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The Impact of Financial Crisis and Policy Response in Croatia

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The Impact of Financial Crisis and Policy Response in Croatia*

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Abstract

We conducted the simulation of the impact of financial crisis on Croatian economy using the newly developed DSGE model for Croatia. We model the impact of the crisis by proxing it with two distinct shocks: an increase in foreign interest rate (cost of foreign borrowing) and a drop in export demand. Furthermore, we introduce monetary policy response in the form of regulatory requirement reduction. The results to a large extent match the actual data confirming the early impact of the crisis. More precisely, the financial crisis led to significant slowdown in real activity, international trade and financial aggregates. The real activity is in decline, despite significant monetary policy response. With monetary policy regime based on a stable exchange rate, the central bank is limited in its attempt to counter the impact of the foreign shocks, and significantly stimulate the real activity by simply adjusting the regulatory framework. By decreasing the regulatory burden and thereby increasing the banks' liquidity, the CNB managed only partially (and to the small extent) to offset the negative impact of the foreign shock(s). However, this limited success must be evaluated in the context of highly eurolized small open economy, where the primary goal of the monetary authority is to keep the exchange rate broadly stable.

Keywords: Small and open economy, financial crisis, eurozation.

*This paper represents personal opinion of the authors and does not necessarily reflect the views of the Croatian National Bank. We would like to thank David Vavra, Jaromir Benes and Jan Vlček for helping us with model development, as well as Ana-Maria Čeh and Vjerana Spajić for help with paper editing.

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1 Introduction

The current economic and financial crisis presents a new and large challenge for monetary policy throughout the world. In order to understand the possible impact of the crisis and choose the appropriate policy response, it is important to understand the mechanism by which the crisis propagates throughout the economy. In a case of a small and open economy, the impact of the crisis comes from abroad in form of smaller and dearer capital (in)flows and weaker export demand. The question is how to analyze this effect. It is widely accepted that due to large and unprecedented shocks, standard econometric methods for assessing the possible impacts of this crisis may not be appropriate. For that reason, we built a dynamic stochastic general equilibrium model (DSGE) of a small and open economy to analyze the impact of the crisis on Croatian economy as well as the monetary policy response. The model was initially built[1] as a policy analysis tool to be used for assessing different scenarios. Therefore it includes many sectors with many shocks in order to capture as much of the real world as possible. As such, the model is not simulated and evaluated in terms of standard norms found in the "academic" DSGE literature. Instead, the output of our model are impulse responses of macroeconomic variables of interest which are used as a practical guidance for understanding possible economic developments in Croatia.

The model differs from the standard inflation targeting model because of different monetary policy regime. Large eurozation present in Croatian economy and, in particular, in the financial sector, makes the nominal exchange rate the natural anchor. Keeping the exchange rate stable has been very successful for achieving low inflation during the last 15 years and has contributed to the stability of the financial system. Therefore, standard monetary instruments, such as foreign exchange interventions and domestic liquidity management, are used primarily to keep the exchange rate stable. Instead, the Croatian National Bank (CNB) relies heavily on administrative measures, in particular different regulatory requirements (similar to reserve requirement), in order to influence the domestic economy through the banking system.

We model the impact of the crisis by proxing it with two distinct shocks. More precisely, the exogenous increase in foreign interest rate (cost of foreign borrowing)

[1]The CNB received the IMF's Technical Assistance for building a macroeconomic model as a policy tool. The external experts involved in building and development of the model are Jaromir Benes, David Vavra and Jan Vlcek.

and a drop in export demand are assumed to be the triggers how the world financial crises effects Croatian economy. Furthermore, we introduce monetary policy response in the form of regulatory requirement reduction. The magnitudes of the shocks are calibrated on actual data, and the model was used for simulation of the impact and analysis of the transmission mechanism of the aforementioned shocks through the model economy.

Results to a large extent correspond to actual and expected macroeconomic development. More precisely, the financial crisis led to significant slowdown in real activity, international trade and financial aggregates. Monetary easing in the analyzed scenario was not able to counter the negative real effect of the financial crisis. However, by reducing the regulatory requirement, the CNB can create enough foreign currency liquidity to offset some of possible problems that could develop in the financial sector.

The paper proceeds as follows. The next section describes the monetary policy framework and recent economic developments in Croatia. It is followed with a detailed description of the model and its calibration and the main findings. The last section concludes.

2 Recent Economic Developments and Financial Crisis

The current financial crisis was slow to unravel. It escalated gradually since Summer 2007 when the problems with subprime mortgages became known. However, the full extent of which those products were spread throughout the financial system had yet to be discovered. By Spring 2008 the US authorities were recapitalizing some of their largest financial institutions. The peak of the financial crisis happened at the end of September 2008 with the fall of Lehman Brothers, which shaked the entire financial world.

The first impact of the financial crisis on the emerging markets[2] was transmitted through financial markets as aversion to risk increased. The stock markets fell worldwide, and capital flows to emerging markets retracted. As a result, the cost of foreign borrowing increased for many emerging markets, despite the expansionary

[2]There was significant drop in commodity prices which severily affected comodity exporters. However, this shock is not particularly important for Croatia. In addition, the slowdown of commodity (especially oil) prices helped as it had positive effect on the economy.

monetary policy by the FED and the ECB that lowered interest rates in developed economies. The increase in the cost of borrowing was particularly pronounced following September 2008 (Figure 1.a).[3]

Faced with increasing borrowing costs, the real activity in Croatia started slowing down from mid-2008.[4] The economy decelerated further by the end of the year, and in the beginning of 2009 a significant recession took place. The annual rate of contraction of industrial production and retail trade was in double digits (Figure 1.b).[5] Similarly, the growth of GDP and personal consumption also slowed down in the second half of 2008 and preliminary data indicate severe recession in the first half of 2009 (Figure 1.c).

As the financial crisis spread to the real sector in developed economies, their final demand also contracted. This decreased the demand for Croatian exports which started to decline since mid-2008. It further affected already weakened demand for both final and intermediary goods, so merchandise imports also contracted. Due to weak domestic consumption, imports contracted more than exports, and the chronic merchandise trade deficit slightly improved (Figure 1.d).

In the financial sector, the CNB measures were successful in keeping the nominal domestic credit growth contained at around 12% per annum for the last few years. However, since the mid-2008, credits to households virtually stopped, and the growth of total credits to private sector slowed further (Figure 1.e). As a result, monetary aggregates also decelerated, especially in the last quarter of 2008 when rumors about problems in mother banks led to a massive deposit withdrawal from Croatian banks. Instead to private sector, banks lent heavily to the government. Interestingly, borrowing from abroad continued, although slower, for both banks and firms, regardless of the interest rate increase (Figure 1.f). Banks borrowed from their owners (mother banks) to obtain necessary funds, especially during the deposit withdrawal in the last quarter of 2008. The CNB encouraged such foreign borrowing by commercial banks as a way of providing necessary foreign liquidity by abolishing the Marginal Reserve Requirement, which during the previous few years presented

[3] The increase in credit default swaps (CDS) might overemphasize the actual increase in the cost of foreign borrowing for emerging markets, since some of the large players in the CDS market faced significant problems so the liquidity of such instruments retracted. Also, virtually no emerging markets issued bonds during 2008, and the actual increase in the price of foreign borrowing is difficult to assess.

[4] Oil prices reached its peak in Summer 2008 which also had additional negative effect on real activity.

[5] Croatia was also severely affected by the natural gas dispute between Ukraine and Russia, as many factories and retailers had to reduce their activity due to temporary gas shortage.

a heavy tax on banks' foreign borrowing.

Increase in domestic interest rates was relatively modest. Interest on short-term loans (to firms) reacted the most, while other kind of loans reacted less. The reason for relatively modest increase in interest rates were the CNB's reaction which decreased regulation cost and also popular pressures which prevented banks to put the entire burden of interest rate increase on borrowers. High interest rate and banks' profits prior to the crises provided additional cushion for banks to be able to bear some of the funding cost. However, there is also the evidence that banks have engaged in credit rationing in order to improve their loan portfolio.

3 Simplified monetary policy framework and policy response in Croatia

Monetary policy in Croatia is based on nominal exchange rate anchor to euro. Such monetary regime was chosen because of large eurozation present in Croatian economy and, in particular, in the financial sector as most of banks' assets and liabilities are in or indexed to foreign currency (primarily euro). This policy has been very successful in achieving low inflation since 1993 and has helped to keep the banking sector stable. The exchange rate is not fixed and small oscillations are tolerated in order to discourage likely speculators. The CNB uses standard monetary policy instruments, such as money market operations and foreign exchange interventions, to keep the exchange rate stable.

However, by concentrating on the exchange rate stability, the central bank lost room for active monetary policy. Also, the central bank's ability to act as a lender of the last resort is greatly reduced and amounts to the level of its foreign currency reserves, as the bulk of commercial banks' liabilities is in foreign currency.[6] In such circumstances, the CNB relies heavily on administrative measures, such as different regulatory requirements, in order to primarily insure banking sector stability but also to influence the domestic economy through banks' behavior.

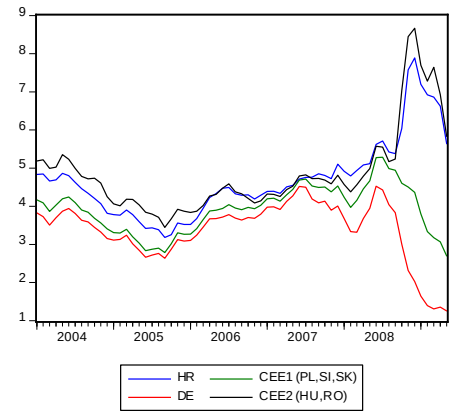
The CNB's regulatory framework is quite complex, and in its core are four different regulations resembling the reserve requirement.[7] The first is the *proper* reserve

[6] The issue of the lender of the last resort in case of crisis was analyzed by Čeh and Krznar (2008).

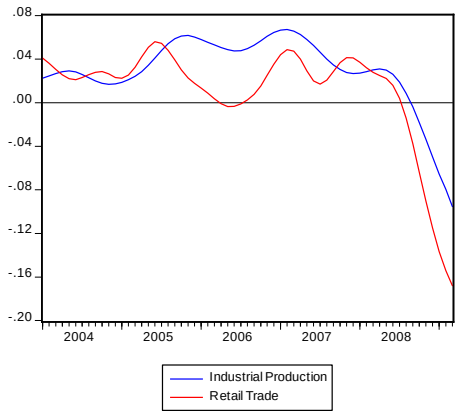
[7] For discussion of reserve requirement see Lang (2007).

Figure 1: Recent Economic Developments

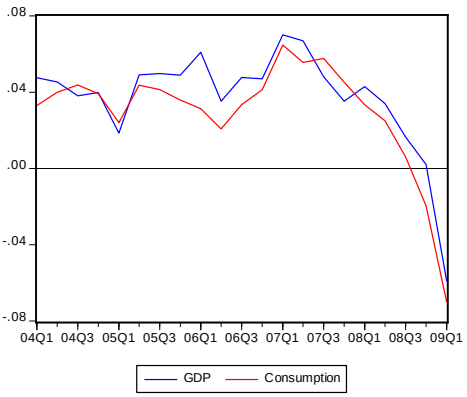
a. Yield to maturity of government bonds
(in percentage points)



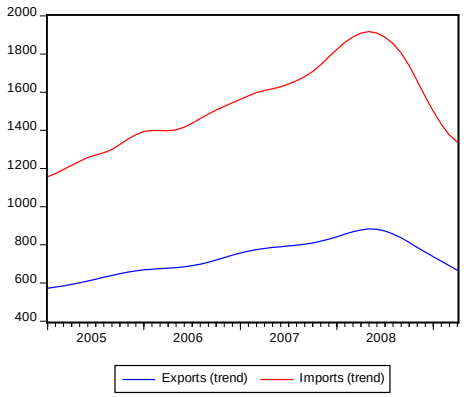
b. Industrial production and retail trade
(annual rate of change YoY)



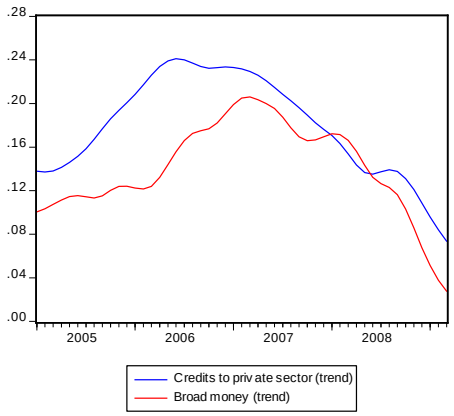
c. GDP and Personal Consumption
(annual rate of change YoY)



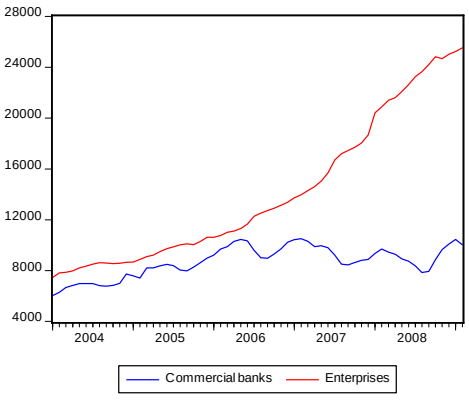
d. Merchandise Trade
(million EUR)

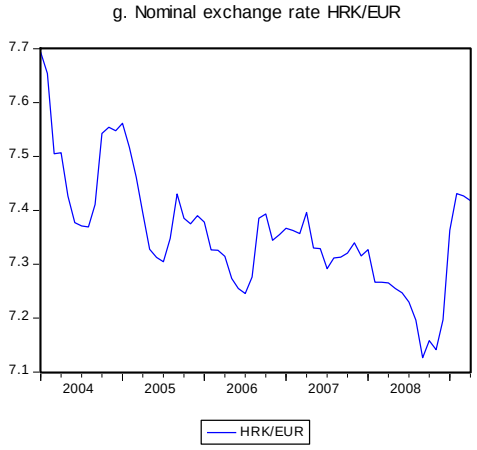


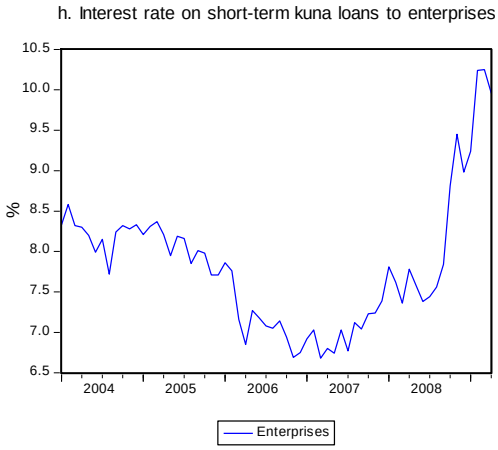
e. Monetary Aggregates
(trend, annual rate of change YoY, constant exchange rate)



f. Foreign Debt
(million EUR)







requirement, which is levied to almost all liabilities, regardless of their maturity.[8] In addition to a very broad base, the rate is also very high and currently amounts to 14%. Furthermore, a part of the reserve requirement is maintained in domestic and another part in foreign currency, both at the CNB and in the form of liquid foreign assets. There have been many changes in the rate, scope and maintenance procedure of the reserve requirement primarily in order to change the monetary policy stance, but also to create and withdraw both kuna and foreign exchange liquidity.

The second type of the regulatory requirements is the Minimum Required Amount of Foreign Currency Claims which requires banks to hold a certain ratio of the foreign currency liabilities in the form of liquid foreign assets. This requirement stems from the facts that Croatian households prefer to keep their savings in foreign currency. Since the central bank is unable to create foreign currency, commercial banks should keep a large share of their foreign currency liabilities in the form of liquid foreign currency assets, so that they can use it when needed. This instrument has also experienced a number of changes in its rate and scope.[9] The rate is quite high and during the last year has been lowered from 32% to 20%, as the main channel for providing foreign currency liquidity, as the capital inflows decreased during the crisis.

The third type of the regulatory requirements was the "Marginal Reserve Re-

[8] All liabilities except capital and liabilities due to the government and central bank.

[9] It was initially levied only on short-term foreign exchange liabilities (up to 1 year) and since 2001 extended to include all foreign currency liabilities; in addition, in 2006 it was extended to include liabilities indexed to foreign currency as commercial banks were encouraging this type of savings due to then lower regulatory cost.

quirement" levied on new commercial banks' foreign borrowing since 2005.[10] It was introduced in order to discourage heavy foreign borrowing by commercial banks in order to finance domestic credit expansion, which was prevalent in mid 2000's. The rate was gradually increased from 25% to 55% of commercial banks new foreign borrowing. This measure managed to stop the growth of commercial banks' foreign borrowing, and was replaced with heavy recapitalization of banks (foreign mother banks increased capital of domestic banks in order not to pay the marginal reserve, which made Croatian banks highly capitalized) and direct foreign borrowing by firms. The marginal reserve was revoked in October 2008 in order to remove a strong obstacle for capital inflows through the banking sector during the crisis.

The last regulatory requirement is a penalty on fast growing banks in form of the Obligatory CNB Bills. Commercial banks whose credit to private sector grow above the certain limit are required to purchase low yielding Obligatory CNB Bills in amount of 75% of the "prohibited" excess credit growth. This measure was in place in 2003 and again since 2006. In both episodes, it effectively managed to decrease the growth of domestic credits in Croatia, while other countries in the region experienced much faster credit growth.

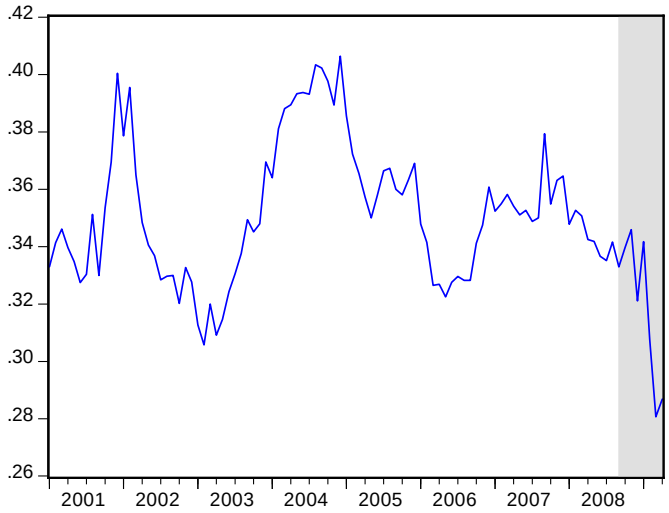
In addition to those regulatory reserve requirements, the CNB requires the commercial banks to meet high capital adequacy requirement. In addition, loans granted in foreign currency (or indexed to fx) to clients who do not have appropriate income or assets in foreign currency are marked as especially risky. As a result, the Croatian banks have entered the financial crisis with higher capital cushion and sounder credit portfolio than banks in the region, which proves to be very helpful in present circumstances.

Such complexity of the described regulatory requirements is quite difficult to model, as each particular requirement can influence the behavior of commercial banks and other economic agents in a slightly different way. In order to simplify our analysis without a loss of generality, we define the "total regulatory cost" as a percentage of liquid assets (defined as banks' assets held at the CNB and foreign assets) to total liabilities (excluding capital accounts and credits received from the government and central bank). The regulatory cost is very high and amounts to approximately a third of total bank liabilities (Figure 2).

Monetary policy response to the financial crisis was limited by the ability of the

[10] There was also Special Reserve Requirement, which was similar to the Marginal Reserve Requirement. It was introduced as some banks tried to circumvent the marginal reserve requirement by issueing domestic securities which were supposed to be purchased by the foreigners.

Figure 2: Regulatory Cost (immobilised assets due to regulation/liabilities). Shaded area shows period after September 2008.



Croatian National Bank to act countercyclically, and at the same time protect the exchange rate stability. In such circumstances, at the beginning of the crisis the CNB reacted strongly in order to prevent the exchange rate depreciation, hoping to reduce the danger of self-fulfilling depreciation expectations (Figure 1.h). This was especially the case since the demise of Lehman Brothers started rumors about similar problems in some Italian banks that own Croatian banks. As confidence in Croatian banks became (temporarily) shaken, a significant withdrawal of household deposits took place in October 2008.[11] In order to protect the exchange rate, the CNB provided foreign currency through foreign exchange interventions and kept domestic money market interest rates high through limited supply of domestic liquidity. While these measures were restrictive in the sense that they increased domestic interest rates, the CNB engaged in a series of measures to relax the regulatory cost (Table 1). This provided the necessary (fx) liquidity to counter the withdrawal of deposits from the banking sector and also to provide additional funding for domestic credits. Moreover, it has particularly helped the government, whose ability to access the financial markets was (temporarily) impaired. In addition, measures put in place during the previous years in order to contain fast credit growth were successful and

[11] Croatian oil company (INA) was purchased by foreign company (MOL), and the transaction was paid in October 2008. This was very helpful as it provided additional capital inflow at very sensitive time. Indeed, the CNB *raised* regulatory tax as it feared that this inflow could bring some appreciation pressures to the economy.

have contributed to the soundness of the Croatian banking system. That further encouraged the foreign mother banks to retain trust in their holdings in Croatia and keep investing in Croatia. Finally, stable exchange rate insured that debt service of households and firms remained intact since most credits are indexed to foreign currency. As a result, the impact of the financial crisis to Croatian banking and financial sector was limited so far.

Table 1: Measures taken by the CNB for containing the impact of the financial crisis

Date	**Change in Regulatory Requirement**	**Impact on Liquidity (Regulation Cost)**
May 2008	Minimum Required Amount of Foreign Currency Claims lowered from 32% to 28.5%	Relaxation
October 2008	Restrictions in the Maintenance of the Required Reserve (cash in vaults no longer counted for maintaining the reserve requirement)	Tightening
October 2008	Marginal Reserve Requirement abolished	Minor Relaxation
December 2008	Reserve Requirement lowered from 17% to 14%	Relaxation
January 2009	Kuna share of maintenance of Reserve Requirement on foreign liabilities raised from 50% to 75%	Tightening
February 2009	Minimum Required Amount of Foreign Currency Claims lowered from 28.5% to 25%	Relaxation
February 2009	Special Reserve Requirement abolished	Minor Relaxation
February 2009	Minimum Required Amount of Foreign Currency Claims lowered from 25% to 20%	Relaxation

4 The model economy

In this section, we first describe the environment of the model. Then we present our model together with its calibration. We provide and interpret the optimality conditions that are used in order to calculate impulse responses in the next section.

4.1 The environment

The model economy consists of nine sectors: households, labor union, domestic producers, retail firms, importers and exporters of final goods, banking sector, monetary authority and foreign sector.

Households consume two types of goods: imported final goods and goods that are produced on domestic market. Both goods are bought on a monopolistically competitive market where households meet importers and retailers. Demand for imported and domestic goods depends on the relative prices (hence on the exchange

rate) and the overall amount of consumption as a function of the households income. We assume persistency of the domestic and imported goods consumption over time, reflecting the existence of habits. Households' labor services are "sold" to the labor union that is involved in a "bargaining" process over households wage with domestic producers. In a bargaining process the union negotiates a wage that keeps track with the domestic prices and workers productivity growth. Since the households are at the same time the owners of the firms (in the model economy), they are entitled to the profits from all of the sectors present in the economy.

Households take loans from banks to finance their consumption expenditure.[12] Excess income is invested in banks' deposit. Therefore, high deposit and loan interest rates make household inclined to postpone their consumption. It is important to point out that the exchange rate will not only affect households decisions about consumption of imported goods, but it will also have intertemporal effects on overall consumption since loans and deposits are linked to the exchange rate.

On the production side, domestic producers use capital, labor and intermediary goods to produce final goods. Capital and oil are imported from abroad, whereas labor is "bought" from the labor union. Producers take loans either from domestic banks or from abroad to pay for their input costs. Demand for loans depends on the relative interest rates (making substitution between domestic and foreign financing possible) and the total borrowing (that depends on the total production). Produced final goods are sold to retail firms. The amount of produced final goods depends on the cost of production (determined by interest rates on loans, kuna depreciation, and factor prices) and retailers' demand that is induced by the households demand for domestic goods. To close down the producer sector, under the assumption of small open economy we model exporting firms' behavior as exogenous.

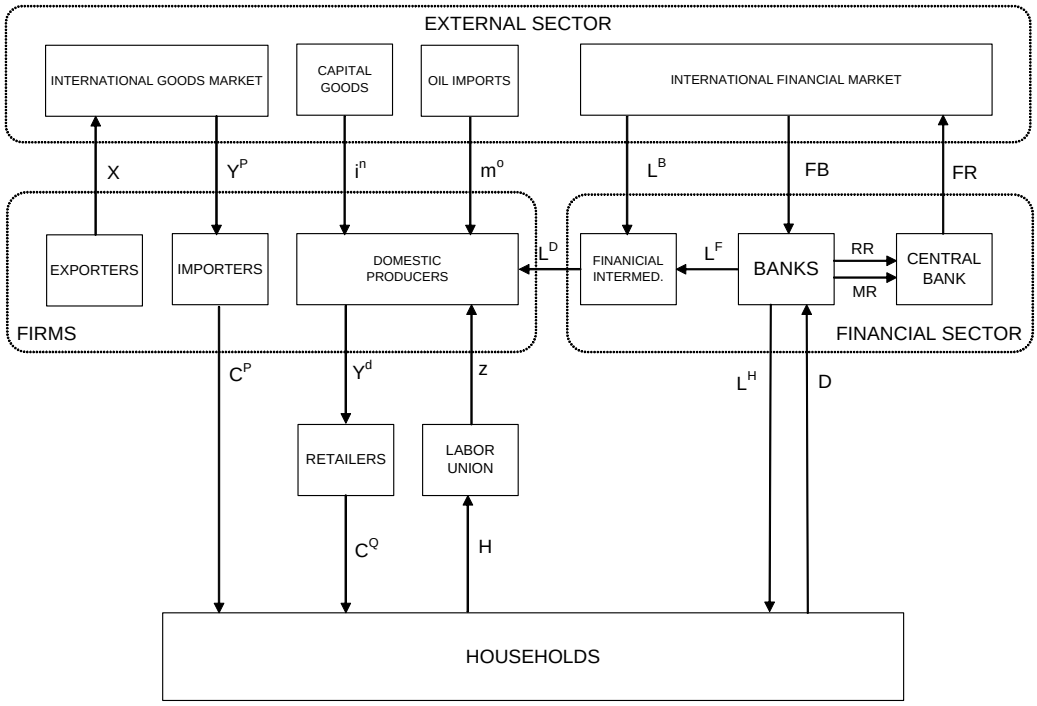
Finally we describe the financial side of the model. We treat domestic banks as loan granting institutions to both households and domestic producers. To finance loans, banks collect deposits from households and borrow from abroad thereby making interest rates on households' and producers' loans dependent on the foreign interest rate. Moreover, the regulation costs in terms of reserve requirements imposed by monetary authority as well as the aggregate amount of deposits and loans determine the interest rates charged by the commercial banks. The exchange rate has

[12] We assume full eurization in our model economy, making the loans fully indexed to the exchage rate. Although it might seem extreme, it makes sense because of the high eurization in banking sector; at the same time, it simplifies the models analitical tractability without having an impact on the general results.

negligible effects on the interest rates since banks completely transfer the exchange rate risk to households and firms as a consequence of the full eurozation assumption (household income, wages and profits, are in domestic currency). In order to make the model suitable for policy analysis in the context of the Croatian economy, we model monetary authority as the one in charge of the reserve requirement rate imposed on both total and specifically foreign liabilities of commercial banks.

The structure of our model economy is shown in Figure 3.

Figure 3: The Structure of the Model Economy



4.2 Households

We assume the existence of a continuum of infinitely lived households, of measure one. All households have identical preferences (that are subject to preference shock - shock to the discount rate, e_t^{cd}) over a real composite consumption index, q_t and leisure, $(1 - H_t)$, where H_t denotes hours spent at work (normalized to one). The composite index represents a bundle of real consumption of imported goods, c_t^p, real consumption of domestically produced goods, c_t^q, past consumption of both type of goods denoted by h_t^p and h_t^q. Both imported and domestic good represent a bundle of different varieties of the same good, c_{it}^p and c_{it}^q, respectively, over which households

do not form habits. Imported goods are bought from importers, whereas domestic goods are bought from retailers. Preferences are represented by constant relative risk aversion utility function. We consider simple time additive non-persistent habit specification proposed by Constantinides (1990).[13]

On the other hand, households "sell" their working services, H_t, to domestic producers, letting the labor union to negotiate their wages. In exchange for their work household obtain wages v_t. Household takes a bank loan to buy goods[14], l_t^h, that is repaid the next period, together with the interest $(1+i_t^h)$. As already pointed out, we assume full eurozation so the interest rate on loans is completely indexed to the exchange rate change, $\frac{s_t}{s_{t-1}}$. In addition to consumption decision on both type of goods, households also decide on the amount of their savings in the form of real deposits, d_t. We also assume incomplete markets thereby making it impossible for the representative household to fully insure against aggregate shocks.

We can state the representative household optimization problem as follows:

$$\max_{\{d_t,l_t^h,q_t,c_t^q,c_t^p,H_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} (\beta^t \exp(e_t^{cd})) \left[\frac{q_t^{1-\sigma}}{1-\sigma} - \frac{H_t^{1+\eta}}{1+\eta} \right] \tag{1}$$

subject to a nominal budget constraint :

$$\begin{aligned} P_t d_t + P_t^q c_t^q + P_t^p c_t^p + (1+i_{t-1}^h)\frac{s_t}{s_{t-1}} P_{t-1} l_{t-1}^h &= v_t H_t + P_t l_t^h + (1+i_{t-1}^d)\frac{s_t}{s_{t-1}} P_{t-1} d_{t-1} + \pi_t + \\ &+ P_{t-1}\vartheta(D_{t-1}, L_{t-1}) + AC_t + e_t^{bop} \end{aligned} \tag{2}$$

a credit-in-advance constraint

$$\kappa^h (P_t^q c_t^q + P_t^p c_t^p - \varphi^h (P_{ss}^q c_{ss}^q + P_{ss}^p c_{ss}^p)) \exp(e_t^{lh}) \frac{1}{1-\varphi^h} = P_t l_t^h \tag{3}$$

with

$$d_{-1},\ l_{-1}^h \text{ given.}$$

where β is the discount rate, P_t^q and P_t^p denote prices of domestically produced and imported goods, κ^h is the share of consumption purchases financed through a bank

[13] In other words we adopt "externatl habits" or "Catching up with the Joneses" formation. This assumption allows us to capture hump-shaped impulse responses of the consumption.

[14] When buying goods household only need to borrow a certain percentage of the consumption bundle price. This threshold value takes the value of the steady state consumption of non-tradable and tradable goods with the parameter of elasticitiy of household loans to consumption beeing different from one.

loan, φ^h is the parameter that controls elasticity of loans with respect to consumption. Parameter σ denotes utility curvature parameter (coefficient of relative risk aversion). The cost of financial intermediation, $\vartheta(D_{t-1}, L_{t-1})$, and all adjustment costs[15], AC_t, are transferred to households as a lump sum for the reasons explained later. Adjustment costs include adjustment costs on capital, employment, oil (faced by domestic producers) and wage change (faced by labor union) and are

$$\begin{aligned} AC_t &= \overline{Z_t W_t}\frac{\zeta_z}{2}\left(\ln(z_t) - \ln(z_{t-1})\right)^2 + \overline{p_t^n m_t^n}\frac{\zeta_n}{2}\left(\ln(m_t^n) - \ln(m_{t-1}^n) - \alpha\right)^2 + \\ &+ \overline{Z_t W_t}\frac{\zeta_w}{2}\left(\Delta\ln(w_{it}) - \Delta\ln(P_{it-1}) - \alpha + e_t^w\right)^2 + \\ &+ \overline{p_t^o m_t^o}\frac{\zeta_o}{2}\left(\ln(m_t^o) - \ln(m_{t-1}^o) - \alpha\right)^2 \end{aligned} \tag{4}$$

We also introduce an additive exogenous income shock, e_t^{bop} which can be interpreted as the balance of payments shock, as well as a multiplicative loan demand shock, e_t^{lh}.

It is useful to define the households current income. It consists of three components: wage, interest on deposits, and nominal profits from domestic producers, retailers, labor union, importers, exporters, banks, financial intermediaries, including net operating surplus of monetary authority which can be considered as lump sum transfer:

$$\pi_t = \Pi_t^d + \int_0^1 \Pi_{it}^r di + \int_0^1 \Pi_{it}^h di + \Pi_t^b + \Pi_t^f + \Pi_t^{mp} + \int_0^1 \Pi_{it}^m di + \int_0^1 \Pi_{it}^x di \tag{5}$$

Similar to Obstfeld and Rogoff (2000), we define the real consumption index in a Cobb-Douglas fashion as:

$$q_t = \frac{1}{\omega^\omega(1-\omega)^{1-\omega}}(c_t^q - \chi e_t^\alpha h_t^q)^\omega (c_t^p - \chi e_t^\alpha h_t^p)^{1-\omega} \tag{6}$$

where χ denotes the habit importance parameter which is assumed to be the same in consumption of both types of goods[16]. Parameter ω represents the share of

[15] We need adjustment costs to enter households' budget constraint for the balance of payments equation to look nice and intuitive.

[16] The possibility that households do not simply form habits over their overall consumption level, but rather are capable of becoming "addicted" to the consumption of tradable and non-tradable goods is a generalized concept of habit formation - deep habits that was introduced in the literature by Ravn, Schmitt-Grohe, and Uribe (2006). Notice that this is not really the case of deep habits as in Ravn, Schmitt-Grohe, and Uribe (2006) since households preferences do not include habits in individual goods (on interval $[0, 1]$) "inside" tradable or non-tradable good.

each type of a good in the composite index adjusted for habits. α denotes growth rate of consumption along the balances growth path and it is determined by the growth rate of technological progress. Furthermore, both types of goods, c_t^q and c_t^p, are represented by Dixit-Stiglitz constant elasticity of substitution (CES) indices defined over variety of each type of good

$$c_t^q = \left[\int_0^1 c_{it}^{q\,\frac{\varepsilon-1}{\varepsilon}} di\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{7}$$

$$c_t^p = \left[\int_0^1 c_{it}^{p\,\frac{\varepsilon-1}{\varepsilon}} di\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{8}$$

where c_{it}^j denotes the demand for consumption good sold by monopolistically competitive firm i in the sector j, for $j = \{n, \tau\}$, and ε denotes the elasticity of substitution among various goods. The overall real consumption index is defined as:

$$c_t = \frac{1}{\omega^\omega (1-\omega)^{1-\omega}} \left(c_t^q\right)^\omega \left(c_t^p\right)^{1-\omega} \tag{9}$$

In addition to the aggregate consumption, savings and working decision a household must decide how to allocate its consumption expenditures among different type of goods. Optimal demands of different varieties of imported and domestic goods are respectively given by

$$c_{it}^p = \left(\frac{p_{it}^p}{P_t^p}\right)^{-\varepsilon} c_t^p \text{ and } c_{it}^q = \left(\frac{p_{it}^q}{P_t^q}\right)^{-\varepsilon} c_t^q \tag{10}$$

where the P_t^p and P_t^q are the aggregate price of imported and domestic goods given by:

$$P_t^p = \left[\int_0^1 p_{it}^{p\,1-\varepsilon} di\right]^{\frac{1}{1-\varepsilon}} \text{ and } P_t^q = \left[\int_0^1 p_{it}^{q\,1-\varepsilon} di\right]^{\frac{1}{1-\varepsilon}} \tag{11}$$

Once the household decides on optimal expenditure on different varieties of different types of goods, it decides on the domestic and imported aggregate consumption. Optimality conditions for the domestic and imported aggregate consumption are:

$$c_t^q = \omega \left(\frac{P_t^q}{P_t}\right)^{-1} q_t + \chi e_t^\alpha c_{t-1}^q \text{ and } c_t^p = (1-\omega) \left(\frac{P_t^p}{P_t}\right)^{-1} q_t + \chi e_t^\alpha c_{t-1}^p \tag{12}$$

where P_t is the overall consumption price index:

$$P_t = (P_t^q)^{\omega}(P_t^p)^{1-\omega} \tag{13}$$

Optimality conditions (12) yield demand function for imported and domestic goods - a demand for each good is proportional to real consumption index, with proportionality index being equal to the decreasing function of the relative price (good's price to the overall price index). Moreover, today consumption will be higher if yesterdays aggregate consumption was high, reflecting the existence of habits.

Finally the representative household decides on the real composite consumption index, q_t, real deposits, d_t and labor, H_t by maximizing (1) subject to (2). The solution gives Euler condition determining the optimal intertemporal allocation of consumption given by:

$$q_t^{-\sigma} = \beta(1+i_t^d)E_t\left[q_{t+1}^{-\sigma}\frac{P_t}{P_{t+1}}\frac{s_{t+1}}{s_t}\frac{\frac{1+i_t^h}{1+i_t^d}\kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h}+1-\kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h}}{\frac{1+i_{t+1}^h}{1+i_{t+1}^d}\kappa^h\frac{\exp(e_{t+1}^{lh})}{1-\varphi^h}+1-\kappa^h\frac{\exp(e_{t+1}^{lh})}{1-\varphi^h}}\exp(e_{t+1}^{cd}-e_t^{cd})\right] \tag{14}$$

and labor supply function

$$H_t^{\eta} = \frac{v_t}{P_t}\frac{1}{q_t^{\sigma}\left[\frac{1+i_t^h}{1+i_t^d}\kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h}+1-\kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h}\right]} \tag{15}$$

The Euler equation implies that if a household decides to consume less and save more today it will have more money for buying goods tomorrow taking into account that a part of the spending is financed through loans. In other words, if deposit rate rises it will be more attractive to postpone consumption today. The same would happen if loan rates increases today, if exchange rate depreciates tomorrow (since saving today or taking less loans today is more attractive) or if expected future inflation is lower. Labor supply equation determines the amount of labor offered to the labor union depending on the real wage (measured in utility units).

4.3 Labor union

The labor union is buying working services from households at a competitive market and then resells it to the domestic producers. Before selling to domestic producers,

the labor union is differentiating working services, Z_{it}, bought from households. Thus, a labor union is facing downward sloping demand for the working services. In other words, working services are sold to domestic producers at a monopolistically competitive market at a markup over labor union's marginal cost (wage that is paid to households). On the other hand, the labor union faces costs that will be nonnegative if a wage, w_{it}, that the union gets from domestic producers deviates from the last period domestic inflation and/or their productivity growth. This is to say that the labor union is introducing indexation of wages and has almost all power in negotiating over wages with domestic producers.

In deciding how much working services to supply to domestic producers, the labor union is deciding about the wage level to maximize its profit. The profits depend on the wage bill that the labor union gets from producers as its revenue, whereas wage bill that it has to pay to households together with wage adjustment costs constitute the labor union's costs. Maximization problem is stated as:

$$\max_{\{w_{it},Z_{it}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} Q_{t,0} \left\{ Z_{it} w_{it} - h_t v_t - \overline{Z_t W_t} \frac{\zeta_w}{2} \left(\Delta \ln(w_{it}) - \Delta \ln(P_{it-1}) - \alpha + e_t^w \right)^2 \right\}$$

subject to the demand for labor given by

$$z_{it} = \left(\frac{w_{it}}{W_t} \right)^{-\varepsilon} z_t \tag{16}$$

where $Q_{t,0} = \left(\frac{(\beta^t \exp(e_t^{cd})) u'(q_t) s_t P_0}{\exp(e_0^{cd}) u'(q_0) s_0 P_t} \frac{\left(\frac{1+i_0^h}{1+i_0^d} \kappa^h \frac{\exp(e_t^{lh})}{1-\varphi^h} + 1 - \kappa^h \frac{\exp(e_t^{lh})}{1-\varphi^h} \right)}{\left(\frac{1+i_t^h}{1+i_t^d} \kappa^h \frac{\exp(e_t^{lh})}{1-\varphi^h} + 1 - \kappa^h \frac{\exp(e_t^{lh})}{1-\varphi^h} \right)} \right)$ is firm's stochastic discount factor (the marginal rate of substitution of consumption between the time period t and time period 0 of the firm's owner) for nominal payoffs[17]. $\overline{Z_t}, \overline{W_t}$ are average values of z_{it}, w_{it}[18], and ζ_w is the wage adjustment cost parameter. There is also an additive exogenous wage shock e_t^w.

By substituting market clearing condition between households and the labor union

$$h_t = \int_0^1 Z_{it} di$$

representing diffentiation process of work in services and taking first derivative with

[17] Remember that the owners of the firms are households who derive utility from real consumption goods.

[18] This is introduced for the sake of analitical convenience.

respect to w_{it}, the supply of labor services is

$$\begin{aligned}&\frac{\mu}{w_{it}}v_t - 1 = \\ &(\mu-1)\zeta_w\left[(\Delta\ln(w_{it}) - \Delta\ln(P_{it-1}) - \alpha + e_t^w) - \right. \\ &\left. -\frac{1}{1+i_t^d}\left(\Delta\ln(w_{it+1}) - \Delta\ln(P_{it}) - \alpha + e_{t+1}^w\right)\right] \end{aligned} \tag{17}$$

or substituting for v_t

$$\begin{aligned}&\frac{\mu}{w_{it}}P_t h_t^\eta q_t^\sigma\left[\frac{1+i_t^h}{1+i_t^d}\kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h} + 1 - \kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h}\right] - 1 = \\ = \;&(\mu-1)\zeta_w\left[(\Delta\ln(w_{it}) - \Delta\ln(P_{it-1}) - \alpha + e_t^w) - \right. \\ &\left. -\frac{1}{1+i_t^d}\left(\Delta\ln(w_{it+1}) - \Delta\ln(P_{it}) - \alpha + e_{t+1}^w\right)\right] \end{aligned} \tag{18}$$

where $\mu = \frac{\varepsilon}{\varepsilon-1} > 1$. The supply function of labor services is determining the wage in a bargaining process with domestic producers. The wage would be a markup over the labor union's marginal cost (wage that it is paying to the households, v_t) taking into account that it is costly for the labor union to set wage increase different from previous period price inflation and/or technological progress (which is labor augmented). The wage (inflation) adjustment costs are bringing dynamics into play, since setting the wage today has influence on the wage decision tomorrow.

Notice that in case of no indexation ($\zeta_w = 0$), supply of labor services is given as a simple markup over the labor union's marginal cost:

$$\begin{aligned} w_{it} &= \mu v_t \\ &= \mu P_t h_t^\eta q_t^\sigma\left[\frac{1+i_t^h}{1+i_t^d}\kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h} + 1 - \kappa^h\frac{\exp(e_t^{lh})}{1-\varphi^h}\right] \end{aligned} \tag{19}$$

4.4 Domestic producers

Each variety of domestic goods is produced by a monopolistically competitive firm. Hence, our small open economy is inhabited by a representative producer producing domestic good, Y_t^d. We assume that the firm has access to the production technology of the Cobb-Douglas form with labor, z_t, oil, m_t^o, and imported capital, m_t^n, as factors of production. Moreover, the production function exhibits decreasing return to scale and is given by:

$$Y_t^d = \left(m_{t-1}^n\right)^{1-\gamma_o-\gamma_h} \left(m_t^o\right)^{\gamma_o} \left(z_t\right)^{\gamma_h} A_t^{\gamma_h} \tag{20}$$

where $\gamma_o + \gamma_h < 1$ controls the property of decreasing returns and where the log of labor augmented total factor productivity, A_t, follows random walk with drift

$$\log(A_t) = \log(A_{t-1}) + \alpha + e_t^A \tag{21}$$

We also assume that firms face "credit-in-advance" constraint[19], i.e. producers must use financial intermediary credit to pay for its input factor bill in advance. As a result firms have to borrow from the financial intermediary in order to purchase input factors at the beginning of the period. Formally the "credit-in-advance" constraint is:

$$P_t l_t^d = \kappa^d (z_t W_t + p_t^n i_t^n + p_t^o m_t^o - \varphi^d (z_{ss} W_{ss} + p_{ss}^n i_{ss}^n + p_{ss}^o m_{tss}^o)) \frac{1}{1-\varphi^d} \exp(e_t^{ld}) \tag{22}$$

where l_{it}^d denotes the real stock of financial intermediary loans, φ^d is the parameter that controls elasticity of loans with respect to input costs, κ^d is the share of input costs that is financed through bank loan and e_t^{ld} represents loan demand shock. Repayment of the loan occurs next period when each firm has to pay the nominal lending rate, i_t^{nl} adjusted for the nominal exchange rate growth. Consequently, firm's total cost at time t are given by the input factor bill, and by the interest on the loan used to pay the input bill at $t-1$, given by $(1 + i_{t-1}^{nl}) \frac{s_t}{s_{t-1}} l_{t-1}^d$. Again, z_t denotes aggregate labor force that is supplied by the labor union, W_t denotes aggregate wage that is paid to the labor union in exchange for labor services. While labor is domestic factor of production, capital and oil are traded on an international competitive market. Prices p_t^o and p_t^n are prices of oil and investment that are simply oil and investment prices in kuna and are equal to foreign prices multiplied by the exchange rate:

$$p_t^n = s_t p_t^{*n} \tag{23}$$

$$p_t^o = s_t p_{it}^{*o} \tag{24}$$

[19] This kind of constraint implicitly recognizes that monetary policy, if conducted through interest rate channel, has an impact on supply side of economy (unexpected interest rate shock raises the input bill. See Christiano, Eichenbaum, and Evans (1997)).

Capital follows a standard law of motion

$$m_t^n = (1-\delta)m_{t-1}^n + i_t^n \tag{25}$$

where δ is depreciation rate of old capital. We also assume that domestic producer is facing convex adjustment costs when it is changing all of the factors of production.

Once the good, Y_t^d is produced, it is sold to retailers at a competitive price p_t^d. This implies that the firm's profit at time t, Π_t^d, can be written as:

$$\begin{aligned}\Pi_t^d &= p_t^d Y_t^d - (1+i_{t-1}^{nl})\frac{s_t}{s_{t-1}}P_{t-1}l_{t-1}^d + P_t l_t^d - (z_t W_t + p_t^n i_t^n + p_t^o m_t^o) - \\ &\quad -\overline{Z_t W_t}\frac{\zeta_z}{2}\left(\ln(z_t) - \ln(z_{t-1})\right)^2 - \overline{p_t^n m_t^n}\frac{\zeta_n}{2}\left(\ln(m_t^n) - \ln(m_{t-1}^n) - \alpha\right)^2 - \\ &\quad -\overline{p_t^o m_t^o}\frac{\zeta_o}{2}\left(\ln(m_t^o) - \ln(m_{t-1}^o) - \alpha\right)^2 \end{aligned} \tag{26}$$

where $\zeta_z, \zeta_n, \zeta_o$ denote labor, capital and imported oil adjustment cost parameters.

Similarly to the households, the firms initially decides on the needed variety of labour services whose demand is represented by the following expression:

$$z_{it} = \left(\frac{w_{it}}{W_t}\right)^{-\varepsilon} z_t \tag{27}$$

where z_{it} is the firm's demand for the labor variety i. The demand for a single variety of labor is proportional to aggregate demand for labor. The proportionality coefficient is an iso-elastic function of the ratio of the variety's price to the price index of labor (aggregate wage). The elasticity of substitution between two varieties represents at the same time the price elasticity of demand for labor variety i. As $\varepsilon \to \infty$, varieties become close substitutes, and as a consequence individual firms have less market power.

After determining the variety of labour services needed, the firm's problem consist of maximizing its expected discounted profit (26) by choosing amount of factors and taking prices as given:

$$\max_{\left\{Y_t^q, m_t^n, m_t^o, z_t, l_t^d, i_t^n\right\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} Q_{t,0}\Pi_t^d \tag{28}$$

subject to the production function (20), "credit in advance constraint" (22) and the law of motion for imported capital (25).

Substituting for Y_t^d and l_t^d in the objective function, and solving for the optimal factors we can obtain demand functions for oil, labour and capital which are respectively given by:

$$\begin{aligned}\gamma_o p_t^d Y_t^d &= p_t^o m_t^o \left\{ \kappa^d \frac{1}{1-\varphi^d} \exp(e_t^{ld}) \left[\frac{1+i_t^{nl}}{1+i_t^d} \frac{s_{t+1}}{s_t} - 1 \right] + 1 + \right. \\ &\left. + \zeta_o \left(\ln(m_t^o) - \ln(m_{t-1}^o) - \alpha \right) - \frac{\zeta_o}{1+i_t^d} \left(\ln(m_{t+1}^o) - \ln(m_t^o) - \alpha \right) \right\} \quad (29)\end{aligned}$$

$$\begin{aligned}\gamma_h p_t^d Y_t^d &= z_t W_t \left\{ \kappa^d \frac{1}{1-\varphi^d} \exp(e_t^{ld}) \left[\frac{1+i_t^{nl}}{1+i_t^d} \frac{s_{t+1}}{s_t} - 1 \right] + 1 + \right. \\ &\left. + \zeta_z \left(\ln(z_t) - \ln(z_{t-1}) \right) - \frac{\zeta_z}{1+i_t^d} \left(\ln(z_{t+1}) - \ln(z_t) \right) \right\} \quad (30)\end{aligned}$$

$$\begin{aligned}(1-\gamma_h-\gamma_o) p_{t+1}^d Y_{t+1}^d &= p_t^n m_t^n \left\{ \kappa^d \frac{1}{1-\varphi^d} \exp(e_t^{ld}) \left[(1+i_t^{nl}) \frac{s_{t+1}}{s_t} - (1+i_t^d) \right] - \right. \\ &- \kappa^d \frac{1-\delta}{1-\varphi^d} \exp(e_{t+1}^{ld}) \frac{p_{t+1}^n}{p_t^n} \left[\frac{1+i_{t+1}^{nl}}{1+i_{t+1}^d} \frac{s_{t+2}}{s_{t+1}} - 1 \right] + \\ &+ (1+i_t^d) - (1-\delta) \frac{p_{t+1}^n}{p_t^n} + \\ &+ \zeta_n (1+i_t^d) \left(\ln(m_t^n) - \ln(m_{t-1}^n) - \alpha \right) - \\ &\left. - \zeta_n \left(\ln(m_{t+1}^n) - \ln(m_t^n) - \alpha \right) \right. \quad (31)\end{aligned}$$

Each demand for a different factor depends on its price, the amount of overall production, loan interest rate, expected exchange rate change and the fact that changing amount of factors is costly (which brings dynamics to the decision making process). For example, if investment gets more expensive, domestic producer will buy less investment and will produce less. The same will happen if loan interest rate increases (financing of production more expensive) or if kuna depreciates (price of imported investment higher). Moreover, by buying more investment from abroad today, domestic producer will be able to produce more in the future (since the capital stock, part of which depreciated, increases).

Notice that if capital is not financed by a loan but through retained profit,

demand for capital becomes:

$$\begin{aligned}(1-\gamma_h-\gamma_o)p^d_{t+1}Y^d_{t+1} &= p^n_t m^n_t \Big\{(1+i^d_t)-(1-\delta)\frac{p^n_{t+1}}{p^n_t}+ \\ &+\zeta_n(1+i^d_t)\left(\ln(m^n_t)-\ln(m^n_{t-1})-\alpha\right)- \\ &-\zeta_n\left(\ln(m^n_{t+1})-\ln(m^n_t)-\alpha\right)\Big\} \qquad (32)\end{aligned}$$

4.5 Retailers

We again assume the existence of a large number of retail shops of measure one. The role of retailers is to buy a single good on a competitive market from domestic producers, Y^q_t, differentiate them into number of finished goods, Q^q_{it}, and sell them to households at a monopolistically competitive price, p^q_{it} which is defined as a markup over the marginal cost, p^d_t. In choosing how much goods to sell, every retailer is determining the price of a variety of finished good to maximize its profits subject to the demand for finished goods $Q^q_{it}=\left(\frac{p^q_{it}}{P^q_t}\right)^{-\varepsilon}Q^q_t$. Substituting for market clearing condition for domestic goods between producers and retailers $Y^q_t=\int_0^1 Q^q_{it}di$ and market clearing condition for finished goods between retailers and households $Q^q_{it}=c^q_{it}$, the solution to retailers' problem is:

$$p^{q*}_{it}=\mu p^d_t \qquad (33)$$

where $\mu=\frac{\varepsilon}{\varepsilon-1}$ is desired markup over nominal marginal costs, p^d_t. Hence, the only thing that a retailer does is charging a markup over its cost of production. Similarly to the households problem, the price index of finished goods, P^q_t is given by $P^q_t=\left[\int_0^1 (p^q_{it})^{1-\varepsilon}\,di\right]^{\frac{1}{1-\varepsilon}}$.

In addition to the flexible price case, we assume that the firms are subject to the costly price adjustment in a fashion introduced by Rotemberg (1982). In Rotemberg (1982) framework, it is costly to change prices (menu costs or implicit costs that result from unfavorable reaction of customers).[20] The existence of costs to changing prices alters the firms' maximization problem. In the presence of price adjustment costs, today's price decision affect tomorrow's profits since tomorrow it will be costly to charge a price different from the one the firm decides to charge today, making the firms decision problem dynamic. For example, at time $t=0$, the optimal price for

[20] See Caplin and Leahy (1991) or Dotsey, King, and Wolman (1999) for model with the micro-foundation of price stickiness.

$t = 0$ must be determined by maximizing the expected present discounted value of future profits. As shown in Rotemberg (1982), this expected discounted values can be approximated (to a second order, around p_{it}^q) by:

$$E_0 \sum_{t=0}^{\infty} Q_{t,0} \left\{ \Pi_{it}^q(p_{it}^{q*}) - w_q(\ln(p_{it}^{q*}) - \ln(p_{it}^q))^2 - c_q(\ln(p_{it}^q) - \ln(p_{it-1}^q))^2 \right\} \tag{34}$$

where w_q is coefficient in second order expansion of the profit function around p_{it}^q, c_q is a price adjustment cost parameter and $\Pi_{it}^q(p_{it}^{q*})$ denotes the profits in the flexible price equilibrium, p_{it}^{q*}, discussed above. Notice that with flexible prices, the last two terms disappear (since $p_{it}^{q*} = p_{it}^q$ and there is no price adjustment costs i.e. $c_q = 0$), and the objective function of the firm can be written as in (26). Now the firm chooses p_{it}^q to maximize (34) taking p_{it}^{q*} as given. Hence $\Pi_{it}^q(p_{it}^{q*})$ is given, the firm's problem in sticky price environment is the following:

$$\min_{\{p_{it}^q\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} Q_{t,0} \left\{ \xi_q(\ln(p_{it}^{q*}) - \ln(p_{it}^q) + e_t^q)^2 + (\ln(p_{it}^q) - \ln(p_{it-1}^q))^2 \right\}$$

where ξ_q is defined as a ratio of w_q and c_q and will be loosely interpreted as the price adjustment cost parameter,[21] and e_t^q is cost push shock. In other words, the firm minimizes its costs that consist of the cost of deviating from flexible price equilibrium and the cost of deviating from the last period's price.

The first order condition of (34) with respect to p_{it}^q yields the dynamics of aggregate price index of domestic, finished good:

$$\Delta \ln(p_{it}^q) = \frac{E_t(\Delta \ln(p_{it+1}^q))}{1 + i_t^d} - \frac{\Delta \ln(P_t^q)}{1 + i_t^d} + \Delta \ln(P_{t-1}^q) + \xi_q(\ln(p_{it}^{q*}) - \ln(p_{it}^q) + e_t^q) \tag{35}$$

Today's individual price change depends on today's and yesterday's overall price change, expected future individual price change and the price adjustment cost if the individual price is deviating from the optimal flexible price equilibrium. The interpretation of the law of motion of aggregate price index will be given in the next section.

[21] Notice that $\xi_n = \infty$ implies flexible price environment.

4.6 Importers

Similar to retailers, the economy is populated by a continuum of importers of mass one indexed by $i \in [0,1]$.We model importers as the sellers of finished foreign goods to households. More precisely, each importer buys a single variety of foreign good, y_{it}^p at price p_{it}^{*p}, costlessly transforms it to the same variety of tradable good, Y_{it}^p and sells it on the domestic market to the households, whose demand for a single variety of imported good at the price p_{it}^p is given by (10)). We abstract from any impediments to trade, which allows us to impose law of one price condition for each variety of imported good. Using the nominal spot exchange rate, s_t we can write

$$p_{it}^m = s_t p_{it}^{*m} \tag{36}$$

Under the assumption of monopolistically competitive markets for different varieties of imported goods, each importer determines the domestic price of its own diversified good p_{it}^p, by maximizing its profits, $\Pi_{it}^p = p_{it}^p Y_{it}^p - p_{it}^m Y_{it}^p$ subject to demand condition $Y_{it}^p = \left(\frac{p_{it}^p}{P_t^p}\right)^{-\varepsilon} y_t^p$, where y_t^p denotes overall demand for tradable goods. Optimal behavior implies the following price setting condition:

$$p_{it}^{*p} = \mu p_{it}^m \tag{37}$$

where $\mu = \frac{\varepsilon}{\varepsilon - 1}$ is desired markup over nominal marginal cost, p_t^m. Implicit in all of our demand functions is the assumption of the zero price homogeneity, which allows to normalize of the one of prices for analytical convenience. Thus we set the price of imported goods $p_{it}^{*m} = 1$.

As in the retailers' problem, we proceed by solving for the sticky price equilibrium where producers face convex costs of price adjustment as in Rotemberg (1982). The first order condition with respect to p_{it}^p yields the dynamics of individual price of imported good given by:

$$\Delta \ln(p_{it}^p) = \frac{E_t(\Delta \ln(p_{it+1}^p))}{1 + i_t^d} - \frac{\Delta \ln(P_t^p)}{1 + i_t^d} + \Delta \ln(P_{t-1}^p) + \xi_p(\ln(p_{it}^{p*}) - \ln(p_{it}^p) + e_t^p) \tag{38}$$

where ξ_p denotes imported goods price adjustment costs parameter, and e_t^p represents importers' cost-push shock. Interpretation of this first order condition follows the analogue in the retailers case.

To complete the description of the production side of our model economy, we

need to describe the behavior of exporting sector. As stated in the introductory model description, we abstract from explicit modelling the export sector. Instead, the decisions about exports, x_t and its price, p_{it}^x, are exogenous. Exporters costlessly sell varieties of goods, x_{it} on foreign markets at price p_{it}^{x*}. Assuming the law of one price holds, we can write $p_{it}^x = s_t p_{it}^{x*}$ where p_{it}^x is the home currency price of a single variety of exported good and p_{it}^{x*} is the foreign currency price of the same variety of exported good. The profit of the whole export sector that represent net earnings of households is given by

$$\int_0^1 \Pi_{it}^x di = \int_0^1 p_{it}^x x_{it} di = p_t^x x_t \tag{39}$$

where log of exports follows a first order autoregressive process given by:

$$\ln x_t = \rho_x \ln x_{t-1} + e_t^x \tag{40}$$

4.7 Financial intermediaries

There are infinite number of financial intermediaries involved in perfect competition for loans supply to domestic producers. The role of financial intermediaries is to link foreign financial sector and banking sector with domestic producers. More precisely, financial intermediaries serve as a financing agent which borrows from both domestic banks, l_t^f and foreign banks, l_t^{fb} and then extends the "loan bundle", L_t^d to domestic producers at the cost of nominal interest rate, $(1 + i_t^{nl})$, using the constant elasticity of substitution technology.[22] Therefore, representative financial intermediary problem can be stated in the following way:

$$\max_{\left\{l_t^f, l_t^{fb}, L_t^d\right\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \quad Q_{t,0} \left\{ P_t l_t^f + P_t l_t^{fb} - P_t L_t^d + P_{t-1} L_{t-1}^d (1 + i_{t-1}^{nl}) \frac{s_t}{s_{t-1}} - \right.$$
$$\left. - P_{t-1} l_{t-1}^f (1 + i_{t-1}^f) \frac{s_t}{s_{t-1}} - P_{t-1} l_{t-1}^{fb} (1 + i_{t-1}^*) \frac{s_t}{s_{t-1}} \right\}$$

subject to bundling constraint

$$L_t^d = \psi \left[\eta \left(l_t^f \right)^{\frac{\nu-1}{\nu}} + (1 - \eta) \left(l_t^{fb} \right)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{41}$$

[22] We can think of financial intermediaries as a credit department within a domestic producers that borrows money from the bank (l_t^f) and from abroad (l_t^{fb}) and delivers the loan bundle (L_t^d) to finance domestic production.

where η is a share of bank loan in financial intermediary loan, ν is elasticity of substitution between domestic bank loan and foreign bank loan and ψ is scaling parameter.

Optimality conditions for financial intermediaries are summarized by the following demand function for domestic bank loan and demand function for foreign loan:

$$l_t^f = \psi^{\nu-1} \left(\frac{\frac{1+i_t^f}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1}{\frac{1+i_t^{nl}}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1} \right)^{-\nu} \left(\frac{1}{\eta} \right)^{-\nu} L_t^d \tag{42}$$

$$l_t^{fb} = \psi^{\nu-1} \left(\frac{\frac{1+i_t^*}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1}{\frac{1+i_t^{nl}}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1} \right)^{-\nu} \left(\frac{1}{1-\eta} \right)^{-\nu} L_t^d \tag{43}$$

where the nominal interest rate charged to a domestic producer is variant of a CES aggregator of the interest rate paid on bank loan and the interest rate paid on foreign loan:

$$\frac{1+i_t^{nl}}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1 = \left(\frac{1}{\psi} \right) \left[\eta^{\nu} \left(\frac{1+i_t^f}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1 \right)^{1-\nu} + (1-\eta)^{\nu} \left(\frac{1+i_t^*}{1+i_t^d} E_t(\frac{s_{t+1}}{s_t}) - 1 \right)^{1-\nu} \right]^{\frac{1}{1-\nu}} \tag{44}$$

Demand for each type of loan depends on the overall demand for a loan bundle, both interest rates, and the exchange rate. If the domestic producers' demand for the loan bundle is high, financial intermediaries will borrow from banks abroad to finance this loan bundle. Furthermore, if the interest rate on foreign borrowing increases, there will be less demand for foreign loans. On the other hand, domestic borrowing will increase since it is now relatively cheaper. Assumed eurozation implies small effects of the exchange rate changes on demand for both type of loans, since financial intermediaries are completely transferring the exchange rate risk to domestic producers.

4.8 Banks

We consider a simple version of the banking sector of Edwards and Vegh (1997) where the only role of banks is to take deposits, D_t, from households and extend loans, L_t, to financial intermediaries, L_t^f, and households, L_t^h. Assuming perfect competition in the banking sector, the whole sector is represented by a representative bank. Representative bank's real assets consists of domestic loans L_t, foreign assets,

and reserves at the central bank R_t. Reserves represent various types of regulatory reserve requirements that monetary authority imposes on bank's sources of funds[23].

The liabilities consist of deposits and foreign borrowing. Foreign assets and foreign liabilities can be combined in net foreign borrowings, FB_t. Investing abroad pays the fixed nominal interest rate, i_t^*, which is the same as the cost of borrowing abroad. Again, assuming full eurozation, loan and deposit values expressed in national currency between two periods depend on nominal exchange rate growth.

Moreover, we assume that financial intermediation is costly. A bank needs real resources, Q, to collect real deposits, D_t, and extend real loans, L_t, through a production function implicitly defined by $H(D_t, L_t, Q)$. Intuitively this production function implies that it is costly to maintain any level of loans or deposits.

Assuming that we can solve $H(\cdot)$ for Q we obtain $Q = \vartheta(D_t, L_t)$ where $\vartheta(\cdot)$ is a convex, strictly increasing, homogenous of degree one cost function. This last property of the bank's cost function allows us to use nominal values since $P_tQ = P_t\vartheta(D_t, L_t) = \vartheta(P_tD_t, P_tL_t)$. In order to produce nominal deposits and nominal loans, the bank needs real resources that should be paid in nominal terms. Moreover, linear homogeneity implies that partial derivatives of this cost function depends only on the ratio of loans to deposits $\vartheta_1(D_t, L_t) = \vartheta_1(\frac{D_t}{L_t}, 1)$ and $\vartheta_2(D_t, L_t) = \vartheta_2(1, \frac{L_t}{D_t})$.

The representative bank chooses the amount of real domestic deposits, real domestic loans and foreign (net) borrowings optimally, i.e. to maximize its profit, taking the nominal interest rates, i_t^f, i_t^h, i_t^d and i_t^*, the nominal exchange rate, s_t, and the aggregate price index, P_t, as given. The bank earns profits by extending loans. We assume that the maturity of bank loans is one period. We also assume that deposits become due after one period. Hence the amount of deposits that the bank has to return to households determine its current costs. Furthermore, if the bank borrows from abroad ($FB_t > 0$), it will have to return it in the next period together with interest determined by exogenous nominal interest rate and exchange rate. By extending the loans abroad ($FB_t < 0$) the bank makes profit in the next period when the loan becomes due.

In order for the model to resemble Croatian monetary policy specifics, we impose the reserve requirement. More precisely, the bank has to meet a reserve requirement rate on both domestic and foreign liabilities, r_t^r, and an additional reserve require-

[23] We simplify our analisis by assuming the monetary authority pays no interest on these reserves.

ment rate on foreign borrowing, r_t^m:

$$R_t = r_t^r(D_t + FB_t) + r_t^m FB_t \tag{45}$$

where FB_t equals the excess domestic assets over domestic liabilities, i.e. the net foreign borrowing of banks:

$$FB_t = R_t + L_t - D_t \tag{46}$$

The reserves are due in the next period and constitute bank's profit[24]. Total loans consist of loan to households and loans to financial intermediaries:

$$L_t = L_t^f + L_t^h \tag{47}$$

Given previous description of the bank's environment, we can state the bank's problem as follows:

$$\begin{aligned}
&\max_{\left\{D_t, L_t^f, L_t^h, FB_t, R_t\right\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} Q_{t,0} \Big\{ P_t D_t + P_t FB_t - P_t L_t^f - P_t L_t^h - P_t R_t + \\
&+ P_{t-1} L_{t-1}^f (1 + i_{t-1}^f) \frac{s_t}{s_{t-1}} + P_{t-1} R_{t-1} + P_{t-1} L_{t-1}^h (1 + i_{t-1}^h) \frac{s_t}{s_{t-1}} - \\
&- P_{t-1} FB_{t-1} (1 + i_{t-1}^*) \frac{s_t}{s_{t-1}} - P_{t-1} D_{t-1} (1 + i_{t-1}^d) \frac{s_t}{s_{t-1}} - P_{t-1} \vartheta(D_{t-1}, L_{t-1}) \Big\}
\end{aligned}$$

subject to equations (45) and (46).[25]

The first order conditions represent the optimal bank's behavior given the foreign interest rate, the rate of reserve requirement, expected exchange rate dynamics, domestic interest rates and domestic loan or lending market conditions given by:

$$i_t^f = \frac{1}{(1 - r_t^r - r_t^m)} i_t^* + \frac{(r_t^r + r_t^m)}{(1 - r_t^r - r_t^m)} (1 - \frac{s_t}{E_t(s_{t+1})}) + \vartheta_2(D_t, L_t) \frac{s_t}{E_t(s_{t+1})} \tag{48}$$

$$i_t^d = \frac{1 - r_t^r}{1 - r_t^r - r_t^m} i_t^* + \frac{r_t^m}{1 - r_t^r - r_t^m} (1 - \frac{s_t}{E_t(s_{t+1})}) - \vartheta_1(D_t, L_t) \frac{s_t}{E_t(s_{t+1})} \tag{49}$$

$$i_t^h = \frac{1}{(1 - r_t^r - r_t^m)} i_t^* + \frac{(r_t^r + r_t^m)}{(1 - r_t^r - r_t^m)} (1 - \frac{s_t}{E_t(s_{t+1})}) + \vartheta_3(D_t, L_t) \frac{s_t}{E_t(s_{t+1})} \tag{50}$$

Using the properties of the linear homogenous function we parameterize partial

[24] Note that the reserve have no rate of return.

[25] Notice that $P_t D_t + P_t FB_t - P_t L_t - P_t R_t = 0$ because of (46).

derivatives of the costs function as:[26]

$$\vartheta_1(D_t, L_t) = \xi_D(\ln(D_t) - \ln(L_t^f + L_t^h)) + e_t^{id} \tag{51}$$

$$\vartheta_2(D_t, L_t^f) = \xi_{Lf}(\ln((L_t^f + L_t^h)) - \ln(D_t)) + sp_t^f \tag{52}$$

$$\vartheta_3(D_t, L_t^h) = \xi_{Lh}(\ln((L_t^f + L_t^h)) - \ln(D_t)) + sp_t^h \tag{53}$$

where ξ_D and ξ_L are positive parameters (loosely interpreted as elasticities of the bank's cost function), e_t^{id} is the deposit rate shock and sp_t^f and sp_t^h denote deposit-loan rate spreads that follow AR(1) stochastic processes:

$$sp_t^f = \rho_{sp} sp_{t-1}^f + e_t^{spf} \tag{54}$$

$$sp_t^h = \rho_{sp} sp_{t-1}^h + e_t^{sph} \tag{55}$$

Each interest rate depends on the foreign interest rate, regulation costs captured by reserve requirements as well as the banking cost, implicitly defined through the amount of deposits and loans. Again, the exchange rate effects are small for the reasons of assumed full eurozation.

Costly banking introduces an additional wedge between the lending rates and the deposit rate (in addition to reserve requirement levied on all liabilities). Higher banking costs imply higher spread between active and passive interest rate. It is also necessary to include banking costs in the budget constraint of households in order to make it only private cost for the bank, but not a social cost.[27] Also notice that both lending and deposit supply schedules gives uncovered interest parity conditions.

We should also point out the bank's cost function is introduced in order to circumvents non-stationarity problems associated to market incompleteness. Using the cost function we close our small economy model in a way similar to those surveyed by Schmitt-Grohe and Uribe (2003).

[26] Notice that if the function is homogenous of degree 1, then its first derivative is homogenous of degree 0.

[27] Including bank's profit and banking costs in the budget constraint of households implies that the latter does not have any effect on income of households (see Balance of payment identity in the next section). We assume that the banking costs are not social cost since we only focus on the distortion introduced by costly financial intermediation.

4.9 Monetary authority

We model monetary policy by introducing three policy instruments: the reserve requirement (rate) on all bank's liabilities, r_t^r, the reserve requirement (rate) on bank's foreign liabilities, r_t^{mr}, and foreign exchange interventions. All policy instruments are used discretionaly by the central bank. We abstract from the microfounded modeling of the foreign exchange interventions in order to concentrate on the various reserve requirement used by the CNB. However, we implicitly allow the central bank to intervene in the foreign exchange market to control against large swings of nominal exchange rate, whereby foreign exchange interventions alter the official foreign exchange reserves, FR_t, which are invested in foreign securities abroad and remunerated at the world interest rate next period. To capture this effect we allow for disturbances or monetary policy surprises in the foreign exchange market. We also assume that nominal exchange rate is not fluctuating around some central parity and describe the nominal exchange rate process as a random walk:

$$s_t = s_{t-1} + e_t^{mp} \tag{56}$$

where e_t^{mp} represent monetary policy shock that can be thought of as a result of foreign exchange policies.[28]

Croatian monetary policy can hardly be captured by single policy reaction function. In order to simplify the analysis without loosing general insights we assume that the reserve requirement rates follow stationary first order autoregressive processes around their unconditional means:

$$r_t^r = \rho_{rr} r_{t-1}^r + (1-\rho_{rr}) Rr^{ss} + e_t^{rr} \tag{57}$$

$$r_t^{mr} = \begin{cases} \rho_{mr} r_{t-1}^{mr} + (1-\rho_{mr}) Mr^{ss} + e_t^{mr} \text{ for 2004:3-2006:3} \\ 0 \text{ for 1999:1-2004:3} \end{cases} \tag{58}$$

where ρ_{rr} and ρ_{mr} are autoregressive coefficients of the processes, Rr^{ss} and Mr^{ss} denote the unconditional mean of two reserve-requirement ratios and e_t^{rr} and e_t^{mr} represent shocks of each reserve requirement rate's processes.

To complete the description of the monetary authority we need to define its profit function. The central bank earns money by receiving interest on its net foreign assets

[28] This disturbance can have wider interpretation and can be also thought as a result of all other factors not under direct influence of the monetary policy.

(foreign exchange reserves) that are invested abroad in the previous period and by collecting the required reserve. The outflows include a new flow of purchasing foreign assets and giving back the reserves that were deposited on the central bank's account in the last period. Hence the profit of the central bank is:

$$\Pi_t^{mp} = P_t R_t + P_{t-1} F R_{t-1}(1 + i_{t-1}^*)\frac{s_t}{s_{t-1}} - P_{t-1} R_{t-1} - P_t F R_t \tag{59}$$

We assume that all of the central bank profits are transferred to households.

4.10 The rest of the world

Since Croatia is a small open economy, all variables that pertain to the rest of the world are exogenous: the foreign-currency import price of finished goods, p_t^{m*}, the foreign-currency import price of oil, p_t^{o*}, the foreign-currency import price of investment goods, p_t^{n*} and the world interest rate, i_t^*. Each of these variables, together with terms of trade, τ_t, defined as the ratio of p_t^{x*} and p_t^{m*}, follows a stationary, first order autoregressive process:

$$\ln \tau_t = \rho_{tot} \ln \tau_{t-1} + (1 - \rho_{tot})\tau_{ss} + e_t^{\tau} \tag{60}$$

$$i_t^* = \rho_{if} i_{t-1}^* + (1 - \rho_{if}) i_{ss}^* + e_t^i \tag{61}$$

$$\ln p_t^{m*} - \ln p_{t-1}^{m*} = \rho_{pmf} * (\ln p_{t-1}^{m*} - \ln p_{t-2}^{m*}) + (1 - \rho_{pmf})\pi_{ss}^{pmf} + e_t^{pmf} \tag{62}$$

$$\ln p_t^{n*} - \ln p_{t-1}^{n*} = \rho_{pnf} * (\ln p_{t-1}^{n*} - \ln p_{t-2}^{n*}) + (1 - \rho_{pnf})\pi_{ss}^{pmf} + e_t^{pnf} \tag{63}$$

$$\ln p_t^{o*} - \ln p_{t-1}^{o*} = \rho_{pof} * (\ln p_{t-1}^{o*} - \ln p_{t-2}^{o*}) + (1 - \rho_{pof})\pi_{ss}^{pmf} + e_t^{pof} \tag{64}$$

We also assume that prices of imported final and investment goods, as well as the oil prices have the same steady state growth rate. The terms of trade and domestic exports follow a first order autoregressive process in logs. Foreign interest rate and foreign inflation of the three imported goods, behave also according to an AR(1) process but they fluctuate around their unconditional mean, i_{ss}^* and π_{ss}^{pmf}, respectively. Shocks e_t^{τ}, e_t^i, e_t^{pmf}, e_t^{pof} and e_t^{pnf} represent the corresponding AR(1) innovations.

5 Equilibrium

We now turn to the description of the equilibrium in our model economy. We consider symmetric equilibrium in which all of the firms behave identically. Hence for two firms i an j $(i, j \in [0,1])$ we have that $p^p_{it} = p^p_{jt} = P^p_t$, $p^q_{it} = p^q_{jt} = P^q_t$, $Y^p_{it} = Y^p_{jt} = Y^p_t$, $Q^q_{it} = Q^q_{jt} = Q^n_t$, $z_{it} = z_{jt} = z_t$.

Definition 1 *The equilibrium of our small open economy is a set of stochastic processes for prices* $\{P_t\}_{t=0}^{\infty} = \{p^p_{it}, p^q_{it}, p^m_{it}, p^o_{it}, p^n_{it}, p^{*m}_{it}, p^{*o}_{it}, p^{*n}_{it}, i^d_t, i^h_t, i^f_t, i^{nl}_t, i^*_t, s_t, w_t, v_t\}_{t=0}^{\infty}$ *for all the histories of shock realizations, for all time periods* $t > 0$ *and for all good varieties* $i \in [0,1]$, *such that a list of stochastic processes for*

1. an allocation $\{d_t, l^h_t, c^p_t, c^q_t, q_t, H_t\}_{t=0}^{\infty}$ *solves the household's problem given a sequence of prices* $\{P_t\}_{t=0}^{\infty}$ *and the initial conditions for deposits and household loans;*

2. an allocation $\{Z_t\}_{t=0}^{\infty}$ *and prices* $\{w_t\}_{t=0}^{\infty}$ *solve the labor union's problem*

3. an allocation $\{Y^d_t, l^d_t, z_t, m^n_t, m^o_t, i_t\}_{t=0}^{\infty}$ *solves the domestic producer's problem taking sequence of prices* $\{P_t\}_{t=0}^{\infty}$ *as given*

4. an allocation $\{Q^q_{it}\}_{t=0}^{\infty}$ *and the price of a single variety of domestic finished good* $\{p^q_{it}\}_{t=0}^{\infty}$ *solve the retailer's problem given the exchange rate process,* $\{s_t\}_{t=0}^{\infty}$, *and price of domestic producers,*$\{p^d_t\}_{t=0}^{\infty}$;

5. an allocation Y^p_{it} *and the price of a single variety of imported good* p^p_{it} *solve tradable firm's problem i.e. an allocation and the price that satisfy equations (35) in the case of flexible prices or (38) in the case of sticky prices taking given foreign price and the exchange rate and assuming that PPP holds (equation (36));*

6. an allocation $\{l^f_t, l^{fb}_t, L^d_t\}_{t=0}^{\infty}$ *solves the financial intermediary's problem given interest rates and the exchange rate process;*

7. an allocation $\{D_t, L^f_t, L^h_t, FB_t, R_t\}_{t=0}^{\infty}$ *solves the bank's problem given interest rates and the exchange rate process;*

given processes for export, (40), technological progress, (21), spreads (54) and (55), exchange rate, (56), reserve requirement ratios, (57), (58), terms of trade, (60), foreign interest rate, (62), foreign price of oil, (63),and foreign export prices, (64).

8. All markets clear (supply equals demand):

a) the market for domestic goods: $Y^q_t = \int_0^1 Q^q_{it} di$ *for every* $i \in [0,1]$ *and* $Q^q_{it} = c^q_{it}$ *or* $Y^q_t = c^q_t$ *at aggregated level*

b) the market for imported goods: $Y^p_{it} = c^p_{it}$ *for every* $i \in [0,1]$ *or* $Y^p_t = c^p_t$ *at aggregated level*

c) the market for deposits: $d_t = D_t$

d) the market for domestic production loans: $l_t^d = L_t^d$

e) the market for household loans: $l_t^h = L_t^h$

f) the market for financial intermediary loans: $l_t^f = L_t^f$

g) market for labor (between households and labor union): $h_t = H_t$

h) market for labor (between labor union and domestic producers): $\int_0^1 Z_{it}di = z_t$

9. All agents have rational expectations over the sequences of the following shock processes: $e_t^{cd}, e_t^{ld}, e_t^{lh} e_t^{pn}, e_t^{p\tau}, e_t^{id}, e_t^{bop}, e_t^{spf}, e_t^{sph}, e_t^x, e_t^{mp}, e_t^{rr}, e_t^{mr}, e_t^{\tau}, e_t^{i*}, e_t^{pmf}, e_t^{pnf}, e_t^{pof}, e_t^w, e_t^a$

Assuming symmetry (35) can be rewritten as:

$$\begin{aligned}\Delta \ln P_t^q &= \frac{1}{2+i_t^d} E_t(\Delta \ln P_{t+1}^q) + \frac{1+i_t^d}{2+i_t^d}\Delta \ln P_{t-1}^q + \frac{1+i_t^d}{2+i_t^d}\xi_q(\ln P_t^{q*} - \ln P_t^q + e_t^q) \\ &= \frac{1}{2+i_t^d} E_t(\Delta \ln P_{t+1}^q) + \frac{1+i_t^d}{2+i_t^d}\Delta \ln P_{t-1}^q + \frac{1+i_t^d}{2+i_t^d}\xi_q \ln(mc_t^q \mu + e_t^q) \quad (65)\end{aligned}$$

which gives the hybrid New Keynesian Phillips curve. It implies that the inflation process is determined by marginal costs and is both forward and backward looking, Similarly, the inflation of imported goods can be rewritten as:

$$\Delta \ln P_t^p = \frac{1}{2+i_t^d} E_t(\Delta \ln P_{t+1}^p) + \frac{1+i_t^d}{2+i_t^d}\Delta \ln P_{t-1}^p + \frac{1+i_t^d}{2+i_t^d}\xi_p(\ln P_t^{p*} - \ln P_t^p + e^p) \quad (66)$$

Nominal GDP is given as the sum of consumption, investment and net exports:

$$\begin{aligned}NGDP_t &= p_t c_t + p_t^n i_t + nx_t = \\ &= p_t^q c_t^q + p_t^p c_t^p + p_t^n i_t + (p_t^x x_t - p_t^n i_t - p_t^o m_t^o - p_t^m c_t^p)\end{aligned}$$

whereas budget constraint of a representative household can be rewritten to obtain the balance of payments identity. By substituting all profits into (2) and interpreting income shock, e_t^{bop} as the balance of payments shock capturing accounting discrepancies, we obtain:

$$FR_t - FB_t - L_t^{fb} = \left(1 + i_{t-1}^*\right) \frac{s_t}{s_{t-1}} \left(FR_{t-1} - FB_{t-1} - L_{t-1}^{fb}\right) \frac{P_{t-1}}{P_t} - \frac{1}{P_t} \left(\left(\int_0^1 p_{it}^m Y_{it}^p di + p_t^n i_t^n + p_t^o i_t^o \right) - p_t^x x_t \right) + e_t^{bop} \quad (67)$$

Since FR_t represents the central bank's net foreign reserves, whereas FB_t and L_t^{fb} are net foreign borrowing of commercial bank and financial intermediary respectively, $FR_t - FB_t - L_t^{fb}$ represents the net foreign borrowing of the economy as a whole. This net foreign position today is equal to the net foreign position in the previous period augmented by the foreign interest rate that the economy has to pay (in case of short position) or receive (in case of long position) and the current account that increases the foreign debt if it's negative or decreases it if it's positive.
Notice also that the following identity holds:

$$FR_t - FB_t - L_t^{fb} = D_t - L_t^h - L_t^f - L_t^{fb} \quad (68)$$

This is the consequence of the consolidated balance sheet of the financial sector that includes banking sector and the monetary authority, but excludes the financial intermediary, so that the balance of payment identity (67) can be rewritten as:

$$D_t - L_t^h - L_t^f - L_t^{fb} = \left(1 + i_{t-1}^*\right) \frac{s_t}{s_{t-1}} \left(D_{t-1} - L_{t-1}^h - L_{t-1}^f - L_{t-1}^{fb}\right) \frac{P_{t-1}}{P_t} - \frac{1}{P_t} \left(\left(\int_0^1 p_{it}^m Y_{it}^p di + p_t^n i_t^n + p_t^o i_t^o \right) - p_t^x x_t \right) + e_t^{bop} \quad (69)$$

Using $E_t(s_{t+1}) = s_t$, the bank's behavior, (49), (50) and (48) can be rewritten as:

$$\begin{aligned} i_t^f &= \vartheta_2(D_t, L_t) + \frac{i_t^*}{(1 - r_t^r - r_t^m)} = \\ &= \xi_{Lf}(\ln(L_t^f + L_t^h) - \ln(D_t)) + sp_t^f + \frac{i_t^*}{(1 - r_t^r - r_t^m)} \end{aligned} \quad (70)$$

$$\begin{aligned} i_t^h &= \vartheta_3(D_t, L_t) + \frac{i_t^*}{(1 - r_t^r - r_t^m)} = \\ &= \xi_{Lh}(\ln(L_t^f + L_t^h) - \ln(D_t)) + sp_t^h + \frac{i_t^*}{(1 - r_t^r - r_t^m)} \end{aligned} \quad (71)$$

$$
\begin{aligned}
i_t^d &= -\vartheta_1(D_t, L_t) + \frac{i_t^*(1-r_t^r)}{(1-r_t^r-r_t^m)} = \\
&= \frac{i_t^*(1-r_t^r)}{(1-r_t^r-r_t^m)} - \xi_D(\ln(D_t) - \ln(L_t^f + L_t^h)) - e_t^{id} \qquad (72)
\end{aligned}
$$

6 Calibration and Solution

By calibrating the model we assign numerical values to the models parameters that characterize the stochastic disturbances, preferences and technology to make it roughly consistent with some empirical regularities that reflect the structure of the Croatian economy. This requires construction and reorganization of the data set for Croatian economy in a way that makes it consistent with our model economy. Furthermore, if the parameter value can not be pinned down from the constructed data, we adopt its value from the existing literature or to match the data as best as possible.

In our model economy most of the parameters are pined down from the steady state conditions. It what follows we will divide the set of the parameters for calibration into four major groups: preference, technology, financial and foreign sector parameters.

Preference parameters

There are eleven parameters related to households that need to be calibrated: discount factor, β, coefficient of relative risk aversion, σ, the inverse of Frish elasticity (labor supply elasticity), η, share of consumption financed by household's loans, κ^h, steady state consumption, c_{ss}, steady state of prices, p_{ss}^p and p_{ss}^q, elasticity parameter of loans with respect to consumption, φ^h, habit importance parameter, χ, the share of domestically produced good in the composite index, ω, and the elasticity of substitution, ε. The last three parameters are assumed to be equal among imported and domestically produced goods. Furthermore, only β, κ^h, ω and ε, c_{ss}, p_{ss}^p and p_{ss}^q can be pinned down from the steady state of the model by imposing real world restriction. Values for other parameters are either based on the values of corresponding parameters in the literature or were estimated.

The discount rate, β, was pinned down from the steady state version of the Euler equation, (14). Weighted average nominal interest rate on kuna and foreign deposits of households (all durations, with the weight on kuna interest rates equal to 0.14[29]),

[29] The weight on kuna interest rates was calculated as an average share of household kuna deposits in overall houshold deposits that consist of kuna and foreign exchange deposist.

i_t^d, from the Croatian data is annually 3.99%[30], and the assumed annual steady state inflation of 0%, assumed also to be equal to the foreign inflation, so that such that on the quarterly basis we have $\pi_{ss} = \pi_{ss}^{pmf} = 1,000$ This results in β equal to 0.9913.

The share of domestically produced consumption good in the composite good, ω, was pinned down from the demand function for a domestic good, (12), which in steady state equals $\frac{p^q c^q}{pc_{ss}}$. Hence, ω was calibrated so as to match the ratio of domestic goods in the overall consumption (that includes both domestic and imported goods) that fluctuates around 0.4. This restriction was taken from consumption price index statistics (COICOP disaggregation[31]) where the weight of a particular good is actually its share in overall private consumption.

Steady state consumption, c_{ss} and steady state prices, p^q and p^p were calculated as a solution of the system of the models steady state equations. The share of consumption financed by household's loans, κ^h, was calculated from household's cash-in-advance constraint and is equal to 4. The elasticity of substitution between varieties of goods ε, was calibrated from the steady state balance of payments identity by finding a reasonable value for the desired markup so that the value for nominal exports to overall nominal consumption, the ratio of net foreign assets (net international investment position, H16 Table CNB Bulletin) to overall consumption, investment to consumption ratio and imported oil to consumption ratio match averages of these ratio in the Croatian data. They are equal respectively to 0.85,-1, $0,4$, and 0.05. Given the calibrated value for ω, π_{ss} and i^* (average of 1-year Euribor equal to 5.2% plus spread) we found quarterly markup equal to 33%, $\mu = 1.33$ which gives us $\varepsilon = 4$. This markup value is in line with most of the existing literature (see for example Domowitz, Hubbard, and Petersen (1988), Morrison (1994) or Olive (2002)).

As mentioned before, the values of other parameters can not be pinned down from the steady state. The values of those parameters were set using the values from a corresponding literature or to match the data as best as possible. Therefore, we set the risk aversion parameter σ to 2 and inverse of the Frish elasticity, η to 3. We adopt habit importance parameter, χ, from the existing empirical studies

[30] This value has to be calibrated to be almost equal to foreign interest rate (4%, the avarage is 4.22%) so that cost parameter of deposit production is close to zero. Otherwise, this parameter would take negative values i.e. elasticity of bank's costs with respect to production of deposits would be negative.

[31] The following categories were considered as tradables: non-alcoholic drinks, alcoholic beverage, clothing, energy and gas, furniture, textile products, medical products, cars, audio, video and other electrical accessories, as well as 50% of meat, fruit and vegetables.

that suggest plausible estimates to take values between 0.4 and 0.8. We choose $\chi = 0.4$. This value seems to match the overall consumption volatility reasonably well. Finally, loan elasticity parameter, φ^h, is set to 0.4.

Technology parameters

There are eighteen technology parameters that we need to calibrate: parameters that controls the diminishing returns to scale, γ_h, γ_o, the share of input bill financed by firm's loans, κ^d, the two parameters that characterize the sticky price environment: price adjustment parameters, ξ_q and ξ_p, wage adjustment cost, ξ_w, labor, capital and oil adjustment costs, ξ_z, ξ_n and ξ_o, a parameter that controls elasticity of firm's loans with respect to input bill, φ^d, capital depreciation rate, δ, growth rate of technological progress, α and $z_{ss}, W_{ss}, p^n_{ss}, i^n_{ss}, p^o_{ss}, m^o_{ss}$. The steady state values of the last six variables are found again as a solution of the system of models steady state equations. Parameters that pertain to exogenous processes of exports and terms of trade were simply estimated.

The depreciation rate of capital was pinned down form capital law of motion (25) assuming that investment to GDP ratio and capital to GDP ratio is equal to 0.2 and 10 respectively. Hence, $\delta = 0.03$ (on quarterly basis). The share of input bill financed by producer's loans, κ^d, was calculated from firm's cash-in-advance constraint and is equal to 8.

We calibrate γ_h from the steady state producer's demand for labor that is approximately similar to the share of the total wage bill in domestic production and set its value to 0.68. γ_o is calibrated from the producer's steady state demand for oil and is approximately similar to the share of the nominal spending on imported oil in domestic production (domestic consumption) equal to 0.1.

Price adjustment parameters ξ_q and ξ_p were calibrated to match domestic and imported inflation as best as possible and are set respectively to 100 and 0.1. Wage adjustment cost parameter, ξ_w, labor, capital and oil adjustment costs parameters, ξ_z, ξ_n and ξ_o were set to capture impulse responses of wages, employment, investment and oil as best as possible

The technological progress growth α is set to 0 and loan elasticity parameter, φ^d, is set to 0.15.

The autoregressive coefficients in exports and terms of trade processes are estimated to be $\rho_{tot} = 0.77$ and $\rho_x = 0.99$. Terms of trade in the steady state is set to the average value of its counterpart in the data and are equal to one.

Financial sector parameters

Financial sector parameters include parameters that characterize financial intermediary sector (ψ, η, ν) and parameters that pertain to banking sector (Rr^{ss}, Mr^{ss}, ξ_D, ξ_{Lf}, ξ_{Lh}, i^*). Furthermore, there are parameters that characterize exogenous processes of foreign interest rates, reserve requirement ratios, spreads, foreign prices that we parametrize by estimation.

Banking costs parameters ξ_D, ξ_{Lf} and ξ_{Lh} were calculated from the steady state supply functions of deposits, firm's loans and household's loans, (49), (48) and (50)[32]. We set the values for these parameters such that the interest rates on deposits, interest rates on firm's loans, interest rates on household's loans[33], foreign interest rates in the model match the average (annual) interest rates in the data ($i^d = 3.5\%$, $i^* = 5,2\%$, $i^f = 7,2\%$, $i^h = 7,3\%$). Furthermore, we match deposits to total loans ratio ($\frac{d}{l^f+l^h} = 1$), long run values of both total reserve requirement ratio $Rr^{ss} = 0.33$ and marginal reserve requirement ratio[34] $Mr^{ss} = 0.01$. Hence, $\xi_D = 0.44$, $\xi_{Lf} = 0.14$, $\xi_{Lh} = 0.17$. Estimation of processes (58), (57), (54), (55), (61) and (62) yields the value of the autoregressive coefficients $\rho_{mr} = 0.83$, $\rho_{rr} = 0.61$, $\rho_{spf} = 0.9, \rho_{sph} = 0.9$, $\rho_{if} = 0.92$, $\rho_{pmf} = 0.01$[35].

Two of three financial intermediary sector parameters were pinned down from the steady state by imposing data restriction. Elasticity of substitution, ν, was set arbitrarily to 4 implying the fact that foreign and domestic borrowing are substitutes. The "share" parameter, η, is calculated from demand for loans, and is equal to 0.67, implying that overall firm's borrowing is slightly home biased. Finally, the normalization parameter, ψ, was calculated from CES aggregation function, (41), such that the aggregator equals the sum of firm's domestic loans and foreign bor-

[32]Since the banking costs are introduced to solve the technical problem of closing the model, in general, costs parameters should be such that these costs are minimal and do not affect the short-run properties of the model.

[33]Interest rates on deposits are defined as weighted average of interest rates on kuna deposits (where the weight was calculated as ration of kuna deposits in overall deposits (8.86) and interest rates on foreign exchange deposits (0.14)). Interest rates on firm's loans are defined as weighted average of interest rates on kuna loans (0.57) and interest rates on foreign exchange loans (0.43). Interest rates on households loans are defined as weighted average of interest rates on kuna loans (0.70) and interest rates on foreign exchange loans (0.30).

[34]Marginal reserve requirenment ratio was calculated as the ratio of sum of marginal reserve requirment values paid on the base I (40%) and base II (15%) and the stock of foreign borrowings over the period 2004-2007. Notice that in practice a marginal reserve requirenment is paid on the change of foreign borrowings and not on the stock.

[35]All the processes were estimated using quaterly data over the period 1997-2006 except for the marginal reserve requirenment where we used monthly data over the period 2004-2007. For the in-sample shock calibration (see Shock processes below) we set $Mr = 0$ for all the periods before the third quater 2004.

rowing by firms $L^n = l^f + l^{fb} = \psi \left[\eta \left(l^f \right)^{\frac{\nu-1}{\nu}} + (1-\eta) \left(l^{fb} \right)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}$. By imposing that $l^f = 105$ billion of kunas and $l^{fb} = 80$ billion of kunas (values of 2 quarter 2007) and using previously calculated share parameter and the elasticity of substitution, we calibrate the normalization parameter to take the value of $\psi = 2.1$.

Foreign sector parameters

Foreign sector parameters pertain to autoregressive parameters of processes for foreign interest rate (ρ_{if}), foreign inflation of final goods (ρ_{pmf}), foreign inflation of investment goods (ρ_{pnf}) and foreign inflation of oil (ρ_{pof}). These were estimated as $AR(1)$ processes are respectively equal to $0.92, 0.01, 0.01$ and 0.01.

The model is solved using IRIS toolbox which implements first order approximation techniques based on the Schur decomposition developed by Klein (2000).

7 Findings

Using the described model, we conducted the simulation of the crisis. The results indicate the impact and possible transmission channels of the crisis. We use the results in order to assess possible monetary policy response. At the end, we compare the simulation results with the actual data containing initial effects of the crisis, in order to evaluate the simulation exercise.

7.1 Crisis simulation

From the perspective of a small open economy, the current financial crisis can be treated entirely as an external shock. The national economic circumstances influence the propagation and severity of impact of such external shock on domestic economy. For that reason, we treat the crisis as a combination of two external shocks: increase in the price of foreign borrowing (foreign interest rate) and drop in export demand. The results of the simulation is shown in the Appendix.

In reality, the crisis initially manifested itself through a drop in demand for risky investments, i.e. increase in the borrowing cost for emerging markets debt, which escalated in September 2008. Expansionary monetary policy and interest rate decreases by the FED and ECB were not enough to compensate for the increase in the spreads of the emerging market debt, so the net effect was an increase in the cost of foreign borrowing for emerging markets.

As the financial crisis spread to the real sector, the final demand in developed economies dropped. This decreased the demand for imports. From the perspective of a small open economy, it can be treated as a negative export demand shock.

The existence of both shocks (the foreign interest rate shock and the export demand shock) in the model, allows us to use it for analyzing the impact of the crisis on Croatian economy. We proceed by simulating the impact of these shocks on various variables of interest. The size of the foreign interest rate shock was based on the actual increase in the cost of foreign borrowing measured by the price of Croatian government bond at the peak of the crisis and amounts to 300 bp. The size of the export demand shock was more difficult to assess. In line with the expected drop in consumption and investment in the Eurozone, this shock was calibrated to reflect 10% drop in exports.

7.1.1 Transmission of the foreign interest rate shock

As it is widely accepted, economic developments in a small open economy are to a large extent determined by foreign variables and driven by external shocks (see for example Maćkowiak (2007)). The level of foreign interest rates (the cost of foreign borrowing) determines the domestic interest rates because of the free capital flows. Therefore, the increase of the foreign interest rates makes the foreign borrowing for domestic banks and firms more expensive. However, the regulation cost, in the form of regulatory requirement, implies that the domestic interest rates are larger than foreign, as the regulation cost acts as a wedge between foreign and domestic interest rates.

The model further implies that the increase in domestic interest rate results in lower credit demand by households and firms. For that reason, banks need less funds to finance domestic credits, so they decrease their foreign borrowing. As both banks and firms decrease their foreign borrowing, the total foreign debt also decreases. Faced with higher foreign interest rates, banks try to substitute more expensive foreign funds with less expensive domestic funds, by offering higher deposit interest rates to attract household deposits. Nevertheless, household deposits decrease, as the household wealth and income also decrease as explained below.

The increase of interest rates transmits to the real sector through its effect on households consumption and increase in production cost. The decrease in demand for domestic goods leads to a drop in their supply, i.e. domestic production, which results in lower employment, investments and imports of intermediary goods. This,

together with the interest rate increase, leads to lower credit demand by firms, and both their domestic and foreign borrowing.

Finally, the lower aggregate demand decreases inflationary pressures, and net exports improve due to a decline in imports of both final, intermediate, and investment goods. Nominal wages drop as there is less demand for labor.

7.1.2 Transmission of the export demand shock

After being initially hit by the foreign interest rate shock, the crisis unraveled yet another foreign shock. As the financial crisis caused recession abroad, export (demand) declined. A drop in exports by definition decreases domestic production which further decreases households income. With less income, households must decrease their consumption. A decrease in households consumption (and exports) leads to lower demand for goods, which transmits into lower production, employment, wages, import of intermediaries and investments. On the financial side, the model indicates that household credits and deposits also decrease due to the loss of income, while lower production leads to less borrowing by firms (both domestic and foreign). Lower aggregate demand reduces inflation pressures (prices decrease).

The full impact of the financial crisis can be derived by combining the effects of both shocks. Interestingly, both shocks affect the main variables in the same direction, so their combined effect is potentially quite large. The expected impact of the crisis on Croatian economy, as suggested by the model, is a significant decline in real activity and consumption. Lower domestic demand reduces inflationary pressures and lowers imports. Finally, both shocks suggest significant drop in domestic credits and foreign borrowing.

7.1.3 Simulation of the monetary policy response

As already discussed, there is a limited scope for countercyclical monetary policy in Croatia. As the main effort is put into preserving the exchange rate stability, the only channel through which monetary policy can act is the reduction of the regulatory cost.

Therefore, the policy response to the crisis is simulated as a reduction in the rate of reserve requirement, which reflects the recent CNB's behavior. The model itself does not assume any active monetary policy response to the crisis, so we treat this rate reduction as an exogenous discretionary shock. The size in the reduction of the

reserve requirement rate is calibrated to 10 percentage points, which approximately reflects the amount of released liquidity through the actual measures undertaken by the CNB in the aftermath of the crisis.[36]

The regulatory cost (reserve requirement) acts as a wedge between domestic and foreign interest rates. Thus, by lowering the reserve requirement, the central bank can in effect lower domestic interest rate. Even more importantly, a decrease in the reserve requirement releases a significant amount of previously immobilized assets that can be used for financing domestic credits or reducing commercial banks' foreign liabilities. Since the model itself does not create enough domestic demand for the released reserves (decrease in domestic interest rates create only modest initial domestic credit demand), banks use the released funds to reduce their foreign borrowing.

Therefore, lower reserve requirement decreases domestic interest rates, which increase credit demand of both households and firms. At the same time, interest rates (and amount) on household deposits rise, as banks try to attract deposits in order to meet increasing credit demand. As the interest rates for domestic borrowing decrease, firms substitute a portion of their foreign credits with cheaper domestic ones.

The lower interest rates encourages households to increase their consumption, of both domestically produced and imported goods. Increased demand and cheaper credits are met by higher domestic production which further leads to increase in employment, investments and imports of intermediary goods. Increase in domestic demand leads to increase in domestic prices and imports, so real wages decline.

When comparing the estimated impact of the financial crisis with the impact of the monetary policy response, the real effects of the financial crisis dominate. This suggests that monetary policy response was not large enough to fully counter the expected impact of the crisis. However, the size of the simulated response (10 pp reduction in the regulatory cost) symbolizes a limit to which the CNB can release its international reserves without endangering the present monetary regime.[37]

As the decline in the interest rates due to the lower regulatory cost (reserve requirement) is lower than the expected increase in the cost of foreign borrowing, and as the household income drops due to the decline in exports, the net effect

[36] This may actually somewhat overstate the policy response, as the regulatory reserve declined less (see Figure 2).

[37] Even larger policy response is unable to counter the impact of the crisis on real variables.

suggests significant decrease of domestic credits.

Both the financial crisis and the monetary policy response imply a decrease in foreign borrowing. However, the reasons for it are quite opposite. On one hand, increase in interest rates and the slowdown in the real activity and consumption lead to the decreased demand for credits, which also decreases demand for foreign borrowing by banks and firms. On the other hand, lowering the reserve requirement releases large amount of assets which banks use to finance domestic credits, so they need less foreign borrowing (foreign debt decreases). Therefore, while the financial crisis implies a slowdown in capital inflows, the main effect of the monetary policy response is to substitute dearer foreign funds with previously accumulated reserves.

7.1.4 What happened in reality

The results of the simulation exercise can be compared with the actual (early) impact of the crisis. The expected slowdown in the real activity is already present in the high frequency data, as described in chapter 2. The industrial production slowed markedly in the first quarter of 2009 and similar slowdown is expected to occur in the GDP and consumption. In addition, international trade is also decreasing, with imports reacting more than the exports, which also corresponds to the results predicted by the model.

The simulation results differ from the actual data in two areas: the actual increase of domestic interest rates is smaller than the model suggests, and growth of foreign borrowing did not slow as much as the model implied.

The difference between strong expected growth in domestic interest rates and their modest increase in reality can be explained by three reasons. The first is that the actual foreign interest rate shock used in the model might be exaggerated. It was calibrated as the increase in price of government bonds (yield to maturity) at the peak of the crisis, which decreased significantly until then. Thus, it is likely that many banks borrowed from their owners cheaper than the government bonds indicate, while some foreign borrowing by firms might have been postponed expecting foreign interest rates decrease. The second reason is that the CNB, by reducing the regulatory cost, made the financial intermediation cheaper, which to some extent dampened the effect of foreign interest rate shock. Finally, banks faced popular pressure, so, instead of increasing the interest on the domestic loans, they engaged in credit rationing and restricted their credit supply by increasing the credit quality and granting credits only to clients with better credit-worthiness. Already high

interest rates and profits from previous period made it possible for banks to bear some of the cost of interest rate increase instead of transferring it to the borrowers.

The second difference, a modest slowdown of the growth of foreign borrowing instead of its significant reduction suggested by the model, is easy to explain. The model assumes only minor increase in credit demand as the result of policy response, so the banks use the released funds for reducing their foreign borrowing. In reality, there was a strong fiscal demand for funds, as the government spending remained high regardless of weak fiscal revenues. Thus the released funds were used to support fiscal policy during the time of crisis.

8 Conclusion

We conducted the simulation of the impact of financial crisis on Croatian economy using the newly developed DSGE model for Croatia. The results to a large extent match the actual data confirming the early impact of the crisis. The real activity is in decline, despite significant monetary policy response. With monetary policy regime based on a stable exchange rate, the central bank is limited in its attempt to counter the impact of the foreign shocks, and significantly stimulate the real activity by simply adjusting the regulatory framework. More precisely, by decreasing the regulatory burden and thereby increasing the banks' liquidity, the CNB managed only partially (and to the small extent) to offset the negative impact of the foreign shock(s). However it is important to point out that this limited success must be evaluated in the context of highly eurolized small open economy, where the primary goal of the monetary authority is to keep the exchange rate broadly stable. Nevertheless, it would be wrong to say that the monetary policy effect on the real activity was completely absent.

The major difference between the simulation results and the actual economic developments is caused by existence of forces not captured by our model. Since we do not model government explicitly we were not able to capture the effect of government financial needs on the economy. Significant decline of the fiscal revenue in the aftermath of the crisis, imposed the need for extra funding to the government. What happened is that, instead of the reduction in the foreign borrowing as suggested by the model, the released funds were channeled to the government. However, the easening of the regulatory burden and thereby provided liquidity prevented the government from crowding-out the real sector. Therefore, taking this into account,

the effect of the reduction in the regulatory cost was larger than is captured by the model, but its direction was the same. Abstracting from the effects induced by the government behavior, this exercise shows the potential capability of the model as a tool for understanding the mechanisms at work in the Croatian economy, making it useful for policy analysis.

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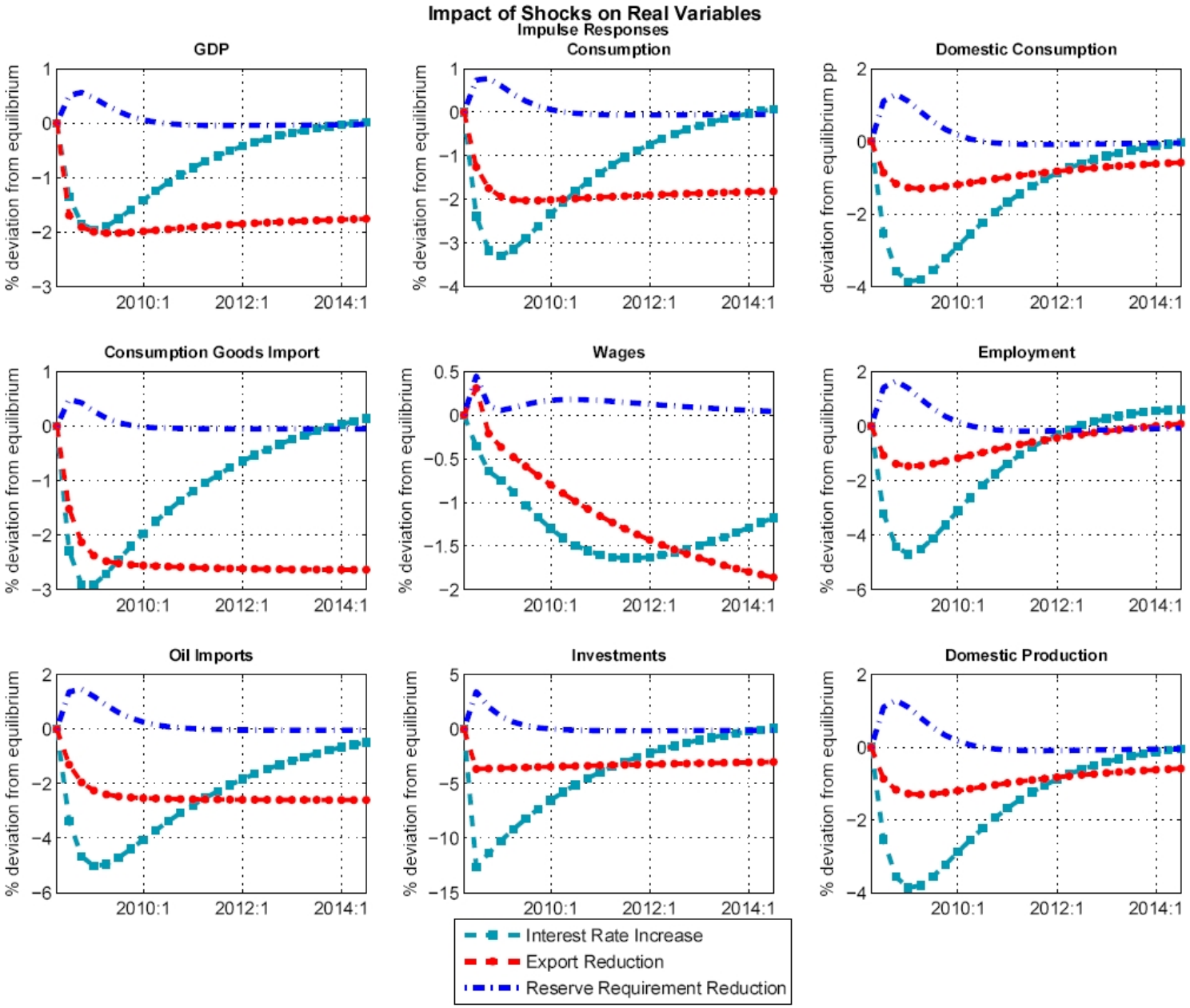
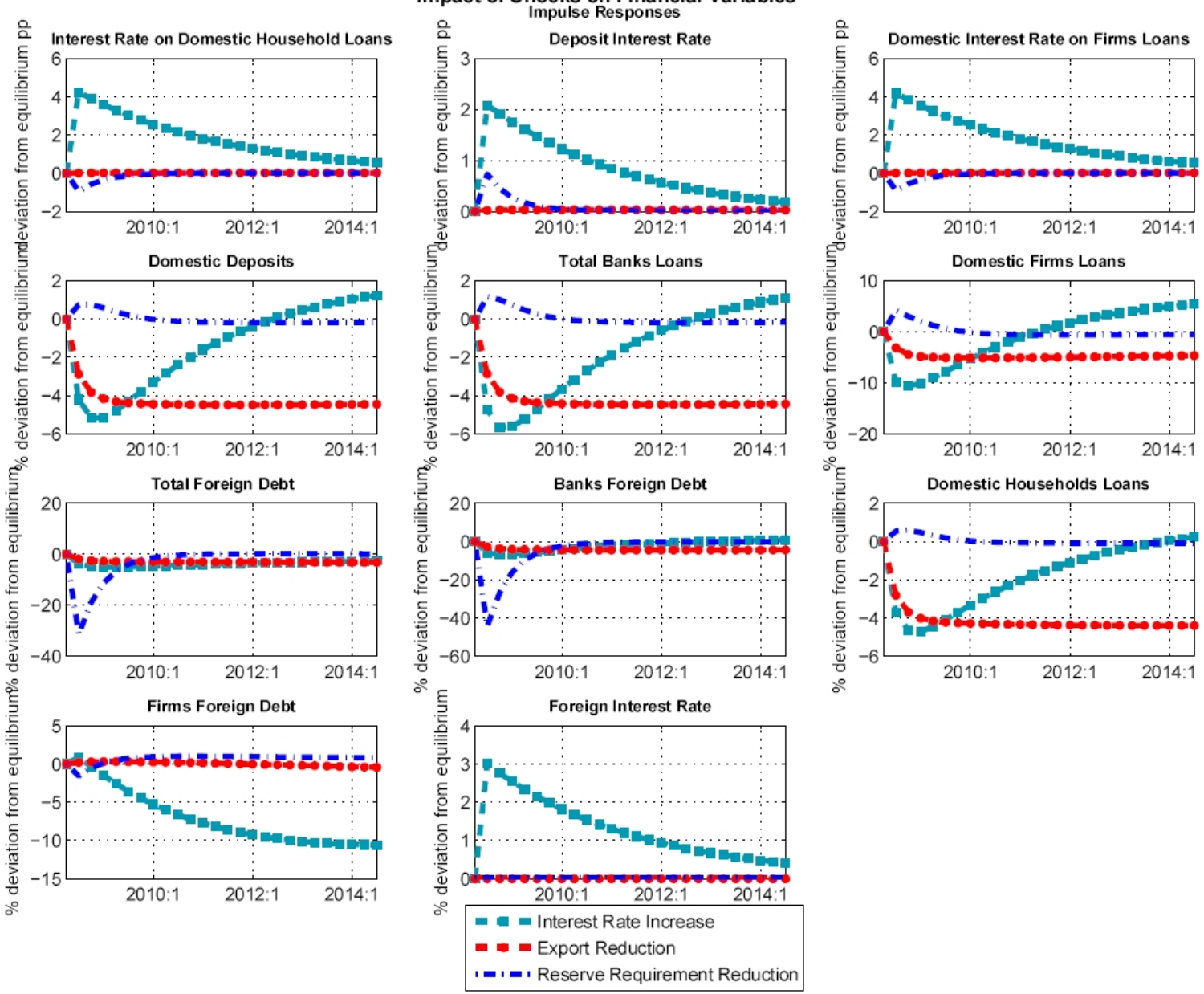
9 Appendix A

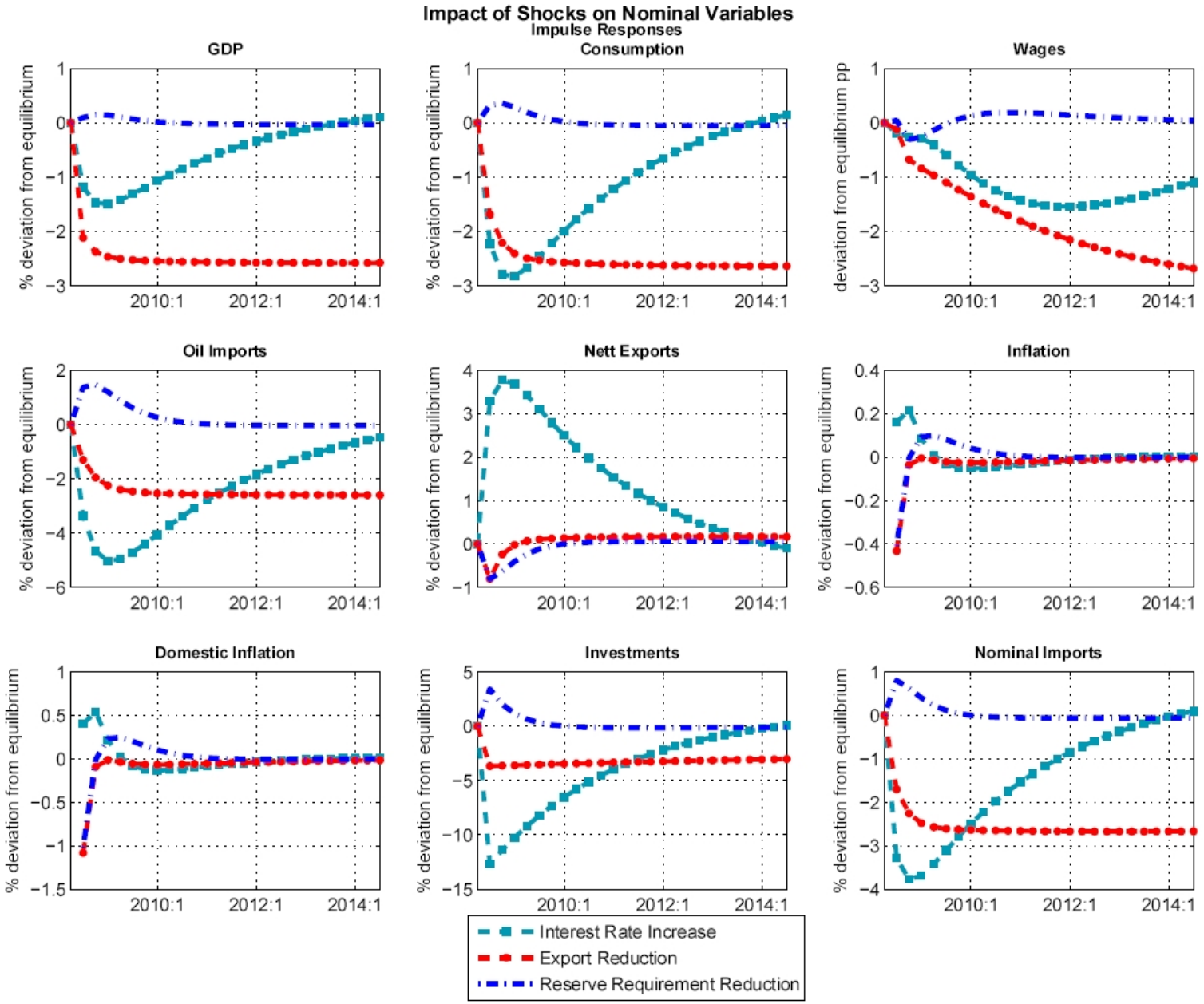
Parameter	Description	Value
Households		
β	discount factor	0.99
σ	relative risk aversion	2
η	labor supply elasticity	3
κ^h	consumption/household's loans	2
c_{ss}	steady state consumption	1.53
p^p_{ss}	steady state of "imported" prices	1.55
p^q_{ss}	steady state of "domestic" prices	1.19
φ^h	loan elasticity parameter	0.75
χ	habit importance parameter	0.4
ω	dom. produced good/composite index	0.4
ε	elasticity of substitution	4
α	growth rate of technology	0
Labor Union		
ζ_w	wage adjustment cost	100
Retailers		
ξ_q	price adjustment cost	100
Importers		
ξ_p	price adjustment cost	0.1
Exporters		
ρ_x	AR coefficient	0.99

Parameter	Description	Value
Domestic Producers		
γ_o	share of oil in production function	0.10
γ_h	share of labor in production function	0.67
κ^d	input costs/bank loan	6
δ	depreciation rate (quart.)	3%
φ^d	elasticity of loans	0.2
ζ_n	capital adjustment cost	20
ζ_z	labor adjustment cost	20
ζ_o	oil adjustment cost	50
Banks		
r_t^r	reserve requirement ratio	1%
r_t^m	GOP	33%
ξ_D	elasticity of deposit rate with respect to costs	0.44
ξ_{Lf}	elasticity of firm's rate with respect to costs	0.17
ξ_{Lh}	elasticity of household's rate with respect to costs	0.14
ρ_{sp}	AR coefficient in spread	0.9
Monetary Policy		
ρ_{rr}	AR coefficient of reserve requirement	0.61
ρ_{mr}	AR coefficient of GOP	0.83
Financial Intermediaries		
ψ	scaling parameter	2.1
ν	elasticity of substitution	4
η	share of bank loan in financial intermediary loan	0.67
External Sector		
ρ_{tot}	AR coefficient of terms of trade	0.77
ρ_{if}	AR coefficient of terms of foreign inflation rates	0.92
ρ_{pmf}	AR coefficient of terms of imported inflation	0.01
ρ_{pnf}	AR coefficient of terms of investment inflation	0.01
ρ_{pof}	AR coefficient of terms of oil inflation	0.01


Impact of Shocks on Real Variables
Impulse Responses
GDP
Consumption
Domestic Consumption
Consumption Goods Import
Wages
Employment
Oil Imports
Investments
Domestic Production
% deviation from equilibrium
deviation from equilibrium pp
2010:1
2012:1
2014:1
Interest Rate Increase
Export Reduction
Reserve Requirement Reduction

Impact of Shocks on Financial Variables




Impact of Shocks on Nominal Variables
Impulse Responses
GDP
Consumption
Wages
Oil Imports
Nett Exports
Inflation
Domestic Inflation
Investments
Nominal Imports
% deviation from equilibrium
deviation from equilibrium pp
2010:1
2012:1
2014:1
Interest Rate Increase
Export Reduction
Reserve Requirement Reduction