\omega_K(S_t - 1)\varrho_{t-1}R_{F,t-1}X_tB'_{F,t-1} = \tau_{K,t}R_{K,t}K_t \tag{3.47}$$

$$(1 - \omega_B - \omega_K)(S_t - 1)\varrho_{t-1}R_{F,t-1}X_tB'_{F,t-1} = \tau_{\Pi,t}\Pi_{F,t} \tag{3.48}$$

The evolution of the subsidy term is given by an AR(1) process in its logarithm

$$s_t = \rho_s s_{t-1} + \zeta_{s,t} \tag{3.49}$$

and the weight of foreign currency loans in the loan index is also governed by a stochastic process

$$\mu_t = \mu_t + \zeta_{\mu,t} \tag{3.50}$$

where the steady state value of μ_t is calibrated exogenously at the beginning of the simulation. The model is closed by a Taylor-type domestic monetary policy rule following Brzoza-Brzezina et al. (2014):

$$\frac{R_{D,t}}{R_D} = \left(\frac{R_{D,t-1}}{R_D}\right)^{\psi_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\psi_\pi} \left(\frac{Y_t}{Y}\right)^{\psi_Y}\right]^{1-\psi_R} e^{\zeta_{R_{D,t}}} \tag{3.51}$$

where variables without the t subscript denote the steady state values, while ψ_π and ψ_Y show the preferences of monetary policy towards inflation and output gap, respectively; ψ_R in turn controls domestic interest rate smoothing and $\zeta_{RH,t}$ is a stochastic monetary policy shock.

3.7 Transmission mechanism

The two examined schemes are modeled in this paper using μ_t and S_t. Through changing μ_t (the ratio of foreign currency loans in the impatient household's loan portfolio) it is possible to follow the effect of the FCL conversion itself, while setting the level of S_t can show how the governmental assistance influences the economy's performance. The ratio (thus ceteris paribus the size, too) of FCLs affects the risk premium, the interest rate of domestic loans (through changing demand) and the financing cost of the impatient household's expenditures. The size of the direct governmental bailout mechanism also influences the impatient household's financing cost, moreover, it distorts the saving and borrowing decision of the households and the investment decision of the foreign actors (both through taxes). Beyond the above direct mechanisms there are further spillover effects as well: changes in prices, output, housing decisions etc. The resultant of all direct and spillover effects is studied in the numerical simulation carried out in Chapter 4.

Chapter 4

Simulations

4.1 Steady state of the model

As usual, shock terms become zero in the non-stochastic steady state

$$\zeta_{a,t} = \zeta_{s,t} = \zeta_{\nu,t} = \zeta_{P,t} = \zeta_{R,t} = \zeta_{C,t} = \zeta_{R_D,t} = 0$$

The evolution processes (3.23) and (3.49) indicates $A = 1$ and $S = 1$, while the latter in turn leads to $\tau_{R,t} = \tau_{K,t} = \tau_{\Pi,t} = 0$ from (3.46) through (3.48). Moreover, in the steady state prices equalize and without frictions identical firms have the same optimal decisions. Thus, $P_H(i) = P_H = P_F = P$, $X = 1$, $Y(i) = Y$, $N_Y(i) = N_Y$ and $K_Y(i) = K_Y$ for all i. Following similar reasoning $C_H(i) = C_H$ and $C'_H(i) = C'_H$ come from the consumers' decision. $C = \frac{1}{1-\alpha}C_H$ follows from (3.7) and (3.11) indicates $R_D = \frac{1}{\beta}$. The equations (3.13) through (3.15) together with the equalizing loan prices, the banking sector optimal decision and $X = 1$ give $\varrho = 1$, $R_H = R_F = R = \frac{\Phi}{\Phi-1}\frac{1}{\beta}$, $B'_H = (1-\mu)B'$ and $B'F = \mu B'$.

Using the above results and substituting the remaining household optimality conditions to each other yields the households' steady state equations. After combining the optimality conditions of the banking, housing, capital and production sector together with the equations characterizing the equilibrium, the remaining steady state conditions are given. The equation system of (A.5) through (A.11)[1] gives the unique steady state of the model economy. Thereafter, the original system of equations has been linearized around this non-stochastic steady state and calibrated to match the characteristics of the Hungarian economy.[2]

4.2 Calibration

In the course of the calibration process three main sources are used: own calculation, parameters from domestic estimations and if none of them were available, standard parameters in the literature.[3] First of all the discount factors are calibrated to be $\beta = 0.99$ and $\beta' = 0.97$ following Jakab and Világi (2008) and the average of Iacoviello (2005), Iacoviello and Neri (2010) and Brzoza-Brzezina et al. (2014), respectively. The depreciation rate of housing stock is chosen to match the average construction to existing stock ratio between 2007-2013: $\delta_H = 0.0052$. The implicit assumption behind this calculation is that with roughly constant population the newly built housing stock plays only a replacement role.[4] Furthermore, the housing utility is calibrated to match the steady state condition[5] coming from (3.10) for the same period: $j = 0.187$.

The calibration of the capital depreciation rate ($\delta_K = 0.025$) is based on Jakab and Világi (2008), as well as the elasticity of labor supply ($\varphi = 8$), the elasticity of substitution across domestic consumption goods ($\epsilon = 6$) and the autoregressive coefficient of foreign prices

[1]All steady state equations are summarized in Appendix A.2.

[2]The linearized model is described in details in Appendix A.3, while the exact steady state values after calibration are summarized in Appendix A.5

[3]The calibrated parameter values are collected in Appendix A.4.

[4]Source of data: Hungarian statistical office (KSH).

[5]$j = \frac{QH(1-\beta(1-\delta_H))}{PC}$

($\rho_P = 0.74$). The other autoregressive parameters (productivity shocks with $\rho_a = 0.552$, foreign demand shocks with $\rho_C = 0.625$ are taken from the estimations of Jakab et al. (2010) and Jakab and Világi (2008). The coefficients of monetary policy are also chosen according the two paper: $\psi_R = 0.761$ (interest rate smoothing) and $\psi_\pi = 1.379$ (response to inflation). Although Hidi (2006) founded that central bank's reaction to the output is insignificant, I let it be different from zero ($\psi_Y = 0.2$) with the implicit observation that the Hungarian monetary council followed a less conservative approach in the last few years.

As Menyhert (2008) estimated a θ between 0.652 and 0.749 for Hungary, my estimations based on the OECD and Eurostat Databases also lie around 0.7 and Gábriel and Reiff (2010) points out a roughly 8 months spell for the domestic prices (which is equivalent to $\theta = 0.625$), the Calvo probability of domestic price changing is set to 0.7. The calibration of output and housing production elasticity with respect to capital ($\nu = 0.35$ and $\chi = 0.3$) is based on Iacoviello and Neri (2010), while the elasticity of substitution between domestic and foreign goods ($\eta = 1.5$), the weight of foreign goods in the aggregate consumption index ($\alpha = 0.184$), the elasticity of risk premium with respect to foreign debt ($\kappa = 0.02$) and the elasticity of substitution between domestic and foreign currency loans ($\Phi = 2$) is chosen according to Brzoza-Brzezina et al. (2014). The elasticity of capital growth with respect to investment ($\gamma = 0.78$) is a simple arbitrary choice with the assumption that investment can be transformed into capital with decreasing return to scale.

The loan to collateral ratio could be set in line with the Hungarian regulations, which maximizes it in 0.8, 0.6 and 0.4 for forint, euro and other currency loans, respectively. However, this law (316/2009. government order) was updated only at the end of 2009, and most of the foreign currency loans were taken without such regulation, thus, I chose $m = 0.8$. This choice is advantageous, because earlier banks could rationally set a similar ratio for FCLs, while at this time it is valid for the almost exclusively used domestic loans. As the steady state value of the weight of FCLs in the aggregate loan index has to be set exogenously by construction, $\mu = 0.65$

is calibrated in order to match the ratio of FCLs to total loan stock at the end of 2011 (Hudecz, 2012). The foreign interest rate shocks are assumed to be permanent ($\rho_R = 1$) in order to use them policy simulations.

The ratio of subsidy cost levied on the banking sector and the foreign shareholders (with and without behavioral effect) is set in order to match the rough burdens implied by the bailout schemes. As most of the burden has been levied on banks, but 30% of their losses is deductable from their sectoral taxes, it seems to be reasonable to set the ratios roughly equivalent: $\omega_B = \omega_K = 0.33$. Finally, the autocorrelation of subsidy shocks is calibrated in order to let the effect of them to decay to almost zero (0.01) within five years (the time frame of the exchange rate ceiling scheme), which corresponds with 20 quarters, with $\rho_s = 0.794$.

4.3 Simulation results

By using meaningful shocks in this model economy it is possible to gain some insights about the economic effects of the FCL bailout schemes. There are three main elements of the schemes which are worth accounting for during the simulation process. One is that during the recession, people faced significantly higher installment *costs* than before, and consequently, they would have liked to have taken optimally less FCL (ex post) or to replace them with forint loans. Second is that by seeing the real risk of FCLs the *preferences* of people towards domestic/foreign currency loans has changed. And the third factor related to the schemes was the government's intention to help the (almost) insolvent households though subsidizing their repayments. The three factors are described by shocks to 1) the exogenous FCL interest rates[6] ($R_{F,t}$), 2) the

[6]Although the main source of rise in installment costs were due to change in the exchange rate, but on one hand it would not be favorable to distort its evolution in the model by imposing an exogenous shock, and on the other hand a substantial amount of the rise originated from other sources (mainly from the banks' unilateral administration price modification).

households' preferences towards holding FCL (μ_t) and 3) the subsidy ratio in the repayments (S_t).

The third shock is calibrated in a way which accounts for the average deviation of the exchange rates from their subsidy-eligibility level during the 2012-2014 period and the rough subsidized ratio of this difference (both explained in Section 2.3). The interest rate shock without accounting for the preference shock would be calibrated in order to match the average increase in the installment costs based on Hudecz (2012) (50%). By using only this shock the resulting impulse response function (IRF) of the foreign currency loan stock would move as in Figure 4.1.

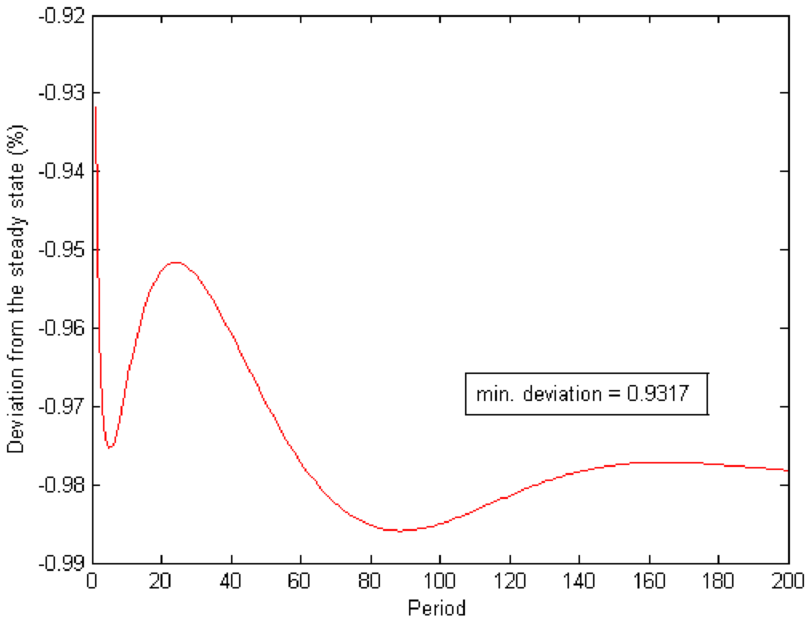

Figure 4.1: Foreign currency loan stock with cost shock

From this result it is obvious that by imposing a shock with this magnitude eliminates almost the whole FCL stock, and leaves no room for the preference shock (which can have different effects on the economy). Consequently, I replace some part of the cost shock by a preference shock, and calibrate $\zeta_{R,t}$ to match a 45% cost increase and $\zeta_{\mu,t}$ to decrease the original

$\mu_t = 0.65$ to $\mu_t = 0.6$.[7] Thus, as illustrated by Figure 4.2, a roughly identical change can be captured in the FCL stock, but having a more sophisticated shock composition.

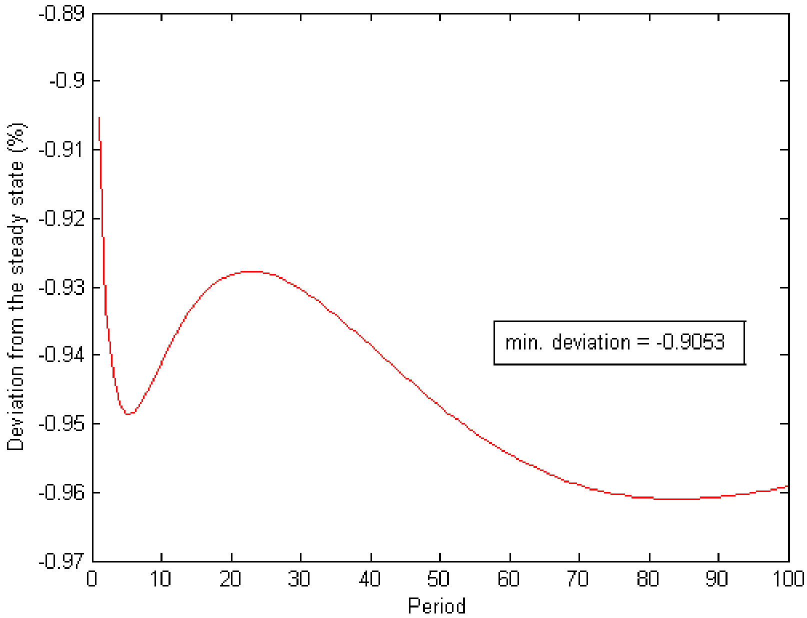

Figure 4.2: Foreign currency loan stock with cost and preference shocks

As the aggregate IRFs of the three shocks characterize the resulting processes in the model economy, it is possible to capture the ceteris paribus effect of the bailout scheme by interpreting them.

As mentioned above - and trivially following from the loan demand functions - by having suffered a cost shock, the borrowing households take less FCLs, and substitute them with domestic loans. However, since the aggregate loan price index is also increasing, not the whole stock is being replaced, thus the aggregate loan stock is also decreasing. Meanwhile, as the

[7] By this setting almost the original size of cost shock is imposed but along with a reasonable (although quite arbitrary) preference shock. I am aware of the fact that an additional positive shock to $\zeta_{S,t}$ increases the demand for foreign currency loans ceteris paribus, but this effect is negligible compared to the other two shocks', and I let it slide.

demand for domestic loans is getting higher, its interest rate is also increasing, motivating the patient households to save more and postpone their consumption.

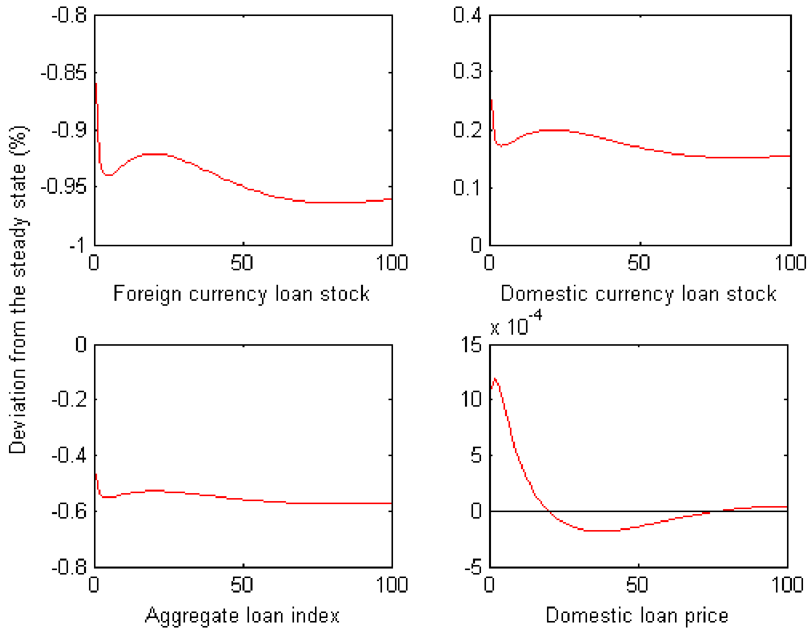

Figure 4.3: Foreign and domestic currency loans

In the starting periods the impatient households consume more partly due to the subsidy's welfare effect, partly due to the loosening collateral constraint, which allows them to spend less on housing (which can be interpreted as selling the family house and buying a flat) and more on consumption. However, later their consumption also decreases due to the worsening economic situation and the higher foreign interest rates.

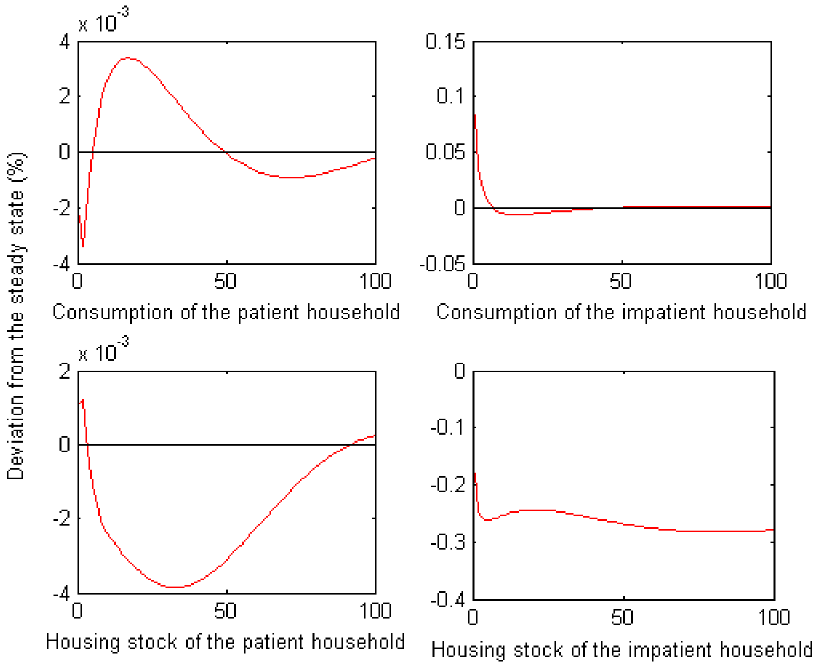

Figure 4.4: Consumption and housing

The aggregate values are moving accordingly. As the movements in the impatient households' indicators are larger in magnitude, they are the main driving force of the aggregate variables. Thus after a short rise in consumption there is a sharp drop, even falling below the steady state value. As the housing stock is also decreasing and never returns to its steady state value, the investments are also falling, which is amplified by the imposed taxes at the starting periods. The aggregate output is moving together with the aggregate demand, but its drop in the middle run is explained by the scarcity in capital as well, which raises the firms' marginal cost. Necessarily, the resulting increase in domestic prices pulls back aggregate consumption, causing a recession.

Thus, although the implementation of the schemes means a temporary improvement in the economic conditions of the model economy, on the whole it not only causes relatively large economic disturbances and welfare redistribution across households, but even a recession in the middle run.

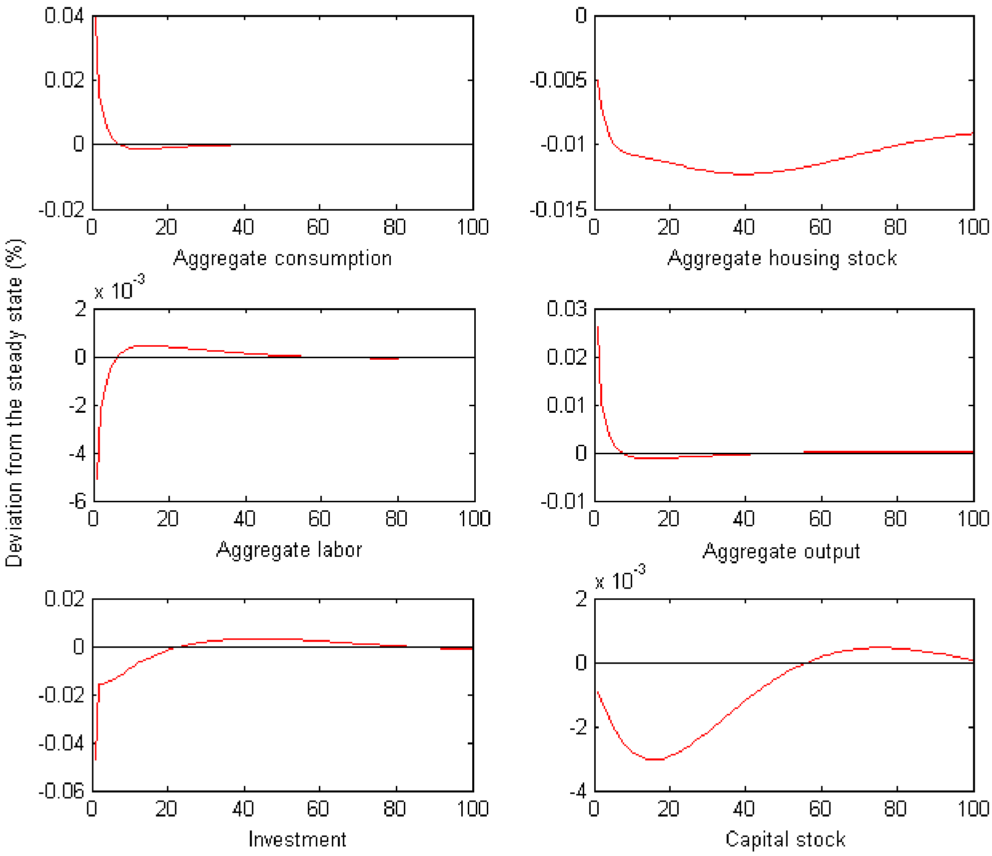

Figure 4.5: Aggregate economic indicators

Chapter 5

Conclusion

Throughout my thesis a New-Keynesian modeling approach was applied to a small open economy, which was supplemented by a linked housing-borrowing part mainly exploiting the features of Iacoviello (2005). After finding the steady state values and log- linearizing the system of solution equations around this non-stochastic steady state, the model was calibrated to match the characteristics of the Hungarian economy.

The simulations describing the behavior of the model economy showed that the foreign currency loan bailout schemes have real economy effects. First, they induce an implicit welfare redistribution, but at the same time, they raise the economic activity and consumption around the time of implementation through loosening liquidity constraints. Unfortunately, in the middle run the economy turns to a recession due to postponed investments and higher financing costs.

Although the above results capture some part of the economic disturbances caused by the FCL bailout schemes, there are some features, which the model cannot account for. One is that due to the permanent change in preferences (and seemingly in financial cost) the *steady state value* of the FCL stock is decreasing, which induces additional change in the risk premium in the middle run. However, a reasonable concern can be that preferences towards domestic and foreign currency loan distribution will change again due to the bailout schemes itself. As people perceive that the government is willing to help highly indebted households, they tend to pay less attention to their borrowing decisions. Since preferences are governed by an exogenous process, the model is not able to control for this moral hazard.

Throughout my work I have endeavored to create a consistent end economically relevant model. Nevertheless, the model has some shortcomings which provide room for later improvements and extension. An extension possibility is the one concerning the risk premium and the evolution of preferences, where including the above mentioned features could improve the model's explanatory power. A similar improvement would be assuming hyperbolic preferences for the impatient household, which could explain foreign currency borrowing even better. Finally, including more or different frictions to the model (Calvo pricing with inflation indexation, banking sector with financial frictions) are also possible to do improvements.

Altogether I conclude that although the whole effect of the FCL bailout schemes can be investigated only several years later, beside their positive impact they also caused several harms to the economy, which can be amplified in the long run.

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Appendix A

Appendix

A.1 Derivation of the export demand equation

Assuming preferences of the foreign household being identical to the domestic ones', the usual expenditure minimization problems give the optimal allocations for imported goods (or exported goods from the perspective of the domestic economy):

$$C^*_{F,t}(i) = \left(\frac{P^*_{F,t}(i)}{P^*_{F,t}}\right)^{-\epsilon} C^*_{F,t} \quad \forall i \in [0,1] \tag{A.1}$$

$$C^*_{F,t} = \alpha^* \left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\eta} C'^*_t \tag{A.2}$$

where $P^*_{F,t} \equiv \left(\int_0^1 P^*_{F,t}(i)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}$ denotes the price index for foreign goods, and $P^*_t \equiv \left[(1-\alpha^*){P^*_{H,t}}^{1-\eta} + \alpha^* {P^*_{F,t}}^{1-\eta}\right]^{\frac{1}{1-\eta}}$ stands for the consumer price index (for the abroad, of course)[1].

[1] $P^*_{F,t}(i) \equiv P_{H,t}(i); \quad P^*_{F,t} \equiv P_{H,t}; \quad P^*_{H,t} \equiv P_{F,t}$

Substituting (A.1) into (A.1), and assuming $\epsilon = \eta$, demand is given by

$$C_t^*(i) = P_{F,t}^*(i)^{-\epsilon} \left(\alpha^* P_t^{*-\eta} C'^*_t\right) \tag{A.3}$$

Taking the whole second term as an exogenous foreign demand, the quasi ad hoc export demand equation is yield:

$$C_t^*(i) = P_{F,t}^*(i)^{-\epsilon} C_t^* \quad \forall i \in [0,1] \tag{A.4}$$

A.2 Equations characterizing the steady state

$$\begin{aligned} W\left(\frac{W(1-\alpha)}{PC_H}\right)^{\frac{1}{\varphi}} = \frac{PC_H}{1-\alpha} + \frac{j\delta_H PC_H}{(1-\alpha)(1-\beta(1-\delta_H))} \\ + \frac{(\beta-1)(1-\mu)jmPC'_H}{\beta(1-\alpha)(\frac{\Phi}{\Phi-1}\frac{1}{\beta}(1-\beta'(1-\delta_H-m))-m)} \end{aligned} \tag{A.5}$$

$$\begin{aligned} \frac{PC'_H}{1-\alpha}\left(1+\frac{j\delta_H\frac{\Phi}{\Phi-1}\frac{1}{\beta}+m\left(\frac{\Phi}{\Phi-1}\frac{1}{\beta}-1\right)}{\frac{\Phi}{\Phi-1}\frac{1}{\beta}(1-\beta'(1-\delta_H-m))-m}\right) \\ = W\left(\frac{W(1-\alpha)}{PC'_H}\right)^{\frac{1}{\varphi}} + \frac{\beta(\Phi-1)(1-\mu)jmPC'_H}{(1-\alpha)(\frac{\Phi}{\Phi-1}\frac{1}{\beta}(1-\beta'(1-\delta_H-m))-m)} \end{aligned} \tag{A.6}$$

$$\left(\frac{R_K}{\nu}\right)^{\nu}\left(\frac{W}{1-\nu}\right)^{1-\nu} = \frac{\epsilon-1}{\epsilon}P \tag{A.7}$$

$$\left(\frac{R_K}{\chi Q}\right)^{\frac{1}{1-\chi}}\left(\frac{(\gamma R_K)^{\frac{\gamma}{1-\gamma}}}{\delta_K} - K_Y\right) + \frac{1-\nu}{\nu}\frac{R_K}{W}K_Y = \left(\frac{W(1-\alpha)}{C_H}\right)^{\frac{1}{\varphi}} + \left(\frac{W(1-\alpha)}{C'_H}\right)^{\frac{1}{\varphi}} \tag{A.8}$$

$$C_H + C'_H + \frac{P^{-\epsilon}}{1-\alpha} C_H = \left(\frac{1-\nu}{\nu} \frac{R_K}{W} \right)^{1-\nu} K_Y \tag{A.9}$$

$$\delta_H (H + H') = \left(\frac{(\gamma R_K)^{\frac{\gamma}{1-\gamma}}}{\delta_K} - K_Y \right) \frac{R_K}{\chi Q} \tag{A.10}$$

$$W = (1-\chi) Q \left(\frac{R_K}{\chi Q} \right)^{-\frac{\chi}{1-\chi}} \tag{A.11}$$

A.3 Loglinearized model

Banking sector

$$r\hat{_{H,t}} = r\hat{_{D,t}} \tag{A.12}$$

$$\pi\hat{_{B,t}} = \Phi(r\hat{_{H,t}} + b\hat{_{H,t}}) - (\Phi - 1)(r\hat{_{D,t}} + \hat{d_t}) \tag{A.13}$$

Capital sector

$$\hat{k_t} = (1-\delta_K) k\hat{_{t-1}} + \gamma \delta_K \hat{i_t} \tag{A.14}$$

$$\hat{i_t} = \frac{1}{1-\gamma} \left((1 \widehat{-} \tau_{K,t}) + r\hat{_{K,t}} - p\hat{_{F,t}} \right) \tag{A.15}$$

Housing sector

$$\Delta \hat{h}_t^s = \hat{a}_t + \chi k\hat{_{H,t}} + (1-\chi) n\hat{_{H,t}} \tag{A.16}$$

$$r\hat{_{K,t}} = \hat{a}_t + \hat{q}_t + (1-\chi)(n\hat{_{H,t}} - k\hat{_{H,t}}) \tag{A.17}$$

$$\hat{w}_t = \hat{a}_t + \hat{q}_t + \chi (n\hat{_{H,t}} - k\hat{_{H,t}}) \tag{A.18}$$

Patient household

$$\widehat{c_{H,t}}(i) = \widehat{c_{H,t}} - \epsilon(\widehat{p_{H,t}}(i) - \widehat{p_{H,t}}) \tag{A.19}$$

$$\widehat{c_{H,t}} = \hat{c_t} - \eta(\widehat{p_{H,t}} - \hat{p_t}) \tag{A.20}$$

$$\widehat{c_{F,t}} = \hat{c_t} - \eta(\widehat{p_{F,t}} - \hat{p_t}) \tag{A.21}$$

$$\varphi \hat{n_t} = \hat{w_t} - \hat{p_t} - \hat{c_t} \tag{A.22}$$

$$0 = E_t \left\{ \hat{p_t} - \widehat{p_{t+1}} + \hat{c_t} - \widehat{c_{t+1}} + (\widehat{1-\tau_{R,t+1}}) + \widehat{r_{D,t}} \right\} \tag{A.23}$$

$$0 = \hat{p_t} + \hat{c_t} - \hat{q_t} - \hat{h_t} + \beta(1-\delta_h) E_t \left\{ \hat{h_t} + \widehat{q_{t+1}} - \widehat{p_{t+1}} - \widehat{c_{t+1}} \right\} \tag{A.24}$$

$$\begin{aligned} \frac{1-\beta(1-\delta_H)}{j}(\hat{p_t} + \hat{c_t} - \hat{w_t} - \hat{n_t}) + \delta_H(\hat{q_t} - \widehat{h_{t-1}} - \hat{w_t} - \hat{n_t}) + \hat{h_t} + \widehat{h_{t-1}} \\ = \frac{D}{QH}\left(\hat{w_t} + \hat{n_t} - \hat{d_t} + \frac{1}{\beta}((\widehat{1-\tau_{R,t}}) + \widehat{r_{D,t-1}} + \widehat{d_{t-1}} - \hat{w_t} - \hat{n_t}) \right) \end{aligned} \tag{A.25}$$

Impatient household

$$\widehat{c'_{H,t}}(i) = \widehat{c'_{H,t}} - \epsilon(\widehat{p_{H,t}}(i) - \widehat{p_{H,t}}) \tag{A.26}$$

$$\widehat{c'_{H,t}} = \widehat{c'_t} - \eta(\widehat{p_{H,t}} - \hat{p_t}) \tag{A.27}$$

$$\widehat{c'_{F,t}} = \widehat{c'_t} - \eta(\widehat{p_{F,t}} - \hat{p_t}) \tag{A.28}$$

$$\hat{b'_{H,t}} = -\frac{\mu}{1-\mu}\hat{\mu_t} + \hat{b'_t} - \Phi(\hat{r_{H,t}} - \hat{r_t}) \tag{A.29}$$

$$\hat{b'_{F,t}} = \hat{\mu_t} + \hat{b'_t} - \Phi(E_t\{\hat{x_{t+1}}\} + \hat{\varrho_t} + \hat{r_{F,t}} - \hat{r_t}) \tag{A.30}$$

$$\varphi\hat{n'_t} = \hat{w}_t - \hat{p}_t - \hat{c'_t} \tag{A.31}$$

$$\hat{b'_t} = \hat{q}_t + \hat{h'_t} - \hat{r}_t \tag{A.32}$$

$$\begin{aligned}
0 = &\left(\frac{\Phi}{\Phi-1}\frac{1}{\beta} - m\right)(\hat{p}_t + \hat{c'_t}) - m\hat{r}_t \\
&+ \left(m - (1-\beta'(1-\delta_H - m))\frac{\Phi}{\Phi-1}\frac{1}{\beta}\right)\hat{h'_t} + \left((1+\beta' m)\frac{\Phi}{\Phi-1}\frac{1}{\beta} - m\right)\hat{q}_t \\
&+ \beta' E_t\left\{\frac{\Phi}{\Phi-1}\frac{1}{\beta}(1-\delta_H)\hat{q_{t+1}} - (1-\delta_H - m)\frac{\Phi}{\Phi-1}\frac{1}{\beta}(\hat{p_{t+1}} + \hat{c'_{t+1}})\right\}
\end{aligned} \tag{A.33}$$

$$\begin{aligned}
&PC'(\hat{p}_t + \hat{c'_t} - \hat{w}_t - \hat{n'_t}) + \frac{\delta_H}{m}\frac{\Phi}{\Phi-1}\frac{1}{\beta}B'(\hat{q}_t - \hat{w}_t - \hat{n'_t} + \hat{h'_{t-1}}) \\
&+ \frac{\Phi}{\Phi-1}\frac{1}{\beta}B'\left(\hat{r_{t-1}} + \hat{b'_{t-1}} - \hat{w}_t - \hat{n'_t} - \mu\hat{s}_t + \frac{1}{m}(\hat{h'_t} - \hat{h'_{t-1}})\right) \\
&= B'(\hat{b'_t} - \hat{w}_t - \hat{n'_t}) + \frac{1}{\beta}\frac{1}{\Phi-1}D(\hat{\pi_{B,t}} - \hat{w}_t - \hat{n'_t})
\end{aligned} \tag{A.34}$$

Other exogenous processes

$$\hat{\mu_t} = \hat{\mu_{t-1}} + \zeta_{\mu,t} \tag{A.35}$$

$$\hat{s}_t = \rho_s\hat{s_{t-1}} + \zeta_{s,t} \tag{A.36}$$

$$\hat{a}_t = \rho_a \widehat{a_{t-1}} + \zeta_{a,t} \tag{A.37}$$

Taylor equation

$$\widehat{r_{D,t}} = \psi_R \widehat{r_{D,t-1}} + (1-\psi_R)(\psi_\Pi \hat{\pi}_t + \psi_Y \hat{y}_t) + \zeta_{R_D,t} \tag{A.38}$$

Risk premium

$$\hat{\varrho}_t = \kappa \frac{\mu B'}{PY} \widehat{b'_{F,t}} \tag{A.39}$$

Production sector

$$\widehat{n_{Y,t}}(i) = (1-\nu)(\hat{w}_t - \widehat{r_{K,t}}) + \widehat{y_t(i)} - \hat{a}_t \tag{A.40}$$

$$\widehat{n_{Y,t}}(\bar{i}) = (1-\nu)(\hat{w}_t - \widehat{r_{K,t}}) + \widehat{y_t(\bar{i})} - \hat{a}_t \tag{A.41}$$

$$\widehat{k_{Y,t}}(i) = -\nu(\hat{w}_t - \widehat{r_{K,t}}) + \widehat{y_t(i)} - \hat{a}_t \tag{A.42}$$

$$\widehat{k_{Y,t}}(\bar{i}) = -\nu(\hat{w}_t - \widehat{r_{K,t}}) + \widehat{y_t(\bar{i})} - \hat{a}_t \tag{A.43}$$

$$\widehat{\pi_{H,t}} = \frac{(1-\theta)(1-\theta\beta)}{\theta}\widehat{mc}_t + \beta E_t \left\{\widehat{\pi_{H,t+1}}\right\} \tag{A.44}$$

$$\widehat{mc}_t = \nu \widehat{r_{K,t}} + (1-\nu)\hat{w}_t - \hat{a}_t - \widehat{p_{H,t}} \tag{A.45}$$

$$\widehat{\pi_{H,t}} = \widehat{p_{H,t}} - \widehat{p_{H,t-1}} \tag{A.46}$$

$$\widehat{y_t(i)} = -\epsilon\left(\widehat{p_{H,t}(i)} - \widehat{p_{H,t}}\right) + \frac{C_H}{Y}\widehat{c_{H,t}} + \frac{C'_H}{Y}\widehat{c'_{H,t}} + \frac{C^*_F}{Y}\widehat{c^*_{F,t}} \tag{A.47}$$

$$\widehat{y_t(\bar{i})} = -\epsilon\left(\widehat{p_{H,t-1}} - \widehat{p_{H,t}}\right) + \frac{C_H}{Y}\widehat{c_{H,t}} + \frac{C'_H}{Y}\widehat{c'_{H,t}} + \frac{C^*_F}{Y}\widehat{c^*_{F,t}} \tag{A.48}$$

$$\widehat{tc_t(i)} = \nu\widehat{r_{K,t}} + (1-\nu)\hat{w}_t + \widehat{y_t(i)} - \hat{a}_t \tag{A.49}$$

$$\widehat{tc_t(\bar{i})} = \nu\widehat{r_{K,t}} + (1-\nu)\hat{w}_t + \widehat{y_t(\bar{i})} - \hat{a}_t \tag{A.50}$$

$$\widehat{\pi_{F,t}(i)} = \epsilon\left(\widehat{p_{H,t}(i)} + \widehat{y_t(i)}\right) - (\epsilon-1)\widehat{tc_t(i)} \tag{A.51}$$

$$\widehat{\pi_{F,t}(\bar{i})} = \epsilon\left(\widehat{p_{H,t-1}} + \widehat{y_t(\bar{i})}\right) - (\epsilon-1)\widehat{tc_t(\bar{i})} \tag{A.52}$$

$$\hat{y}_t = (1-\theta)\widehat{y_t(i)} + \theta\widehat{y_t(\bar{i})} \tag{A.53}$$

$$\widehat{\pi_{F,t}} = (1-\theta)\widehat{\pi_{F,t}(i)} + \theta\widehat{\pi_{F,t}(\bar{i})} \tag{A.54}$$

Abroad

$$\hat{x}_t = \widehat{p_{H,t}} - \widehat{p_{F,t}} \tag{A.55}$$

$$\widehat{c^*_{F,t}(i)} = -\epsilon(\widehat{p_{H,t}(i)} - \hat{x}_t) + \widehat{c^*_{F,t}} \tag{A.56}$$

$$\hat{r_{F,t}} = \rho_R \hat{r_{F,t-1}} + \hat{\zeta_{R,t}} \tag{A.57}$$

$$\hat{p_{F,t}} = \rho_P \hat{p_{F,t-1}} + \hat{\zeta_{P,t}} \tag{A.58}$$

$$\hat{c^*_{F,t}} = \rho_C \hat{c^*_{F,t-1}} + \hat{\zeta_{C,t}} \tag{A.59}$$

Equilibrium[2]

$$H\hat{h_t} - (1-\delta_H)H\hat{h_{t-1}} + H'\hat{h'_t} - (1-\delta_H)H'\hat{h'_{t-1}} = \delta_H(H+H')\Delta\hat{h}^s_t \tag{A.60}$$

$$(1-\theta)N_Y\hat{n_{Y,t}}(i) + \theta N_Y \hat{n_{Y,t}}(\bar{i}) + N_H\hat{n_{H,t}} = N\hat{n_t} + N\hat{n'_t} \tag{A.61}$$

$$(1-\theta)K_Y\hat{k_{Y,t}}(i) + \theta K_Y \hat{k_{Y,t}}(\bar{i}) + K_H\hat{k_{H,t}} = K\hat{k_t} \tag{A.62}$$

$$\hat{c^a_t} = \frac{C}{C+C'}\hat{c_t} + \frac{C'}{C+C'}\hat{c'_t} \tag{A.63}$$

$$\hat{h^a_t} = \frac{H}{H+H'}\hat{h_t} + \frac{H'}{H+H'}\hat{h'_t} \tag{A.64}$$

$$\hat{n^a_t} = \frac{N}{N+N'}\hat{n_t} + \frac{N'}{N+N'}\hat{n'_t} \tag{A.65}$$

[2] $\hat{c^a_t}$, $\hat{h^a_t}$ and $\hat{n^a_t}$ denotes aggregate consumption, housing stock and labor, respectively.

$$\widehat{(1-\tau_{K,t})} = -\frac{\omega_K \mu B'}{\beta R_K K}\hat{s}_t \tag{A.66}$$

$$\widehat{(1-\tau_{R,t})} = -\frac{\omega_B \mu B'}{D}\hat{s}_t \tag{A.67}$$

$$\widehat{(1-\tau_{\Pi,t})} = -\frac{(1-\omega_K-\omega_B)(\epsilon-1)\mu B'}{\beta\left(\frac{R_k}{\nu}\right)^{\nu}\left(\frac{W}{1-\nu}\right)^{1-\nu} Y}\hat{s}_t \tag{A.68}$$

Price indices

$$\hat{p_t} = (1-\alpha)\hat{p_{H,t}} + \alpha \hat{p_{F,t}} \tag{A.69}$$

$$\hat{p_{H,t}} = (1-\theta)\widehat{p_{H,t}}(i) + \theta \hat{p_{H,t-1}} \tag{A.70}$$

$$\hat{r_t} = (1-\mu)\hat{r_{H,t}} + \mu\left(E_t\{\hat{x_{t+1}}\} + \hat{\varrho}_t + \hat{r_{F,t}}\right) \tag{A.71}$$

A.4 Calibrated parameter values

Parameter	Value	Description
β	0.99	Discount factor of domestic patient household
β'	0.97	Discount factor of domestic impatient household
δ_K	0.025	Depreciation rate of capital stock
δ_H	0.0052	Depreciation rate of housing stock
j	0.187	Weight on housing in utility function
η	1.5	Elasticity of substitution btw. domestic and foreign consumption goods
ϵ	6	Elasticity of substitution across domestic consumption goods
α	0.184	Weight of foreign goods in the aggregate consumption index
φ	8	Labor supply elasticity
κ	0.02	Elasticity of risk premium wrt. foreign debt
Φ	2	Elasticity of substitution btw. domestic and foreign loans
m	0.8	Loan to collateral ratio
μ	0.65	Weight of foreign currency loans in the aggregate loan index
θ	0.7	Calvo probability for domestic prices
ν	0.35	Output elasticity wrt. capital
χ	0.3	Housing production elasticity wrt. capital
γ	0.78	Elasticity of capital growth wrt. investment
ω_B	0.33	Ratio of subsidy cost levied on the banking sector
ω_K	0.33	Ratio of subsidy cost levied on the foreign shareholders
ρ_a	0.552	Autocorrelation of productivity shocks
ρ_s	0.794	Autocorrelation of subsidy shocks
ρ_P	0.74	Autocorrelation of foreign price shocks
ρ_R	1	Autocorrelation of foreign interest rate shocks
ρ_C	0.625	Autocorrelation of foreign demand shocks
ψ_R	0.761	Interest rate smoothing in Taylor rule
ψ_π	1.379	Response to inflation in Taylor rule
ψ_Y	0.2	Response to output in Taylor rule

Table A.1: Calibrated parameter values

A.5 The exact steady state values

Variable	Value	Description
C	0.4238	Consumption of the patient household
C'	0.4043	Consumption of the impatient household
C_H	0.3458	Domestic consumption of the patient household
C'_H	0.3299	Domestic consumption of the impatient household
C_F	0.0780	Foreign consumption of the patient household
C'_F	0.0744	Foreign consumption of the impatient household
H	6.4872	Housing stock of the patient household
H'	0.2259	Housing stock of the impatient household
N	1.0069	Labor of the patient household
N'	1.0128	Labor of the impatient household
D	0.0007	Deposit of the patient household
B'	0.0019	Loan of the patient household
B'_H	0.0007	Domestic loan of the patient household
B'_F	0.0012	Foreign currency loan of the patient household
P	0.0260	Domestic price index
P_H	0.0260	Price index of domestic goods
P_F	0.0260	Price index of foreign goods
Q	0.0210	Price of housing
W	0.0117	Labor compensation
R_D	2.0202	Compensation for deposit
R	1.0101	Loan price index
R_H	2.0202	Price of domestic loan
R_F	2.0202	Price of foreign loan
ϱ	1.0000	Risk premium
R_K	0.0108	Interest on capital
K	0.7372	Capital stock
I	0.0060	Investment
K_Y	0.7169	Capital used for production
K_H	0.0203	Capital used for housing
N_Y	1.2361	Labor used for production
N_H	0.0440	Labor used for housing
Y	1.0215	Total output
Δ_H^S	0.0349	Housing construction
C_F^*	0.3458	Foreign demand
C^a	0.8281	Aggregate consumption
H^a	6.7131	Aggregate housing stock
N^a	2.0197	Aggregate labor

Table A.2: Steady state values after calibration