The Effect of Macroeconomic Shocks on a Small Open Economy with Financial Accelerator: Lessons for Eastern Europe

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Abstract

This paper considers the effect of four shocks on the economies of the ten Eastern European transitional countries that recently joined the European Union. Each of these shocks stems from the process of integration and financial liberalization that these countries experience as they move from a centrally planned to a market economy. The paper uses a calibrated small-open-economy dynamic stochastic general equilibrium model with a financial accelerator in the household sector to assess the effect of these shocks on various macroeconomic variables. The four shocks considered are positive productivity growth in tradables, increased access to household credit, a decline in the cost of imports and a fall in spreads. The analysis shows that the financial accelerator magnifies the effect these innovations have on output and consumption, generating a larger spending boom than would take place otherwise. The study also demonstrates that the response of the foreign debt is often not very significant and can be sensitive to the specification of the financial constraint.

JEL Classification: D58, E27, E44, F32, F34, F36, F41

Keywords: Small Open Economy, Macroeconomic Shocks, Transitional Countries, Financial Accelerator, Imperfect Financial Markets

Contents

1 Introduction

In 2004 and 2007 ten new countries[1] from Central and Eastern Europe - Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia - joined the European Union (EU). For all of these countries, admission to the Union signified a break with their socialist past and a reaffirmation of long-held democratic and market-oriented goals. Despite becoming members of the Union, the process of transition is still ongoing as these economies continue their efforts to achieve convergence with the economies of the "old" member states of the EU and liberalize their financial markets. However, the Eastern European countries have a significant degree of imperfections in their credit markets which may amplify the response of various macroeconomic indicators following shocks associated with liberalization. The consequences of this could be difficult for policymakers to stabilize. This is especially undesirable in view of the fact that eight of these transitional economies are currently striving to join the European common currency, the euro, and as a prerequisite for this, they must keep their external deficit and long-term interest rate within the limits stipulated by the European Exchange Rate Mechanism II (ERM II) (Convergence Report 2008). This paper considers four shocks that can take place in such transitional countries and evaluates their effects on the domestic economy.

1.1 The Transition Process

The process of transition is characterized by significant market liberalization and by the integration of the Eastern European economies with those of the rest of Europe. The opening of transitional markets to foreign presence brought significant gains in productivity. Foreign firms arrived on the domestic market and formerly state home enterprises were privatized to outside owners. There was significant improvement in manufacturing due to the adoption of more efficient practices from abroad and to labor shedding. New firms entered the market, occupying emerging niches and displacing obsolete firms that had been forced to exit the market (IMF 2009). In addition to this, since the Eastern European countries joined the EU, the barriers to trade have significantly diminished. This allowed a wider variety of imports

[1] Throughout this paper the terms "new member states", "transitional economies" and "Eastern European countries" may be used interchangeably to describe the countries which are the subject of this study.

which increased competition and brought prices down. The removal of tariffs and taxes also contributed to falling import prices. In addition to that, as emerging markets in the 1990s, Eastern European countries were deemed risky for foreign investors. Their borrowing on the international financial markets attracted a risk premium that was meant to safeguard against a higher chance for default. However, as these countries entered the EU and began to liberalize their financial markets, the risk associated with investing in them started to fall. First, by fully liberalizing the capital account, the EU offered borrowers increased access to foreign funding, both through domestic banks affiliated with foreign parents and directly from abroad. Second, by increasing trade openness, the EU provided hedging opportunities, especially for the corporate sector.

A lot of the improvements in Eastern European countries are due to financial liberalization and improving financial markets. The process has not been entirely smooth, however. These economies have a large fraction of households, which, due to their low income and the imperfect nature of debt enforcement, are constrained in their ability to borrow. These credit-constrained consumers require collateral in order to take out a loan and face a higher interest rate which embodies the riskiness of lending to them. The presence of a non-negligible number of such households has significant consequences for the economy as a whole. Specifically, the fact that these consumers cannot fully optimize their investment and consumption decisions and require a collateral against which to borrow, acts as a financial accelerator that causes any shocks that hit the economy to have a more pronounced effect than they would have if all of these consumers could borrow freely. As a result, financial imperfections may lead to sizable changes in the composition of final demand, and through this, to considerable movements in output and the external deficit.

1.2 Similar Literature on Eastern European Countries

This research considers four shocks to which the new EU member states from Eastern Europe are susceptible and how the financial accelerator magnifies the effect of these disturbances on their economies. Several of the shocks examined are similar to these discussed in Lendvai and Roeger (2008), who consider a calibrated small-open-economy model with financial accelerator to discuss external imbalances in the Baltic countries. These authors find that

imbalances can be explained to a great extent by productivity growth, a fall in spreads and increasing access to household credit. However, their main goal is to explain past deficits rather than to demonstrate susceptibility to potential ones in the future. Moreover, the shocks considered by Lendvai and Roeger do not complete the list of the most common shocks relevant to the new member states of the EU that are the focus of this study. Our research also examines the effect of a decrease in the price of imports. Indeed, a wider variety of approaches than those proposed by Lendvai and Roeger emerges from a careful review of studies on other developing countries. A study of non-transitional countries which comes closest to the purposes of this paper was done by Kuralbayeva (2007) on Kazakhstan. Her small open economy setup considers the effect of terms of trade shocks on an oil exporting country in the presence of credit-constrained consumers. While the results illustrate the magnified responses of the main macroeconomic variables to a change in oil price, the type of shock considered does not reflect the specific issues faced by Eastern European countries. The main shock considered, a permanent rise in the export price of oil, would not benefit a transitional country the way it would an oil-exporting one.

1.3 The Novelty of This Approach

In order to evaluate the effects of transitional shocks on a small open economy with imperfect capital markets, it is explicitly necessary to model the presence of collateral-constrained consumers. Therefore, a simple stochastic dynamic general equilibrium model like that of Smets and Wouters (2002) with consumers and production sectors would not suffice for this purpose. Such a model with infinitely lived optimizing consumers would have very different implications from what is the reality in transitional countries. It assumes that consumers can freely optimize their intertemporal choices and that there are no obstacles to reaching an outcome that is Pareto optimal. In our case, however, we need to account for the fact that while some households indeed reach their Pareto optimal levels of consumption, others cannot due to their limited access to credit. Furthermore, we have to describe the production of the good that is used as collateral, in our case housing, and to specify the way it enters the financial constraint. For this purpose, an approach that simply models house purchasing decisions like Muellbauer (2008) does not allow us to capture the magnifying effect of the

financial accelerator. In order to do so the housing stock needs to enter an explicitly specified collateral constraint amplifies the effect of all shocks by affecting the value of the collateral. Therefore, we need a model that would include a financial constraint that embodies the way decisions by credit-constrained consumers differ from their Ricardian counterparts and that acts as a vehicle of propagating shocks through the economy. Overall, incorporating imperfect financial markets is an integral part of the model framework that allows credit limitations to have a real impact on the economy. For these purposes we must abandon the model of classic real business cycles in favor of one with a financial accelerator.

To begin our analysis, this paper seeks to build on the general idea of financial frictions from Bernanke, Gilchrist and Gertler (1998). However, unlike Bernanke, Gilchrist and Gertler, who place an emphasis on frictions in the financial market, we consider a financial accelerator in the household sector. This is captured by the assumption that there are credit-constrained consumers in the economy who do not have enough wealth, and so when these people borrow credit they need to provide collateral. Their consumption decisions are thus constrained by the amount of collateral they possess. In contrast to Kiyotaki and Moore (1997), who designate land, a production input, as the collateral required, we believe that housing, a consumption good, is a more realistic collateral requirement for credit-constrained households and is in line with empirical observations in Eastern Europe. Hence we place a financial accelerator in the household sector and examine the role it has in transmitting external shocks to the economy. However, unlike aforementioned studies, this research defines a different kind of collateral constraint. In Lendvai and Roeger (2008) the collateral constraint takes the form of a requirement that collateral-constrained consumers borrow up to a fraction of their housing stock. While such an approach is certainly not without merit, it neglects the fact that often the interest rate charged to non-optimizing consumers varies with the amount borrowed. It also fails to capture the reality that credit-constrained consumers, through their optimizing decisions, influence the equilibrium borrowing rate and the amount lent. To account for this, we couple the collateral constraint with the private borrowing rate faced by these consumers. The interest rate at which they borrow is a markup over the risk-free rate that prevails in the economy. This markup is directly proportional to the amount borrowed and inversely related to the housing stock owned. Hence the more credit-constrained consumers borrow, the costlier it is to refinance. The fact that the private

borrowing rate depends on the housing stock captures the essence of the model. Any shock that would affect the value of the housing stock would in turn affect borrowing and overall consumption decisions of these households, and in turn would have significant effects on the economy overall.

1.4 Implications of the Study

This paper finds that following an exogenous shock, which often stems from the process of financial liberalization and convergence, a transitional economy with a financial accelerator experiences a more pronounced response of various macroeconomic variables than does a perfect economy. This finding is in line with other outcomes in the literature such as Kuralbayeva and Vines (2007) and Lendvai and Roeger (2008). Output and consumption are the variables that most often jump excessively in an economy with imperfect financial markets. The effect on external debt is less pronounced and often is short-lived. Relaxing the borrowing constraint of credit-constrained consumers generates an external deficit but it disappears quickly. In our case, this is explained by the fact that while a positive borrowing shock benefits the households subject to the constraint, the rest of the population suffers adverse effects from it. This suggests that the effects of the presence of credit-constrained consumers on the economy are not clear-cut and stabilization policies must do a fine act of balancing these consequences.

The potential shocks chosen reflect the process of convergence and financial liberalization of these countries. The first shock discussed in productivity growth in tradables. The subsequent output expansion increases income for all households. However, similarly to Lendvai and Roeger (2008), the rise in wealth of credit-constrained consumers leads to a more pronounced response of output and consumption. The external surplus in the economy with imperfect financial markets is slightly larger since the collateral constraint augments the effect of increased income. The second shock that transitional countries experience is a change in the price of imports. While this raises overall affordability of consumption goods and amplifies spending, there is no higher external deficit in an imperfect economy. This is due to the fact that credit-constrained consumers sustain the resulting spending boom out of their income rather than finance through extra borrowing. The third macroeconomic dis-

turbance examined is a change to the foreign risk premium. A more favorable risk premium makes borrowing by both Ricardian consumers and credit-constrained households more affordable. This fuels increased borrowing that adds to the external deficit. However, since the economy is very flexible and there is no permanent component to the risk premium change, the effect of the larger deficit is not lasting. The fourth and last shock considered is increased access to credit that affords credit-constrained consumers more borrowing for the same amount of collateral they possess. Such change improves the financial position of credit-constrained consumers by making borrowing more affordable. As a result, their consumption increases and foreign debt rises. However, Ricardian consumers do not benefit from this improvement and this causes the external deficit generated by the expansion of credit to collateral-constrained consumers to be temporary.

1.5 Limitations and Extensions

This study demonstrates that imperfect financial markets indeed augment the response of some macroeconomic variable following a shock. They contribute to a larger swing in consumption and output but do not have a significant effect on the debt position. The response of the deficit, however, is intricately dependent on the collateral feedback rule considered. In this case, the variable interest rate responds only to current values of borrowing and the collateral stock so all effects are instantaneous and short-lasting. If, on the other hand, the collateral constraint includes lags or expectations of the future, the effect of the financial accelerator may be different. In addition to this, the inclusion of nominal rigidities may also make the consequences of shocks more prominent. Another important modification to be considered is modeling the disturbances as permanent rather than temporary. Since the process of integration and financial liberalization is a permanent one, this would capture reality better. Furthermore, it would give rise to different optimization dynamics. Although these issues are beyond the current study, they can be revisited given more time and opportunity. Nevertheless, this modest analysis shows that an imperfect economy behaves differently than an optimizing one and therefore an economy with a financial accelerator could be more difficult to stabilize in the aftermath of a shock.

2 Model of a Small Open Economy with Financial Accelerator

In order to investigate how macroeconomic shocks reverberate through the economies of Eastern Europe, this paper considers a representative model with a small open economy. Its key characteristic is the addition of a financial accelerator which is embodied in the household sector: this is necessary given that there exists a fraction of consumers who are unable to borrow freely unless they provide collateral. This setup captures closely the reality in transitional countries, which are characterized by imperfect monitoring and credit insurance, in addition to the presence of a sizable portion of poor people. While this makes the model rather elaborate, it is necessary in order to evaluate the contribution of the collateral constraint to the response of macroeconomic variables to a shock. Kuralbayeva and Vines (2008) do not consider such financial frictions so their model would not allow us to explore the compounding effects of the financial accelerator. This chapter lays out the microfoundation of the model: it consists of two types of households, of three production sectors, and of foreign markets.

2.1 Consumers

The model assumes two types of households: Ricardian households who can fully optimize their choices, and credit-constrained households. Like in Lendvai and Roeger (2008), the first type of households has access to foreign capital markets, whereas the second group of households is constrained to borrowing only from domestic sources. However, this model departs from the classical definition of a collateral constraint embodied in Aoki et al. (2008) and instead introduces a variable borrowing rate faced by credit-constrained consumers constructed as a markup over the domestic interest rate and which depends both on the collateral owned and the amount borrowed.

2.1.1 Preferences

Both groups of Ricardian and credit-constrained consumers have the same preferences. Households choose consumption C_t^i, housing H_t^i and labor L_t^i subject to their respective budget constraints. Here i denotes the type of consumers: r for Ricardian and c for credit-constrained. Each household seeks to maximize its lifetime expected utility:

$$U = E_0 \sum_{t=0}^{\infty} \beta U(C_t^i, H_t^i, L_t^i) \tag{1}$$

The period-utility of each household is given by:

$$U(C_t^i, H_t^i, L_t^i) = \frac{C_t^{i1-\sigma}}{1-\sigma} + \kappa \frac{H_t^{i1-\theta}}{1-\theta} - \gamma^i \frac{L_t^{i1-\varphi}}{1-\varphi} \tag{2}$$

Unlike the analysis in Kuralbayeva (2007) where housing enters the consumption aggregator, here the period utility function is separable in consumption C_t^i, housing H_t^i and labor L_t^i. Since housing is used as collateral by credit-constrained consumers, this setup explicitly allows us to model how a change in the price of housing affects their consumption and borrowing choices via the collateral constraint. This specification also ensures that all consumers possess housing stock, which is especially important for credit-constrained consumers who borrow against the value of their houses. Hence the trivial corner solution in which credit-constrained consumers are unable to borrow is eliminated.

The γ^iparameter of labor in utility varies by the type of consumers and reflects the share each type of household has in the economy and is equivalent to specifying a percentage for each kind of household. An equal value for all consumers would imply that the economy is populated with consumers of only one type. By varying γ^i by households, one group of consumers had more weight in the economy which is equivalent to this group being more populous. Unlike Lenvdai and Roeger (2008), who employ straightforward share parameters, this feature allows us to vary the share of different consumer groups and at the same time ensures that the outcome is comparable across different versions of the economy. The parameter κ is the same for both Ricardian and credit-constrained consumers and determines the weight housing has in the utility function. In the absence of this parameter, the substitution effect between consumption and housing would depend solely on relative prices and as a result may imply a share of housing of total production that is inconsistent with

empirical observations. Simply put, κ ensures that the price of housing stays within reasonable values while at the same time allowing houses to constitute a small fraction of the total output in the economy.

Consumption C_t^i is a standard constant elasticity of scale (CES) consumption aggregator of tradables ($C_{T,t}^i$) and non-tradables ($C_{N,t}^i$) goods. Tradables goods could be either domestically produced or imported and the two types are perfectly substitutable. Consumers choose the amount of tradables and non-tradables to enter the consumption aggregator in the following form:

$$C_t^i = \left[\varpi^{\frac{1}{\rho}}(C_{T,t}^i)^{\frac{\rho-1}{\rho}} + (1-\varpi)^{\frac{1}{\rho}}(C_{N,t}^i)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{3}$$

where $i = r,\ c$ and $\rho > 0$. Here ρ denotes elasticity of substitution between tradable and non-tradable goods. Consumers maximize this compound consumption function subject to the budget constraint:

$$p_{C,t}C_t^i = p_{T,t}C_{T,t}^i + p_{N,t}C_{N,t}^i \tag{4}$$

where$p_{T,t}$ the price of tradables, $p_{N,t}$ the price of non-tradables and $p_{C,t}$ is the consumption price index.

This forms the Lagrangian:

$$\mathcal{L} = \left[\varpi^{\frac{1}{\rho}}(C_{T,t}^i)^{\frac{\rho-1}{\rho}} + (1-\varpi)^{\frac{1}{\rho}}(C_{N,t}^i)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} - \lambda_t\left(p_{T,t}C_{T,t}^i + p_{N,t}C_{N,t}^i - p_{C,t}C_t^i\right) \tag{5}$$

The first order conditions for tradables and non-tradables that maximize this Lagrangian are:

$\frac{\partial \mathcal{L}}{\partial C_{T,t}^i} =$

$$= \frac{\rho}{\rho-1}\left[\varpi^{\frac{1}{\rho}}(C_{T,t}^i)^{\frac{\rho-1}{\rho}} + (1-\varpi)^{\frac{1}{\rho}}(C_{N,t}^i)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}-1}\left(\frac{\rho-1}{\rho}\varpi^{\frac{1}{\rho}}(C_{T,t}^i)^{\frac{\rho-1}{\rho}-1}\right) - \lambda_t p_{T,t} \tag{6}$$

$\frac{\partial \mathcal{L}}{\partial C_{N,t}^i} =$

$$= \frac{\rho}{\rho-1}\left[\varpi^{\frac{1}{\rho}}(C^i_{T,t})^{\frac{\rho-1}{\rho}} + (1-\varpi)^{\frac{1}{\rho}}(C^i_{N,t})^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}-1}\left(\frac{\rho-1}{\rho}(1-\varpi)^{\frac{1}{\rho}}(C^i_{N,t})^{\frac{\rho-1}{\rho}-1}\right) - \lambda_t p_{N,t} \tag{7}$$

Combining these two conditions we obtain:

$$\left(\frac{\varpi}{(1-\varpi)}\right)^{\frac{1}{\rho}}\left(\frac{C^i_{T,t}}{C^i_{N,t}}\right)^{-\frac{1}{\rho}} = \frac{p_{T,t}}{p_{N,t}} \tag{8}$$

This establishes that the tradeoff between the two types of goods depends on their prices and their weight in the consumption aggregator.

Rearranging this implies:

$$C^i_{N,t} = \left(\frac{(1-\varpi)}{\varpi}\right)\left(\frac{p_{T,t}}{p_{N,t}}\right)^{\rho} C^i_{T,t} \tag{9}$$

Combining with the budget constraint gives the demand for tradables and non-tradables as a share of total consumption:

$$C^i_{N,t} = (1-\varpi)\left(\frac{p_{N,t}}{p_{C,t}}\right)^{-\rho} C^i_t \tag{10}$$

$$C^i_{T,t} = \varpi\left(\frac{p_{T,t}}{p_{C,t}}\right)^{-\rho} C^i_t \tag{11}$$

Hence the demand of each good depends on its share in the consumption aggregator and on the ratio of its price to the consumption price index.

The implied consumption price index is then:

$$p_{C,t} = \left[\varpi(p_{T,t})^{1-\rho} + (1-\varpi)(p_{N,t})^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{12}$$

This defines the consumption price index as a weighted average of the price of the tradables and non-tradables goods. The weight of each price is the share of the respective good in the consumption basket.

2.1.2 Optimizing Consumers

Ricardian consumers are assumed to own all firms and the entire capital stock in the economy. Specifically, they hold foreign bonds $B_{F,t}$ issued by foreign households and real capital stocks of the tradables, non-tradables and housing sectors $K_{T,t}$, $K_{N,t}$ and $K_{H,t}$. They receive regular income from labor and financial assets, rental income from lending capital to firms and profit income from firms owned by the household. Ricardian consumers also lend to credit constrained households ($B_{pr,t}$). The budget constraint for Ricardian households is:

$$p_{C,t}C_t^r + p_{H,t}H_t^r + p_{C,t}\left(\phi_{T,t}K_{T,t} + \phi_{N,t}K_{N,t} + \phi_{H,t}K_{H,t}\right) +$$

$$+p_{T,t}\left(I_{T,t} + I_{N,t} + I_{H,t}\right) + B_{pr,t}^r + R_{t-1}B_{F,t-1} =$$

$$= w_t L_t^r + \left(x_{T,t}K_{T,t} + x_{N,t}K_{N,t} + x_{H,t}K_{H,t}\right) + B_{F,t} + R_{pr,t-1}B_{pr,t-1}^r + \Pi_t \tag{13}$$

In this equation $p_{C,t}$ is the price of the aggregate consumption good and $p_{H,t}$ is the price of housing. $K_{T,t}$ is capital in the tradables sector, $K_{N,t}$ in the non-tradables sector and $K_{H,t}$ in the housing sector. The return on capital is $x_{T,t}$ in the tradables sector, $x_{N,t}$ in the non-tradables sector and $x_{H,t}$ in the housing sector. Respectively, $I_{T,t}$ is investment in the tradables, $I_{N,t}$ in the non-tradables and $I_{H,t}$ in the housing sectors. $B_{F,t}$ are foreign bonds and Π_t denotes firm profits. The domestic interest rate is R_t and the interest rate charged on credit-constrained consumers is $R_{pr,t}$.

Capital accumulation equations in the tradables and non-tradables sectors are:

$$K_{j,t+1} = I_{j,t} + (1-\delta)K_{j,t} \tag{14}$$

where $j = T,\ N$ and $0 < \delta < 0$ is the depreciation rate of capital in all sectors.

That in the housing sector is:

$$K_{H,t+1} = I_{H,t} + (1-\delta^H)K_{H,t} \tag{15}$$

where $0 < \delta^H < 0$ is the depreciation rate of housing capital.

Investment in all three sectors entirely involves expenditure on tradables goods. Installation of capital requires adjustment costs, which represent a basket of goods composed by non-tradables goods and tradables goods in the same mix as the household consumption basket. These capital adjustment costs are:

$$\phi_{j,t}\left(\frac{I_{j,t}}{K_{j,t}}\right)K_{j,t} = \frac{\psi}{2}\left(\frac{I_{j,t}}{K_{j,t}} - \delta\right)^2 K_{j,t} \tag{16}$$

where $j = T, N$ denotes the tradables and non-tradables sectors respectively. Adjustment costs in the housing sector are:

$$\phi_{H,t}\left(\frac{I_{H,t}}{K_{H,t}}\right)K_{H,t} = \frac{\psi}{2}\left(\frac{I_{H,t}}{K_{H,t}} - \delta^H\right)^2 K_{H,t} \tag{17}$$

Ricardian consumers choose their consumption, leisure and housing. Since they own all firms in the economy, they also make all investment decisions and receive firm profits. They refinance themselves via the international credit market and lend to credit-constrained consumers. The Lagrangian for Ricardian consumers is:

$$\mathcal{L}_t^r = \mathcal{E}_t \sum_{t=0}^{\infty} \beta^{rt} U\left[\frac{C_t^{r1-\sigma}}{1-\sigma} + \kappa\frac{H_t^{r1-\theta}}{1-\theta} - \gamma^r\frac{L_t^{r1-\varphi}}{1-\varphi}\right] +$$

$$+\lambda_t^r\left(w_t L_t^r + (x_{T,t}K_{T,t} + x_{N,t}K_{N,t} + x_{H,t}K_{H,t}) + B_{F,t} + R_{pr,t-1}B_{pr,t-1}^r + \Pi_t\right) -$$

$$-\lambda_t^r\left[p_{C,t}\left(\frac{\psi}{2}\left(\frac{I_{T,t}}{K_{T,t}} - \delta\right)^2 K_{T,t} + \frac{\psi}{2}\left(\frac{I_{N,t}}{K_{N,t}} - \delta\right)^2 K_{N,t} + \frac{\psi}{2}\left(\frac{I_{H,t}}{K_{H,t}} - \delta^H\right)^2 K_{H,t}\right)\right] -$$

$$-\lambda_t^r\left(p_{C,t}C_t^r + p_{H,t}H_t^r + p_{T,t}(I_{T,t} + I_{N,t} + I_{H,t}) - B_{pr,t}^r - R_{t-1}B_{F,t-1}\right) +$$

$$+\lambda_t^r\left[q_{T,t}\left(I_{T,t} + (1-\delta)K_{T,t} - K_{T,t+1}\right) + q_{N,t}\left(I_{N,t} + (1-\delta)K_{N,t} - K_{N,t+1}\right)\right] +$$

$$+\lambda_t^r q_{H,t}\left(I_{H,t}+(1-\delta^H)K_{H,t}-K_{H,t+1}\right) \tag{18}$$

The optimization problem yields the standard first-order conditions for consumption, housing, leisure, capital, investment and bonds. The first-order condition for consumption is:

$$\frac{\partial \mathcal{L}^r}{\partial C_t^r} = (C_t^r)^{-\sigma} - \lambda_t^r p_{C,t} \tag{19}$$

Taking the derivative of the Lagrangian with respect to housing yields:

$$\frac{\partial \mathcal{L}^r}{\partial H_t^r} = \kappa\,(H_t^r)^{-\theta} - \lambda_t^r p_{H,t} \tag{20}$$

The optimization of labor is governed by:

$$\frac{\partial \mathcal{L}^r}{\partial L_t^r} = -\gamma^r L_t^{r\varphi} - \lambda_t^r w_t \tag{21}$$

Intertemporal choice is related by:

$$\frac{\partial \mathcal{L}^r}{\partial B_{F,t}} = \lambda_t^r - \beta^r \mathcal{E}_t \lambda_{t+1}^r R_t \tag{22}$$

The maximization of capital in all three sector gives:

$\frac{\partial \mathcal{L}^r}{\partial K_{j,t}} = \beta \mathcal{E}_t \lambda_{t+1}^r$.

$$\left[x_{j,t+1} - p_{C,t+1}\left(\frac{\psi}{2}\left(\frac{I_{j,t+1}}{K_{j,t+1}}-\delta\right)^2 - \psi\left(\frac{I_{j,t+1}}{K_{j,t+1}}-\delta\right)\frac{I_{j,t+1}}{K_{j,t+1}}\right) + q_{j,t+1}(1-\delta)\right] - \lambda_t^r q_{j,t} \tag{23}$$

where $j = T,\ N$ denotes the tradables and non-tradables sectors respectively.

$\frac{\partial \mathcal{L}^r}{\partial K_{H,t}} = \beta \mathcal{E}_t \lambda_{t+1}^r$.

$$\left[x_{H,t+1} - p_{C,t+1}\left(\frac{\psi}{2}\left(\frac{I_{H,t+1}}{K_{H,t+1}}-\delta^H\right)^2 - \psi\left(\frac{I_{H,t+1}}{K_{H,t+1}}-\delta^H\right)\frac{I_{H,t+1}}{K_{H,t+1}}\right) + q_{H,t+1}(1-\delta^H)\right] - \lambda_t^r q_{H,t} \tag{24}$$

Finally, the choice of capital evolves according to:

$$\frac{\partial \mathcal{L}^r}{\partial I_{j,t}} = \lambda_t^r \left[-p_{C,t}\psi \left(\frac{I_{j,t}}{K_{j,t}} - \delta \right) - p_{T,t} + q_{j,t} \right] \tag{25}$$

where $j = T,\ N$ denotes the tradables and non-tradables sectors respectively.

$$\frac{\partial \mathcal{L}^r}{\partial I_{H,t}} = \lambda_t^r \left[-p_{C,t}\psi \left(\frac{I_{H,t}}{K_{H,t}} - \delta^H \right) - p_{T,t} + q_{H,t} \right] \tag{26}$$

Combining equations (2.19) and (2.21) equals the marginal disutility of the labor effort to the utility value of the wage rate, and defines the households' labor supply curve:

$$\gamma^r L_t^{r\varphi} p_{C,t} (C_t^r)^\sigma = w_t \tag{27}$$

The amount of labor supplied depends on the equilibrium wage, consumption, the consumption price and the scaling parameterγ^r. This equation demonstrates how the amount of labor supplied by Ricardians varies with this parameter and this is equivalent to specifying the share of optimizing consumers in the economy.

The housing-consumption tradeoff follows from equations (2.20) and (2.21) and determines the substitutability between housing and the consumption aggregate:

$$p_{H,t} \left(H_t^r\right)^\theta = \kappa p_{C,t} (C_t^r)^\sigma \tag{28}$$

It is obvious that the proportion of housing to consumption demanded is a function of their prices and the scaling parameter κ. Hence κ determines the percent of the change in consumption that translates into a change in housing.

The Euler equation that governs intertemporal allocation follows from equations (2.19) and (2.22) and equates the intertemporal marginal rate of substitution in consumption to the real rate of return on foreign bonds:

$$\mathcal{E}_t \left[\left(\frac{C_{t+1}^r}{C_t^r} \right)^\sigma \frac{p_{C,t+1}}{p_{C,t}} \right] = \beta^r R_t \tag{29}$$

The pricing condition for physical capital obtained from equations (2.19) and (2.24) in the tradables and non-tradables sector equates the revenue from selling one unit of capital today ($q_{j,t}$), to the discounted value of renting the unit of capital for one period, and then selling it, net of depreciation and adjustment costs.

$\beta^r \mathcal{E}_t \left[\left(\frac{C_t^r}{C_{t+1}^r} \right)^\sigma \frac{p_{C,t}}{p_{C,t+1}} \right]$.

$$\left[x_{j,t+1} - p_{C,t+1} \left(\frac{\psi}{2} \left(\frac{I_{j,t+1}}{K_{j,t+1}} - \delta \right)^2 - \psi \left(\frac{I_{j,t+1}}{K_{j,t+1}} - \delta \right) \frac{I_{j,t+1}}{K_{j,t+1}} \right) + q_{j,t+1}(1-\delta) \right] = q_{j,t} \tag{30}$$

This equation determines the evolution of the Tobin's $q_{j,t}$, or the shadow price of capital. Since adjustments stem from decreasing the capital stock, the adjustment function shifts upward as investment decreases as represented by $\left(\frac{\psi}{2} \left(\frac{I_{j,t+1}}{K_{j,t+1}} - \delta \right)^2 - \psi \left(\frac{I_{j,t+1}}{K_{j,t+1}} - \delta \right) \frac{I_{j,t+1}}{K_{j,t+1}} \right)$.

The same equation in the housing sector is respectively:

$\beta^r \mathcal{E}_t \left[\left(\frac{C_t^r}{C_{t+1}^r} \right)^\sigma \frac{p_{C,t}}{p_{C,t+1}} \right]$.

$$\left[x_{H,t+1} - p_{C,t+1} \left(\frac{\psi}{2} \left(\frac{I_{H,t+1}}{K_{H,t+1}} - \delta^H \right)^2 - \psi \left(\frac{I_{H,t+1}}{K_{H,t+1}} - \delta^H \right) \frac{I_{H,t+1}}{K_{H,t+1}} \right) + q_{H,t+1}(1-\delta^H) \right] = q_{H,t} \tag{31}$$

Finally, the cost of producing a unit of capital in the tradables and the non-tradables sector respectively comes from equations (2.19) and (2.26) and equals the shadow price of installed capital, or Tobin's $q_{j,t}$

$$q_{j,t} = p_{T,t} + p_{C,t} \psi \left(\frac{I_{j,t}}{K_{j,t}} - \delta \right) \tag{32}$$

The corresponding equation for the housing sector is:

$$q_{H,t} = p_{T,t} + p_{C,t} \psi \left(\frac{I_{H,t}}{K_{H,t}} - \delta^H \right) \tag{33}$$

The equations describing the problem of optimizing consumers are standard and are similar to these found in most microfounded treatments of a small open economy, including Lenvdai and Roeger (2008) and Kuralbayeva (2008). The treatment of credit-constrained consumers departs from the literature by a core assumption described in the following section.

2.1.3 Credit-Constrained Consumers

Credit-constrained households do not own firms, nor make investment decisions. Hence their only income source is their labor income and private borrowing from Ricardian consumers which must be done against the value of their housing. They differ from Ricardian households in that they face a collateral constraint on their borrowing. They can borrow exclusively from domestic Ricardian households ($B_{pr,t}$). On the other hand, Ricardian households in turn have the possibility to refinance themselves via the international capital markets. Credit-constrained consumers are also more impatient than Ricardians so they discount the future at a higher rate, $\beta^c < \beta^r$. Their budget constraint is

$$p_{C,t}C_t^c + p_{H,t}H_t^c + R_{pr,t-1}B_{pr,t-1}^c = w_t L_t^c + B_{pr,t}^c \tag{34}$$

Similarly to Kuralbayeva (2008), credit-constrained households cannot fully self-finance the purchase of housing so they must rely on private borrowing $B_{pr,t}$. Like Aoki et al. (2008), our model assumes that there is an agency problem that makes uncollateralized external financing more expensive than internal financing. This is especially pervasive in Eastern Europe where fledgling borrowing markets and incompletely harmonized financial monitoring makes lending to credit-constrained consumers a risky endeavor. The idea is that lenders could not observe the borrower's project returns and thus must pay an underlying auditing cost in order to verify repayment ability. Thus the lender and the borrower negotiate a contract which is designed to minimize agency costs. Under the optimal contract the borrower repays the lender the promised amount and keeps the difference. However, if the borrower cannot pay the contractual return and declares default, the lender pays the auditing cost and recovers what he finds. While the process of monitoring and auditing is not explicitly modeled here, the setup captures the idea that the opportunity cost of external financing is more expensive than that of internal financing.

In most models, including Kuralbayeva (2008) and Lenvdai and Roeger (2008), this is captured by an additionally introduced collateral constraint which usually defines possible borrowing up to a fraction of the collateral stock. While this is a straightforward and valid approach, it does not capture reality completely and fails to account for the fact that, in such as setup, credit-constrained consumers are not entirely passive in the determination

of the constraint. For starters, it is difficult to implement a credit constraint uniform to a group of households. Monitoring difficulties and incomplete financial oversight in Eastern Europe make it challenging to ensure that credit-constrained consumers borrow up to the exogenously determined fraction of their housing stock. Furthermore, it is not realistic to assume that there is a uniform credit constraint faced by all consumers regardless of the amount they borrow. It is intuitive to think that there is greater risk associated with higher levels of leveraging so the credit ratio would be increasing in the amount borrowed. Concurrently, a larger value of the collateral possessed decreases the risk inherent in lending. To solve for these shortcomings in the existing models, our study proposes a new framework in which rather than subjecting all credit-constrained consumers to a common collateral constraint, a variable interest rate should be introduced that is linearly proportional to the amount borrowed and inversely related to the collateral stock. A credit constraint that is built into the borrowing rate is easier to implement and does not require compliance monitoring like an external requirement. Furthermore, making the borrowing rate variable allows for richer dynamics, given that credit-constrained consumers are not entirely passive in determining the maximum amount they can borrow. In this way, the variable interest rate can be as much a result of their optimization decisions as the amount they borrow.

Following Lendvai and Roeger (2008), the collateral is chosen to be the housing stock owned by credit-constrained insurers. This ensures that every household possesses some collateral and is in line with empirical observations from transitional countries. The borrowing rate faced by credit-constrained consumers is a function of the domestic interest rate. This ensures that any perturbation to the domestic interest rate is passed down onto the borrowing rate faced by credit-constrained consumers, which can be termed the private borrowing rate. Even when the amount borrowed by credit-constrained consumers is zero, the interest rate to which they are subjected is still higher than the domestic interest rate by a baseline markup ω_0. This reflects the fact that lending to these households is inherently riskier than holding assets in a different form. The private interest rate is also dependent on a fraction ω_1 of the ratio of the amount being borrowed to the housing stock. Having the amount borrowed enter the private interest rate linearly prevents explosive borrowing by making it costlier to refinance as the amount owed increases. It also ensures that credit-constrained consumers cannot run Ponzi games. Conversely, the fact that the housing stock enters the

private borrowing rate inversely stimulates conservative borrowing by affording a more favorable refinancing rate for greater house ownership. Hence when the price of houses goes up and therefore the value of the housing stock rises, households face a tradeoff between higher consumption through private borrowing and a cheaper external finance premium.

$$R_{pr,t} = \omega_0 + \omega_1 \frac{B^c_{pr,t}}{p_{H,t} H^c_t} + R_t \tag{35}$$

Since the parameters ω_0 and ω_1 are both non-negative, the private borrowing rate is always at a markup over the domestic interest return even when there is no borrowing. The private borrowing rate contains two markups: a baseline markup determined by the size of ω_0 that is present even before borrowing takes place, and a variable markup that increases with the loan taken and decreases with the value of the collateral. This is in stark contrast with perfect capital markets where the expected return would equal the opportunity cost of funds for the lender, which is the domestic real interest rate. It is interesting to point out that the parameter ω_1 embodies a fine tradeoff point. On one hand, a higher value of ω_1 indicates a more stringent collateral constraint that makes the effects of the financial accelerator more prominent. However, this also induces credit-constrained consumers to borrow less, so the amount of their credit would not have significant effects on the economy. On the other hand, a low value of ω_1 brings credit-constraint consumers closer to Ricardian households, and as a result, the role of the financial accelerator in transmitting shocks decreases. Here we choose ω_1 in order to demonstrate the contribution of the collateral constraint to propagating disturbances. However in subsequent studies, it is worthwhile to calibrate this parameter to match empirical data from individual transitional countries.

Credit-constrained households choose only their leisure, consumption, housing and private borrowing. Their Lagrangian is:

$$\mathcal{L}^c_t = \mathcal{E}_t \sum_{t=0}^{\infty} \beta^{ct} U \left[\frac{C_t^{c1-\sigma}}{1-\sigma} + \kappa \frac{H_t^{c1-\theta}}{1-\theta} - \gamma^c \frac{L_t^{c1-\varphi}}{1-\varphi} \right] +$$

$$+\lambda^c_t \left[w_t L^c_t + B^c_{pr,t} - p_{C,t} C^c_t - p_{H,t} H^c_t - \left(\omega_0 + \omega_1 \frac{B^c_{pr,t-1}}{p_{H,t-1} H^c_{t-1}} + R_{t-1} \right) B^c_{pr,t-1} \right] \tag{36}$$

The first-order conditions for consumption, housing, labor and private borrowing are:

$$\frac{\partial \mathcal{L}^c}{\partial C_t^c} = (C_t^c)^{-\sigma} - \lambda_t^c p_{C,t} \tag{37}$$

$$\frac{\partial \mathcal{L}^c}{\partial H_t^c} = \kappa \left(H_t^c\right)^{-\theta} - \lambda_t^c p_{H,t} + \beta^c \mathcal{E}_t \lambda_{t+1}^c \omega_1 \frac{\left(B_{pr,t}^c\right)^2}{p_{H,t}(H_t^c)^2} \tag{38}$$

$$\frac{\partial \mathcal{L}^c}{\partial L_t^c} = -\gamma^c L_t^{c\varphi} - \lambda_t^c w_t \tag{39}$$

$$\frac{\partial \mathcal{L}^c}{\partial B_t} = \lambda_t^c - \beta^c \mathcal{E}_t \lambda_{t+1}^c \left(R_{pr,t} + \omega_1 \frac{B_{pr,t}^c}{p_{H,t} H_t^c} \right) \tag{40}$$

Their first-order condition for consumption-leisure tradeoff is the same as that for Ricardian consumers:

$$\gamma^c L_t^{c\varphi} p_{C,t} (C_t^c)^{\sigma} = w_t \tag{41}$$

This implies that credit-constrained consumers do not have inherently different preferences than Ricardian households. Rather, they end up making different decisions due to optimizing more limited resources.

However, the first-order condition for housing differs by the presence of the borrowing constraint:

$$\mathcal{E}_t \left[\left(C_{t+1}^c\right)^{\sigma} p_{C,t+1} \right] \kappa \left(H_t^c\right)^{-\theta} = \mathcal{E}_t \left[\left(\frac{C_{t+1}^c}{C_t^c} \right)^{\sigma} \frac{p_{C,t+1}}{p_{C,t}} \right] p_{H,t} - \beta^c \omega_1 \frac{\left(B_{pr,t}^c\right)^2}{p_{H,t}(H_t^c)^2} \tag{42}$$

In the absence of market frictions that would simply be the same as equation (2.28). The housing-consumption equation for credit-constrained consumers differs by the fact that housing now appears intertemporally in the Lagrangian: twice as present value in utility and the budget constraint and once with a lag in the interest rate repaid on past debt. The last term on the right hand side is always positive unless there is no borrowing. It implies that unlike Ricardian consumers who choose their housing consumption optimally, credit-constrained consumers over-invest in housing since it is not only a consumption good for them but also can be used as collateral. Hence in a marked departure from Lenvdai and

Roeger (2008), here the collateral constraint is not exogenously imposed but comes out of the optimizing decisions of credit-constrained consumers.

Their Euler equation also reflects the presence of a collateral constraint:

$$\mathcal{E}_t \left[\left(\frac{C^c_{t+1}}{C^c_t} \right)^{\sigma} \frac{p_{C,t+1}}{p_{C,t}} \right] - \beta^c \omega_1 \frac{B^c_{pr,t}}{p_{H,t} H^c_t} = \beta^c R_{pr,t} \tag{43}$$

The Euler equation shows that the collateral-constrained households' intertemporal consumption path would be different from that of the Ricardian households since it also depends on the borrowed amount and the current value of the housing stock. The second term on the left hand side is greater than zero for positive borrowing and the private borrowing rate is higher than the domestic interest rate. This implies that higher-valued housing stock today would afford more consumption tomorrow via increased borrowing. This further reinforces the conclusion that credit-constrained consumers would tend to invest more in their housing stock today in order to have increased access to credit and hence to consume more in the future.

2.2 Production by Firms

We assume three sectors of domestic firms. Firms in the tradables sector sell consumption goods and services to domestic households and their output is also an investment good in all three sectors. Tradable goods are also imported and are perfect substitutes with goods produced domestically. The non-tradables sector and the housing sector, on the other hand, sell only to domestic households. The price of domestically produced tradable goods is the numeraire. The price of tradables is $p_{T,t}$ and it differs from that of domestically produced tradable goods since the tradables sold, unlike the tradables produced, contain imports as well. Non-tradables are sold at price $p_{N,t}$ and houses at $p_{H,t}$. Houses are sold for one period only and each period starts with a brand new housing stock. Each firm uses sector-specific capital, labor and sector-specific technology to produce its output. Their production functions are respectively given by:

$$Y_{T,t} = A_T K^{\alpha_T}_{T,t} L^{1-\alpha_T}_{T,t} \tag{44}$$

$$Y_{N,t} = A_N K_{N,t}^{\alpha_N} L_{N,t}^{1-\alpha_N} \tag{45}$$

$$Y_{H,t} = A_H K_{H,t}^{\alpha_H} L_{H,t}^{1-\alpha_H} \tag{46}$$

where A_i $(i = T,\ N,\ H)$ is a productivity parameter that differs by sectors.

The firms in the tradables and non-tradables sectors are perfectly competitive so they maximize profits subject to input costs. The Lagrangian for the tradables sector is:

$$\mathcal{L}_t^t = p_{T,t} A_T K_{T,t}^{\alpha_T} L_{T,t}^{1-\alpha_T} - w_t L_{T,t} - x_{T,t} K_{T,t} \tag{47}$$

The first-order conditions for tradables yield:

$$w_t = p_{T,t}(1-\alpha_T) A_T K_{T,t}^{\alpha_T} L_{T,t}^{-\alpha_T} \tag{48}$$

$$x_{T,t} = p_{T,t} \alpha_T A_T K_{T,t}^{\alpha_T - 1} L_{T,t}^{1-\alpha_T} \tag{49}$$

Firms in the non-tradables sector maximize:

$$\mathcal{L}_t^n = p_{N,t} A_N K_{N,t}^{\alpha_N} L_{N,t}^{1-\alpha_N} - w_t L_{N,t} - x_{N,t} K_{N,t} \tag{50}$$

The first-order conditions in the non-tradable sector are:

$$w_t = p_{N,t}(1-\alpha_N) A_N K_{N,t}^{\alpha_N} L_{N,t}^{-\alpha_N} \tag{51}$$

$$x_{N,t} = p_{N,t} \alpha_N A_N K_{N,t}^{\alpha_N - 1} L_{N,t}^{1-\alpha_N} \tag{52}$$

Similarly, the house producing firms are also perfectly competitive. The Lagrangian for the housing sector is respectively:

$$\mathcal{L}_t^h = p_{H,t} A_H K_{H,t}^{\alpha_H} L_{H,t}^{1-\alpha_H} - w_t L_{H,t} - x_{H,t} K_{T,t} \tag{53}$$

The first-order conditions for housing firms are:

$$w_t = p_{H,t}(1-\alpha_H)A_H K_{H,t}^{\alpha_H} L_{H,t}^{-\alpha_H} \tag{54}$$

$$x_{H,t} = p_{H,t}\alpha_H A_H K_{H,t}^{\alpha_H - 1} L_{H,t}^{1-\alpha_H} \tag{55}$$

2.3 Market Clearing

Market clearing requires that all domestic consumption equals domestic production and imports. The non-tradables sector equates consumption by Ricardian and credit-constrained consumers to the output of non-tradable firms:

$$Y_{N,t} = C_{N,t}^r + C_{N,t}^c \tag{56}$$

In the housing sector, like the non-tradables sector, domestic consumption of houses equals housing production:

$$Y_{H,t} = C_{H,t}^r + C_{H,t}^c \tag{57}$$

Labor demanded by all three sectors equals labor supplied by the two types of households:

$$L_{T,t} + L_{N,t} + L_{H,t} = L_t^r + L_t^c \tag{58}$$

Since collateral-constrained households are restricted to borrow from domestic Ricardian households, equilibrium requires that borrowing by credit-constrained consumers equals lending by optimizing consumers:

$$B_{pr,t}^c = B_{pr,t}^r \tag{59}$$

The current account equation requires that all of the current stock of foreign debt equals payment on past indebtedness and the difference between consumption of tradables by all households and investment in all firms on one hand and output of tradables on the other:

$$B_{F,t} = R_{t-1}B_{F,t-1} + p_{T,t}(C^r_{T,t} + C^c_{T,t} + I_{T,t} + I_{N,t} + I_{H,t-}Y_{T,t}) \tag{60}$$

Any difference between domestic demand of tradables and production of tradables is met via imports and adds to foreign debt.

As explained by Schmitt-Grohe and Uribe (2001), there is also a wedge between the interest rate faced by Ricardian consumers, R_t, and the foreign interest rate $i_{F,t}$, which the small open economy takes as given, that is determined by the amount of foreign debt B_F multiplied by an exogenously determined risk premium parameter $risk$:

$$R_t = riskB_{F,t} + (1 + i_F) \tag{61}$$

Such an equation is necessary to close a small open economy and also reflects the degree of riskiness that foreign lenders attach to the country. It reflects the idea that despite the fact that transitional economies are members of the EU, their bonds are not viewed as perfect substitutes to those issued by "old" Union member states[2].

2.4 Steady State

In the steady state (denoted by the absence of a time subscript on variables) all shocks equal zero. The prices of tradables and nontradables are constant and we assume for simplicity that they are equal to one. This implies that:

$$C^i_T = \varpi C^i \tag{62}$$

$$C^i_N = (1 - \varpi)C^i \tag{63}$$

In the steady state the demand for tradables and non-tradables equals their share of the consumption aggregator.

In the steady state, investment in all sectors equals capital depreciation:

[2]See Dimova and Petrov (2007) for a comparison of bond yield harmonization between new and old EU members.

$$I_j = \delta K_J \tag{64}$$

$$I_H = \delta^H K_H \tag{65}$$

In order for the Euler equation to hold in the steady state and at the same to satisfy the risk premium equation, we must assume that:

$$R = \frac{1}{\beta^r} \tag{66}$$

This implies that in the steady state the domestic interest rate must equal the inverse of the discount rate of Ricardian consumers in order to obtain a unique solution.

Using equations (2.32) and (2.33) and noting the fact that in the steady state investment equals capital depreciation, we determine that the Tobin's price of capital in the steady state is unity:

$$q_T = q_N = q_H = p_T \tag{67}$$

This combined with the steady state value of the risk free rate gives the rate of return of capital:

$$x_j = \frac{1}{\beta^r} - (1 - \delta) \tag{68}$$

where $j = T,\ N$ denotes the tradables and non-tradables sectors respectively.

$$x_H = \frac{1}{\beta^r} - (1 - \delta^H) \tag{69}$$

Combining equations (2.35) and (2.43) implies that in steady state the private borrowing rate is:

$$R_{pr} = \frac{1}{2}\left(\frac{1}{\beta^r} + \frac{1}{\beta^c} + \omega_0\right) \tag{70}$$

This implies that the private borrowing rate is a markup over the domestic interest rate even in the steady state since $\beta^c < \beta^r$ and $\omega_0 > 0$.

Finally, foreign debt equals the wedge between the domestic and the foreign interest rate denominated by the risk premium:

$$B_F = \frac{\frac{1}{\beta^r} - (1 + i_F)}{risk} \tag{71}$$

Hence in steady state the external position is wholly determined by the difference between the domestic and foreign interest rates and the amount of the risk premium. It does not depend on consumer demand or their wealth.

3 Model Simulation

In order to examine the effect of the shocks considered and to determine to what extent the response of macroeconomic variables differs by the presence of the financial accelerator in the economy, we must compare two versions of our model: an economy with both Ricardian and credit-constrained households, as described in the previous chapter, and a baseline economy populated only with optimizing consumers. Such a comparison has not been done before, and its results thus provide an essential new contribution to the literature.

The choice of parameters and the reason each value was selected, as well as how it relates to similar parameters in the literature, are explained in the Appendix.

3.1 Overview of Outcomes

As part of the transition process, the new EU member states of Eastern Europe liberalized their financial markets and experienced technological innovation as new technology and know-how started to enter their economies from other countries. They also saw a fall in spreads as investing in their economies became less risky for outsiders and their citizens began to gain wider access to imported goods as a result of the European Union's free trade union. While these factors undoubtedly improved the welfare of the Eastern European countries, they also brought potential risks in the form of overheating the economy and running up external deficits. We would expect such risks to be especially pronounced in imperfect economies due to the financial accelerator. Here we consider the effect of these risks by modeling them in the form of shocks on a small open economy with imperfect financial markets, all while paying special attention to those factors that are part of the ERM II convergence criteria.

Following an exogenous shock, which often stems from the process of financial liberalization and convergence, an economy with a financial accelerator experiences a more pronounced response of many macroeconomic variables than does a perfect economy. This finding is one of the major contributions of this paper and is in line with other findings in the literature, such as Kuralbayeva and Vines (2007) and Lendvai and Roeger (2008). Output and consumption are the variables that most often jump excessively in an economy

with imperfect financial markets. The effect on external debt is less pronounced and often is short-lived. Relaxing the borrowing constraint of credit-constrained consumers generates an external deficit, but this tends to disappear quickly. This can be explained by the action of two opposing forces. On one hand, a positive borrowing shock benefits the households subject to the constraint. On the other hand, however, the rest of the population suffers adverse effects from it. This suggests that the effects of the presence of credit-constrained consumers on the economy are not clear-cut and policies must do a fine act of balancing these consequences.

The shocks studied in this paper reflect those that might be experienced by transitional countries during their process of convergence and financial liberalization. The first innovation modeled is productivity growth in tradables. Such improvement is often associated with debt reduction and a consumption boom. Following the technological change in tradables, output in that sector expands to afford higher wealth and consumption. Since such innovation requires more capital and labor to sustain increased production, wage tends to rise. A higher wage and higher profits from firms in turn raises the income for all households. As explained previously by Lendvai and Roeger (2008), this rise in wealth leads to a consumption boom enjoyed by both types of households. Credit-constrained consumers divert part of their increased wealth to stock up on collateral. This improves their access to credit and in turn fuels even more consumption. As a result, the financial accelerator cycles the effects of the technological shock one more time through the economy. In the end, all of the consumers are wealthier than they were before, so the need to obtain credit from abroad falls. However, the external surplus in the economy with imperfect financial markets is slightly larger since the collateral constraint augments the effect of increased income.

The second shock that transitional countries experience is a change in the price of imports. While this raises overall affordability of consumption goods, there is no higher external deficit in an imperfect economy. This is due to the fact that credit-constrained consumers sustain the resulting spending boom out of their income rather than finance through extra borrowing. The presence of a collateral constraint does have an effect on the transitional dynamics within the economy. Initially, credit-constrained consumers can sustain higher borrowing due to increased purchasing power. In subsequent periods, however, the tightening of the constraint due to the rising housing price forces credit-constrained consumers to

work more in order to spread out the benefits of the shock. In this case, the amplifier effects of the financial accelerator are almost entirely contained within the economy and generate little more than a spending boom.

The third macroeconomic disturbance examined is a change to the foreign risk premium. An exogenous decrease in a country's risk premium signifies improving financial integration and less riskiness attached to the country. A more favorable risk premium reduces the domestic interest rate, which affects both kinds of consumers: it affects Ricardian households directly on the foreign markets and credit-constrained households in terms of the private borrowing rate, which as we saw earlier, is itself a function of the domestic interest rate. A more favorable risk premium fuels increased borrowing by Ricardian consumers, which in turn increases the external deficit. Credit-constrained households also enjoy more favorable access to credit and increase their borrowing immediately following the shock. However, their contribution to a higher external deficit is short-lived. Since the private borrowing rate adjusts instantaneously without depending on past residuals or future expectations, the economy is very flexible and in the absence of a permanent component to the risk premium change, the effect of the larger deficit is not long-lasting.

The fourth shock considered is a permanent downward shift in the coefficient of the debt-to-equity ratio, which effectively reduces the markup of the private borrowing rate over the domestic interest rate. This scenario results in the case of improving domestic financial markets and an increased access to credit. As Székely and Watson (2007) point out, such a situation tends to be common during the transitional process, although it can cause economies to run significant external deficits. A reduction in the markup of the private borrowing rate over the domestic interest rate improves the financial position of credit-constrained consumers for the same value of their housing stock by making borrowing more affordable. As a result, demand for consumption increases. Imports rise to satisfy this extra demand and the foreign debt increases. However, Ricardian consumers do not benefit from this improvement and they even face a higher domestic interest rate due to increased demand for domestic investment. This diminishes their ability to refinance abroad and causes the external deficit generated by the expansion of credit to collateral-constrained consumers to be short-lived.

3.2 Evolution of the Analysis

Simulating the elaborate model used in this thesis proved challenging, and in this section we turn to describing our discovery process in more detail. The analysis of the behavior of a transitional economy began with a simple stochastic dynamic general equilibrium model of the type Smets and Wouters (2006) describe. This model had one type of optimizing consumers and a single producing sector. Such a simple version of the model could simulate the effects of a technological shock but since it had no financial constraint, it could not demonstrate the magnified effect that external shocks can have in the presence of financial frictions. To begin with, we needed more than one production sector, and most importantly a housing sector, in order to study the dynamics between the sectors and to use the output of the housing sector as collateral. Furthermore, we needed to distinguish between households and introduce limitations on borrowing for a fraction of the population in order to introduce the financial constraint.

Therefore, to the initial version of the model we added the housing sector. However, simply modeling the housing sector like Muellbauer (2008) without introducing any financial frictions did little to improve our analysis. As a result, a crucial part of our approach involved modeling housing as the collateral requirement. However, in the absence of actual credit-constrained consumers this version of the model was still less than satisfactory. It was only when credit-constrained consumers were added that the model was also able to study the contribution that these households had to the overall economy. The presence of a financial accelerator at this stage allowed to capture its possible augmenting effects on consumption and output among other variables. The model, in this form, could demonstrate the effects of both the technological shock and the effect of increased access to borrowing on the economy.

However, this version of the model suffered from a major drawback: namely, it was a closed economy and all effects were contained within the country. As a result, outside influences could not be factored in and the effect of shocks on the external debt could not be determined. The final step in completing the modeling process thus involved including foreign markets and imports. This allowed us to study how the external deficit reacted to disturbances and to permit outside influences to perturb the small open economy. This also made it possible to simulate the last two shocks: a change in the price of imports and a decrease in the risk premium. It was at this stage that the model, finally, came close to

capturing reality in Eastern European countries.

It is worthwhile to note that despite the complexity of the model, there was no need to log-linearize it in order to simulate it. The Dynare tool for Matlab can handle non-linear models and carries out log-linearization up to the second order, which was sufficient for our needs.

Recounting the stages above in the discovery process is necessary to help explain how our model evolved from a simple stochastic dynamic general equilibrium version to the fairly complicated small open economy model with financial accelerator that was finally used in this thesis. Such an explanation also helps us track how the response of the variables of interest changes with the addition of each new element of the final model.

3.3 Positive Productivity Shock

The first shock considered is a productivity growth in the tradables sector (Figures 1-3). Since 1990, the transitional countries of Eastern Europe have managed to attain significant improvements in technological innovation, mostly in the tradables sector. The type of shock modeled is a temporary one but with an extremely slow decay of 1% per annum. Productivity growth is usually associated with a current account surplus since output rises more than it can be consumed domestically and increased income causes the demand for foreign financing to fall. At the same time, there is a spending boom which benefits all domestic consumers. The analysis here suggests that the magnitudes of the surplus and output growth are somewhat more pronounced in an economy with a financial accelerator than in an economy without one.

An innovation in tradables immediately raises output in the tradables sector. In order to sustain higher production, capital and labor must grow in that sector as well. The domestic interest rate must thus fall to stimulate more investment. As a result, capital rises in tradables. The increased capital demands more labor so the wage increases to attract workers to the tradables sector. Labor flows into tradables but more so in a two-consumer economy than in an economy with only one type of household. This is due to the fact that credit-constrained consumers tend to work more than their Ricardian counterparts, so that an economy with a financial accelerator will have more labor. Since the other two sectors

do not experience technological progress, they shed labor when faced with a higher wage rate. This free labor flows into the tradables sector to satisfy increased labor demand. It is important to note that the initial fall in output in non-tradables tends to be greater in an economy with credit-constrained consumers than in the baseline version of the model that contains no credit-constrained consumers. This is, again, due to the fact that non-optimizing households supply more labor, so that when they switch sectors, they induce larger swings in output. On the other hand, the initial change in output in housing does not differ by the type of economy. The higher wage induces an income effect and causes output in housing to fall immediately following the technological shock, and by the same amount in both the imperfect economy and the baseline one. Since it the most labor-intensive sector, it fares equally bad under both scenarios.

The decrease in the domestic interest rate tends to facilitate higher investment. Investment grows in the tradable, non-tradable and housing sectors but predictably the largest capital accumulation is experienced by the tradables sector. The price of tradables does not change since it is internationally fixed at unity. On the other hand, a more expensive wage rate pushes up the cost of producing non-tradables and housing. This forces firms in these sectors to raise the price of their goods. The consumption index reflects the change in the price of non-tradables as well. This makes non-tradable and housing goods both scarcer and more expensive. In order to optimize, consumers freely switch to more tradables and away from non-tradables. There is initially some minor substitution away from housing as well.

The increased demand for labor raises the wage which, in turn, augments disposable income for both types of households. Total expenditure on non-housing consumption grows mostly due to increased availability of tradables and their relative affordability. The non-tradables suffer a decline in attractiveness relative to the sector that has experienced innovation. Consumption of housing initially decreases not unlike the consumption of nontradables, and the change is the same in both economies. Since credit-constrained consumers now have more income from labor, they resort less to borrowing and need less collateral. Their demand for funds from Ricardian consumers falls. The decreased attractiveness of credit diminishes the interest rate charged to them via the collateral constraint.

Furthermore, the economy with credit-constrained consumers experiences additional dynamics beyond these happening in an optimizing economy. Following the shock, credit-

constrained consumers attempt to maintain their higher consumption levels, which they achieve through increased borrowing. Hence their borrowing gradually begins to rise. However, in order to maintain a more affordable interest rate, they must invest in the housing collateral which reduces the markup of the private borrowing rate over the domestic interest rate. Hence credit-constrained consumers begin to accumulate more houses in order to enjoy and maintain their new lifestyle. Consumption of housing begins to rise and soon overtakes the housing demand that happens in an economy populated only by Ricardian consumers. This growth is driven largely by credit-constrained consumers who stock up on collateral. This increased collateral fuels increased borrowing, which in turn finances more consumption.

As a result, the financial accelerator causes the effects of the technological shock to cycle one more time through the economy. A higher demand for goods raises output of tradables, non-tradables and houses further than the change that takes place in an economy without a collateral constraint. Overall demand for the consumption basket continues to be larger in the imperfect economy than in the baseline case for about 30 years after the innovation happens. Output in tradables maintains a higher level than in the baseline economy beyond the initial change induced by the technological innovation. Non-tradables also experience an increase in growth sustained by higher demand by credit-constrained consumers. This increased consumption raises demand for capital in all goods so that the domestic interest rate falls more in the model of the two-consumer economy to accommodate the resulting boom in output. Investment in all sectors rises to provide this extra capital. The accumulation of capital is consistently larger in the model with the financial accelerator, and indeed the difference persists even 40 years after the original shock.

As the aforementioned discussion of the effect of the technological shock implies, the financial accelerator generates higher overall wealth in the credit-constrained economy, which in turn affords a relatively larger consumption boom. As a result, both Ricardian and credit-constrained consumers begin to enjoy more wealth beyond that generated by a higher wage: credit-constrained consumers via more favorable borrowing conditions and Ricardian consumes through increased profit from firms that produce more output. These effects combine to afford more out-of-wealth spending and less need for external finance. Technological innovation reduces the accumulation of foreign debt in both versions of the economy. However,

the effect is slightly larger in the two consumer version due to the magnifying effect of the financial accelerator. Moreover, the overall effect is not especially prominent and disappears ten years after the initial shock. However, the benefits of decreased indebtedness are without questions. Lendvai and Roeger (2008) report an even sharper fall in outside indebtedness, although Ricardian consumers, who have access to foreign markets, constitute a larger portion of the economy in their study. They consider an economy populated 65% with optimizing consumers, whereas these are minority in our case, constituting 40% of the population. In sum, the surplus in our simulations occurs mainly because the increased output can sustain higher domestic consumption without the need to resort to foreign borrowing. The analysis of the effect of a technological shock shows that an economy with credit-constrained consumers experiences higher consumption growth and bigger output expansion than an economy without them. Debt in such a situation tends to diminish, which also improves the external standing of the economy. Despite the presence of credit-constrained consumers, a small open economy can still benefit from the effects of innovation.

3.4 Decrease in the Price of Imports

As the transitional countries of Eastern Europe share the common markets of the EU, imports become relatively cheaper within the European trade union. While this raises the overall affordability of consumption goods, there is the potential for a country to run a higher external deficit in an imperfect economy. However, our analysis suggests that in some cases the consequences of the financial accelerator can be contained within the economy and do not cause debt to increase significantly. This is due to the fact that credit-constrained consumers sustain the resulting spending boom out of a rise in their real income rather than finance it through extra borrowing.

A temporary decrease in the price of imports diminishes the cost of tradable goods below its internationally fixed value of unity. This decrease of the price of tradables makes domestic tradables, which retail at the same price as imports, less expensive relative to non-tradables. Hence total consumption becomes more affordable and consumers substitute tradable goods for their non-tradables counterparts (Figures 4-6). The increased demand for tradables drives their production up while, correspondingly, the output of non-tradables falls. The

increased output of tradables raises demand for labor in this sector. Workers migrate from the non-tradables sector to the tradables sector. Since the non-tradables sector is more labor-intensive than the tradables one, wages fall as a result. Total consumption then rises, since the increase in the attractiveness of tradables is more than the decrease in the desirability of non-tradables. Some freed income from expenditure on tradables goes to housing, meaning that this sector also sees a slight increase in demand for its output. Overall, demand for all kinds of consumption, including housing, rises due to improved purchasing power since the decrease in the price of imports improves the value of disposable income.

Capital in the tradables sector grows in response to increased demand, whereas that in non-tradables falls. Consequently, investment increases in the tradables and diminishes in the non-tradables sector. Since the demand for capital in the tradables sector is larger than the capital freed by firms in non-tradables, overall demand for capital rises. The real interest rate also rises due to this extra demand for investment, whereas the price of non-tradables diminishes due to reduced demand for the output of that sector. This phenomenon, coupled with the falling price of tradables, causes the consumption price index to depreciate. The price of housing also decreases slightly since houses are now less attractive relative to the output of the tradables sector.

The lower housing price in turn decreases the value of the collateral so that the private borrowing rate rises. On the other hand, the income of credit-constrained consumers now has more purchasing power so that credit-constrained consumers can now afford to stock up on collateral, which leads, overall, to an increase in their borrowing despite the rise in the borrowing rate. However, credit-constrained consumers face a higher repayment rate on their debt in subsequent periods when the effect of the shock wears out. As a result, their disposable income begins to fall relative to that of Ricardian consumers, who experience both the higher purchasing power of their labor income and increased profits from more production. Anticipating this as well as their higher repayment rate, credit-constrained consumers begin to work more in order to maintain a similar level of consumption. The increased supply of labor then follows the usual pattern: it flows out of non-tradables and into tradables. This attracts more capital in the tradables sector and less in the non-tradables sector. Output rises further as a result, and both types of consumers thus enjoy higher consumption.

Here the presence of the collateral constraint causes credit-constrained consumers initially to borrow more due to higher purchasing power and later to supply more labor in order to sustain their new level of consumption. The combination of more borrowing and more labor raises both overall output and consumption. This extra consumption goes largely into tradables due to their lower relative price compared to non-tradables. Hence the financial accelerator leads to an increase in the output of tradables beyond that in the baseline economy, which has no credit-constrained consumers. Conversely, the fall in demand for non-tradables is more profound than it would be if the economy was populated only by optimizing consumers. It is interesting to note that this happens largely via an initial increase in the borrowing of credit-constrained consumers and their subsequent higher labor supply, and that both results stem from the presence of the collateral constraint.

A lower price of imports stimulates demand for tradables beyond the capacity that can be met by normal domestic production. This increased demand for imports causes foreign debt to rise. However, the magnitude of the deficit will vary only slightly by the type of the households populating the economy. One explanation for this finding is that, to a large extent, the increased consumption in a two-consumer economy is sustained by the additional labor provided by credit-constrained consumers. As a result, the aforementioned consumption expansion happens through income and not via an increase in the overall debt. Furthermore, it is credit-constrained consumers who work more and it is they who have no access to international credit markets. The Ricardian consumers, who can refinance internationally, experience equally increasing demand for consumption in both cases.

The above discussion points to a surprising example where the effect of a shock does not cause the external position of a transitional economy with imperfect capital markets to worsen more than it would otherwise. That is because the amplifier effects of the financial accelerator are almost entirely contained within the economy and generate little more than a spending boom.

3.5 Fall in the Foreign Risk Premium

Financial liberalization and convergence is usually associated with a lower risk premium as the economy is deemed less risky by outside investors. This has the potential of fueling

increased borrowing by domestic consumers which raises the external deficit. The presence of a financial accelerator has the potential to amplify the effect on the deficit, since the reduced interest rate is passed on to credit-constrained consumers. However, they way the external debt responds is crucially related to how the reduction in the risk premium affects non-optimizing households. When the variable interest rate faced by such households adjusts immediately without depending on lags and expectations, the effect of the credit constraint on the deficit may not be long-lasting.

We model an exogenous but highly persistent temporary reduction in the risk premium. Since the domestic interest rate constitutes a markup over the foreign borrowing rate by the risk premium, the interest rate at home falls on impact (Figures 7-9). This makes foreign borrowing more affordable so Ricardian consumers borrow more for the same level of income they have. Since now fewer resources go into servicing debt and more are available for consumption, demand for all goods increases. Increased demand for tradables is met via imports which are now more affordable. Kuralbayeva and Vines (2007) show that these changes also hold true for countries that are not transitional economies. However, increased demand for non-tradables and housing must be met through domestic production. The pressure on the firms in these sectors causes the prices of non-tradables and housing to appreciate. These higher prices afford firms to hire more capital and labor. Labor flows out of tradables and into non-tradables and housing. However, since both these sectors are more labor-intensive than the tradables sector, the wage must rise to temper increased demand for workers. Furthermore, a lower interest rate makes investment more attractive. Investment in all sectors increases and accumulation of capital accelerates slightly during the first ten years following the shock.

Credit-constrained consumers now face a lower private borrowing rate since it is linear function of the domestic interest rate. This makes credit more affordable so their demand for borrowing from optimizing consumers increases. The extra disposable income is spent primarily on housing which increases the collateral stock of credit-constrained consumers. As the effects of the risk premium improvement wear out, the private borrowing rate returns to normal, but the extra collateral is not sufficient to sustain higher borrowing for long. All benefits to credit-constrained consumers are lost within ten years of the initial shock. As a result, the presence of credit-constrained consumers does not have much of an effect on

the external deficit. Foreign debt is marginally larger than in the baseline economy during the time when credit-constrained consumers engage in increased borrowing since Ricardian households finance lending to them primarily with foreign credit. Indeed, ten years after the initial improvement the contribution of collateral-constrained consumers to the deficit is all but lost.

The transient effect of the financial accelerator on the deficit following a decrease in the risk premium may seem surprising at first. However, it is important to remember that credit-constrained consumers act instantaneously on changes to borrowing terms and these changes do not carry across periods. This is due to the fact that the private borrowing rate, as defined in equation (2.35), depends only on contemporaneous terms and there are no effects by past residuals or future expectations. Furthermore, the housing stock is replaced every period and is not possible to carry off any excess stock into subsequent years. All this makes for an especially flexible economy where all adjustments take place within a short period after the initial shock. Kuralbayeva and Vines (2007) also confirm that in the absence of a permanent component to the risk premium change, the effect of the larger external deficit is short-lived. Financial liberalization and convergence is usually associated with a lower risk premium, as a transitional economy comes to be seen by outside investors as being less risky. This has the potential of fueling increased borrowing by domestic consumers, which in turn is likely to raise the external defect. The presence of a financial accelerator, moreover, has the potential to amplify the effect on the deficit, since the reduced interest rate is passed on to credit-constrained consumers. However, whether the deficit is actually run up turns out to be crucially related to the way the reduction in the risk premium affects non-optimizing households. When the variable interest rate faced by such households adjusts immediately without depending on lags and expectations, the effect of the credit constraint on the deficit may not be long-lasting.

3.6 Change in Access to Borrowing

The process of convergence to the European Union's economies by the new EU member states from Eastern Europe is often characterized by the liberalization of financial markets and by improved access to credit. This implies that credit-constrained consumers often see

their financing possibilities expand and that they also enjoy a higher level of borrowing for the same amount of collateral they possess. As Székely and Watson (2007) point out, however, this process may not always be smooth for transitional countries, and indeed they may be in danger of running a significant external deficit as a result of the convergence process. Our analysis shows that these fears are warranted, and that a small open economy may experience an increase in debt in the first few years following increased access to credit by collateral-constrained consumers.

We can see this phenomenon by looking more closely at an exogenous change in the access to borrowing for credit-constrained consumers (Figures 10-12). This could be due to improved financial oversight or some other non-economic development. In terms of our model, this is captured by a downward shift in the coefficient of the debt-to-equity ratio ω_1, which effectively reduces the markup of the private borrowing rate over the domestic interest rate. This immediately causes the private borrowing rate to fall. Since credit-constrained consumers now owe less interest on the amount borrowed, they can afford to take out larger loans for the same amount of collateral that they posses. Private borrowing jumps up and takes about 30 years to return to its steady state value. At the same time, the private borrowing rate returns to normal a few years after the initial shock. The prolonged borrowing is due to the accelerator effect.

Since now credit-constrained consumers have more disposable wealth, their demand for consumption increases. They consume more of the aggregate consumption good. The demand for both tradables and non-tradables increases with tradables holding the larger share. Houses are less desired now since the change in the debt-to-equity ratio affords credit-constrained consumers the same private borrowing rate for a lower amount of collateral. This said, if before credit-constrained consumers over-invested in housing due to the collateral effect, now they can afford to de-invest a little. Furthermore, the increase of disposable wealth has a substitution effect for credit-constrained consumers. They work less and enjoy more leisure. Since credit-constrained consumers are the larger fraction of the population, they fuel a consumption boom that raises overall demand for all consumption goods. As a result, the price of non-tradables goes up and so does the price of the consumption basket. The price of tradables, however, is exogenously fixed at one (via international arbitrage) and hence the demand for tradables, which are now the cheaper good, increases more than

the demand for non-tradables, although the former have a smaller share in the consumption basket. Output of the non-tradables rises to meet increased demand. The improved attractiveness of tradables is met via imports. As a result, labor in non-tradables must rise to satisfy the new demand. To stimulate extra labor demand, the wage increases. Following this, labor moves from the tradables and housing sectors into non-tradables firms. The diminished output in the tradables and housing sectors leads to capital shedding by these firms. In order to reduce investment, the domestic interest rate must thus tighten.

The higher interest rate now means less access to international financing for Ricardian consumers. This, coupled with rising commodity prices and decreased income from lending to credit-constrained consumers, spells lower wealth for them. Faced with high interest rates, Ricardian consumers decrease their borrowing from abroad. As Lendvai and Roeger (2008) explain, in such situations foreign debt rises overall, following improved access to credit. However, there are two opposing forces at work here. First, increased spending by credit-constrained consumers drives demand for imports up and so adds to the external deficit. On the other hand, Ricardian households now face higher interest rates and so diminish their refinancing from abroad. Overall, the effect on credit-constrained consumers dominates the market, since they comprise a larger percentage of the economy. However, the effect is not long-lasting and eventually the influence of optimizing consumers catches up.

Overall, as Lendvai and Roeger (2008) point out, the increasing access to credit is confirmed to be a major driver of a spending boom and an initially enlarged external deficit. There are several dynamics at work behind the adjustment of the debt however, and overall effects are short-lived before they eventually neutralize one another.

4 Conclusion

This paper examined four shocks that may affect the eight transitional countries of Eastern Europe that are currently in the process of rapidly integrating into the rest of the European Union and liberalizing their financial markets. An important question to consider is to what extent market imperfections in the household sector could make the process of their convergence to EU standards more difficult. In order to look into this issue, we needed a model that not only includes\d consumers and a housing sector like Muellbauer (2008), but also implemented a collateral constraint for a fraction of the population. Therefore, we devised a model of a small open economy with an innovative specification of the borrowing rate faced by credit-constrained consumers, one where it is proportional to the borrowed amount and inversely related to the collateral stock owned. By building the collateral constraint into the interest rate, we let the prevailing rate be determined in the optimization process. The main reasons for this are twofold: first, the interest rate varies, making it costlier to refinance as the amount borrowed increases; and. second, it avoids the need for costly observation and enforcement of an external collateral constraint. Using this setup, our model considered four potential shocks to which these economies are vulnerable and then studied how the presence of a financial accelerator in the household sector changes the response of macroeconomic variables to exogenous disturbances relative to a baseline model.

4.1 Main Findings

The analysis in Chapter 2 shows that following an exogenous shock, an economy with a financial accelerator experiences a more pronounced response in terms of some macroeconomic variables than an economy without market imperfections does. Output and consumption are usually the main indicators that jump excessively following an innovation. This is in line with other findings in the literature such as Kuralbayeva and Vines (2007) and Lendvai and Roeger (2008). By contrast, the effect on external debt is less pronounced and is often short-lived. Relaxing the borrowing constraint of credit-constrained consumers generates an external deficit but it disappears quickly. In our case, this is explained by the fact that while a positive borrowing shock benefits the households that may be subject to a credit

constraint, the rest of the population suffers adverse effects. This suggests that the effects of the presence of credit-constrained consumers on the economy depend on the way their credit limitations are modeled.

A technological innovation the production of traded goods enriches domestic consumers and fuels a consumption boom. The financial accelerator amplifies the response of these variables and leads to a slightly larger external surplus than in a baseline economy. A reduction in the price of imports, one of the benefits of joining the European Union, has the effect of raising the overall affordability of consumption goods and improves consumer welfare. However, this paper showed that it has not led to a higher external deficit in an imperfect economy since credit-constrained consumers manage to sustain the resulting spending boom out of their income rather than finance through extra borrowing. An exogenous decrease in the risk premium signifies improving financial integration and less riskiness attached to investing in the economy of each country. This affords more favorable borrowing for both types of households studied and increases the external deficit. The fact that the private borrowing rate adjusts instantaneously causes the role of the financial accelerator to magnify the effect of the deficit, but this actually turns out to be short-lived. Finally, the increased access to borrowing by credit-constrained consumers raises the demand for consumption and increases output. However, Ricardian consumers do not benefit from this improvement and, as a result, this causes the effect of increased access to borrowing on the external deficit to be temporary.

Overall, this paper demonstrates that imperfect financial markets can indeed amplify the response of many macroeconomic variables following a shock. They contribute to a larger change in consumption and output and, albeit to a lesser degree, to a swing in the debt position. However, the response of the deficit remains intricately dependent on the collateral feedback rule adopted in the country and usually lasts only in the first decade following the initial shock. Nevertheless, the analysis confirms that an imperfect economy behaves differently than an optimizing one—and could be more difficult to stabilize in the aftermath of a shock.

4.2 Extensions and Further Work

While our model seems to have captured the major effects that the financial accelerator has on macroeconomic variables, the results could be more robust if nominal rigidities are included. These would serve to prolong the response of the shock and would capture its effects on inflation and nominal price levels. Furthermore, the addition of a government would allow for richer modeling of the possible interactions between sectors in the economy. In addition to that, calibrating the model to match empirical data from individual Eastern European countries could make the analysis more robust. Another fruitful approach would be to examine the robustness of the results by changing the specification of the private borrowing rate. Rather than adjusting instantaneously so that the full impact of the shock is immediately felt, the private borrowing rate could react to the disturbance with a lag. Following the recent work of Miller and Stiglitz (2009), it may also be worthwhile to define the borrowing rate as a function of the expected future price of housing rather as a function of the current rate. This would allow an economist to incorporate the possible effect of an expected appreciation in housing prices on the economy. Finally, given that the processes of integration and financial liberalization are long-lasting phenomena, considering permanent shocks to the economy would change the intertemporal optimization dynamics and could contribute to a more prominent effect of the financial accelerator on the external deficit and other macroeconomic variables. Given more time and the opportunity, we plan to elaborate on the research presented here in subsequent work.

Appendix

Choice of Parameters

Table 1 summarizes all of the parameters used throughout our model while the discussion below elaborates on the reasoning behind each choice. Most parameters are the same for both versions of the model that we have considered in this study: an economy populated only with Ricardian consumers and an economy with both Ricardian and credit-constrained households. Only one parameter, γ, differs by the type of economy. This is necessary due to scaling issues: the parameter varies to ensure that the economies are of comparable size. In both versions of the model, one period represents one calendar year, so all values provided are annual.

- we assume a standard annual discount rate of 0.95 for Ricardian consumers. This is the most widely used value of β^r in annual models and it corresponds to a 5% annual domestic interest rate. For comparison, Lendvai and Roeger (2008) set the quarterly discount rate to 0.9875 for Ricardian consumers, which corresponds to a 5% annual rate. The discount rate for credit-constrained consumers, β^c, is lower than that for Ricardian consumers since it captures the fact that these households are more impatient. It is set to 0.93 and is slightly lower than Lendvai and Roeger's quarterly value of 0.97. Making credit-constrained consumers more impatient guarantees that they will tend to borrow positive amounts from Ricardian consumers. This guarantee is a crucial part of our model.

- We set the inverse elasticity of substitution in consumption, σ, and housing, θ, at 0.99. This is consistent with a wide body of literature. The inverse elasticity of leisure in utility is $\varphi = 1.3$, which implies a Frisch elasticity of labor supply of 0.325, similar to the one used in Kuralbayeva (2008).

- The value of γ is set to 1 in Kuralbayeva (2008). However, in our case it is not only a coefficient of labor in utility, but also determines the weight of each type of household in the economy. Hence we must depart from the existing literature in order to allow for a comparison between the two versions of our model. The value of the coefficient on labor γ is set to 3.15 in the reference economy. Since this parameter directly influences the amount of labor in the economy, by varying its value between the two versions of the economy we consider, we can ensure that both economies are of comparable size.

In the version of the model with two types of consumers, γ^r in the utility function of Ricardian consumers is set to 3.85. The coefficient on labor γ^c in the utility function of credit-constrained consumers is set to 1.85. The two coefficients vary by the type of consumer and are calibrated in such a way so that Ricardian consumers constitute 40% of the total number of households in the economy and credit-constrained consumers constitute 60% of the economy. This distribution is in line with empirical observations in transitional countries. Here the different coefficients for the two types of consumers act as a weighting parameter. Hence the coefficient of labor in utility plays a two-pronged role: it both ensures that the two versions of the economy discussed are of comparable size and also determines the share of the two consumer groups in the economy with imperfect financial markets.

- The coefficient of housing in utility for both types of consumers, κ, has no direct analog in the literature. In our case it is set to 0.175. This is calibrated so that the share of housing in total production is 10%. This is consistent with empirical observations and avoids the need to vary the price of housing significantly to achieve a comparable effect.

- There is not much consensus about the value of the elasticity of substitution between non-tradables and tradables goods in consumption. Kuralbayeva (2008) assumes this value to be 1.2 while Lendvai and Roeger (2008) prefer 0.5. We side with the former author in order to capture a relatively high degree of substitutability between the two factors. Therefore we set $\rho = 1.2$.

- We set the value of ϖ, the share of tradables goods in CPI, equal to 0.4. This is slightly higher than the parameter chosen in Kuralbayeva (2008) and it reflects a greater tilt toward tradables goods.

- The depreciation rate of capital in the tradables and non-tradables sectors is assumed to be $\delta = 0.05$ which implies an annual rate of 5%. The depreciation rate of houses is $\delta^H = 0.05$ which implies that all goods depreciate at the same rate. This is consistent with the literature, especially Kuralbayeva (2008) who assumes an annual depreciation of 5% .

- There is wide disagreement in the literature regarding the investment adjustment cost

ψ. Lendvai and Roeger (2008) assume it is 15 while Kuralbayeva (2008) prefers the much lower value of 0.1. We assume that the former is more realistic for our purposes since a higher adjustment cost prevents investment from jumping excessively following a shock.

- There is no precedent in the literature regarding the value of the coefficients ω_0 and ω_1. We assume that $\omega_0 = 0.005$ which implies that even when credit-constrained households start with zero debt, their borrowing rate is still a markup of 0.5% over the domestic interest rate. This shows that lending to these households is inherently riskier than to Ricardians even when they begin debt-free. The coefficient of the ratio of debt to housing stock in the private borrowing rate is assumed to be 0.1, which implies that any change in debt or in the housing stock adds about 10% to the variation of the borrowing rate faced by credit-constrained consumers.

- The tradables sector is the most capital-intensive one so we give capital a share of 0.3 in the production function. Following Kuralbayeva and Vines (2008), the non-tradables sector uses slightly less labor so its capital share is 0.25. The least capital-intensive sector is housing in which capital has a weight of 0.2.

- The risk premium $risk$ drives a wedge between the foreign interest rate and the domestic interest rate. Unlike Lenvdai and Roeger (2008), this wedge is proportional to foreign debt. Following Schmitt-Grohe and Uribe (2001), we assign it the value of 0.1. This ensures that a 10% increase in foreign indebtedness translates into a 1% markup of the domestic interest rate over the foreign interest rate.

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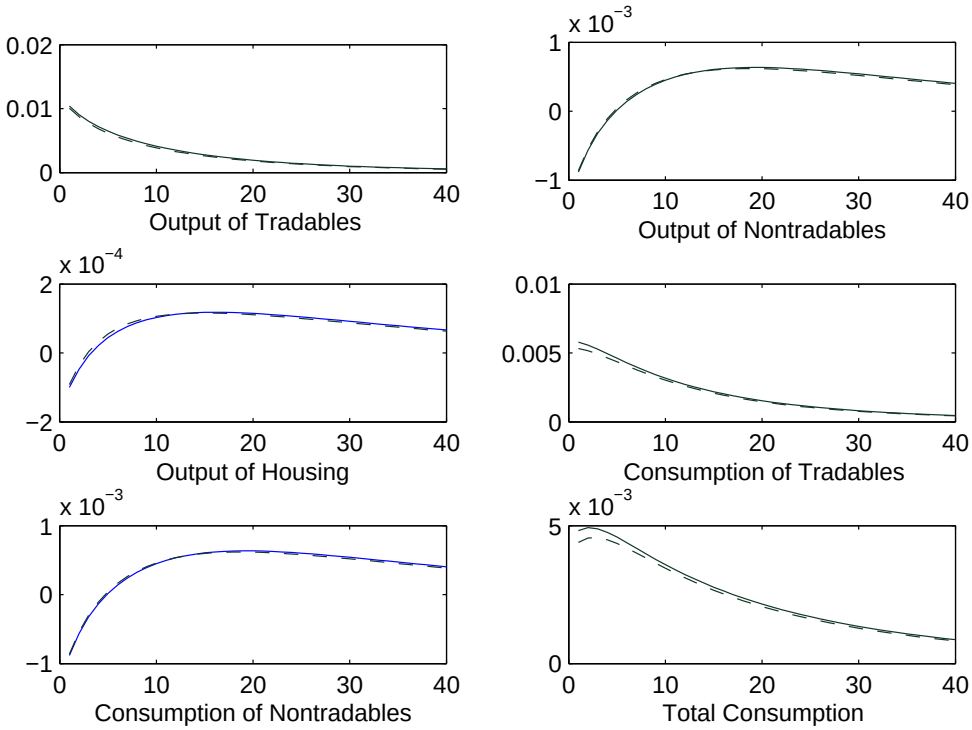
Tables and Figures

Table 1. Parameter Values for Calibration of the Model

Parameter	**Value**	**Description**
β^r	0.95	Discount factor for Ricardian consumers
β^c	0.93	Discount factor for credit-constrained consumers
σ	0.99	Inverse of elasticity of substitution in consumption
θ	0.99	Inverse of elasticity of substitution in housing
φ	1.3	Inverse of elasticity of substitution in leisure
γ	3.15	Coefficient of labor in utility in single consumer economy
γ^r	3.85	Coefficient of labor in utility of Ricardian consumers
γ^c	1.85	Coefficient of labor in utility of credit-constrained consumers
κ	0.175	Coefficient of housing in utility
ρ	1.2	Elasticity of substitution between non-tradables and tradables goods
ϖ	0.4	Share of tradables goods in the consumption basket
δ	0.05	Annual rate of capital depreciation in tradables and non-tradables
δ^H	0.05	Annual rate of capital depreciation in the housing sector
ψ	15	Investment adjustment cost (same across sectors)
ω_0	0.005	Baseline markup of private borrowing rate over domestic rate
ω_1	0.1	Coefficient of the ratio of debt to housing stock in the borrowing rate
α_T	0.3	Share of capital in the tradables sector
α_N	0.25	Share of capital in the non-tradables sector
α_H	0.2	Share of capital in the housing sector
$risk$	0.1	Risk premium
r_F	4%	Foreign interest rate

Figure 1. Effect of Technological Shock

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)



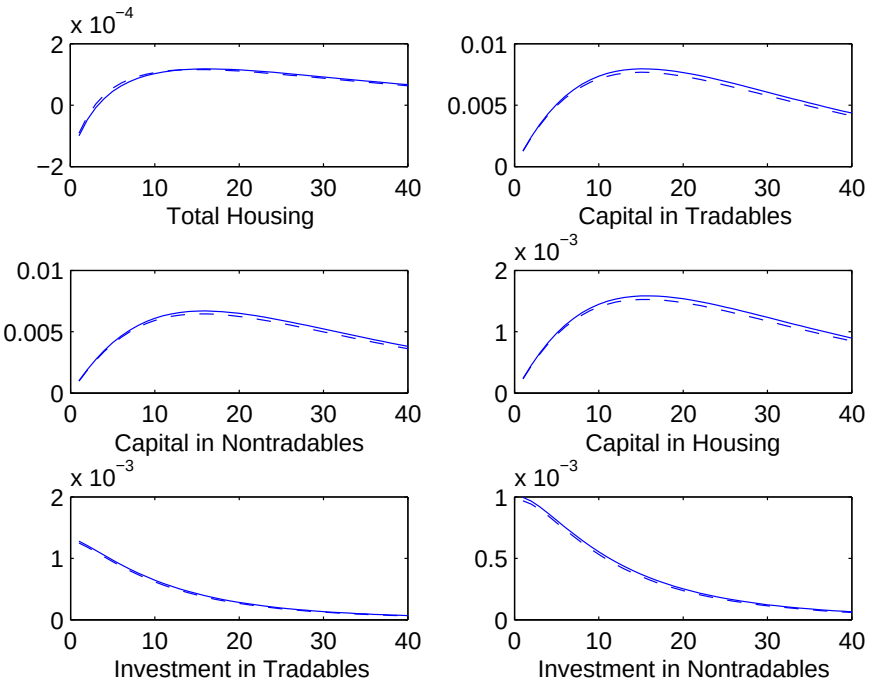

x 10^-4
2
0
−2
0
10
20
30
40
Total Housing
0.01
0.005
0
0
10
20
30
40
Capital in Tradables
0.01
0.005
0
0
10
20
30
40
Capital in Nontradables
x 10^-3
2
1
0
0
10
20
30
40
Capital in Housing
x 10^-3
2
1
0
0
10
20
30
40
Investment in Tradables
x 10^-3
1
0.5
0
0
10
20
30
40
Investment in Nontradables

Figure 2. Effect of Technological Shock (continued)

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

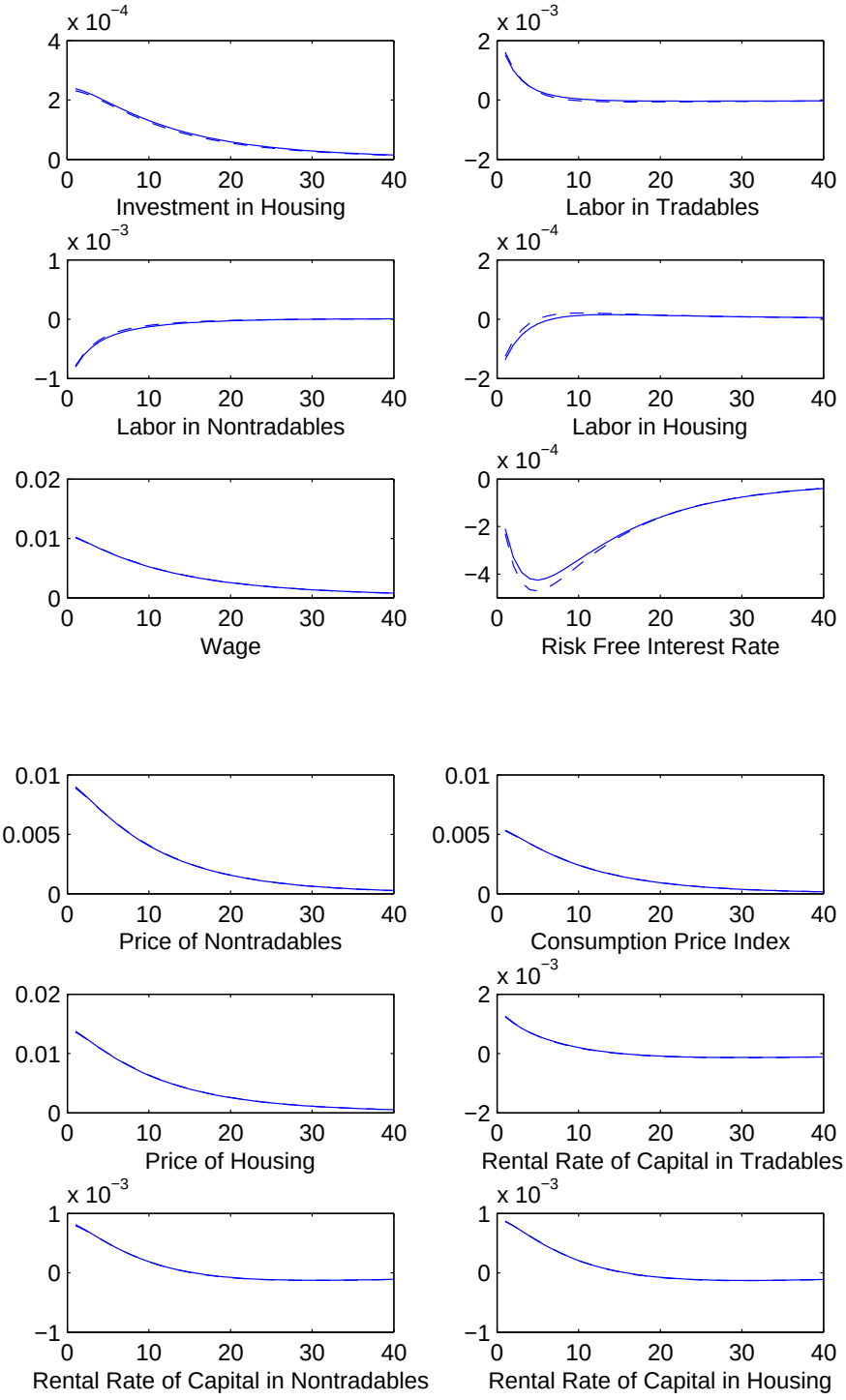


Figure 3. Effect of Technological Shock (continued)

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

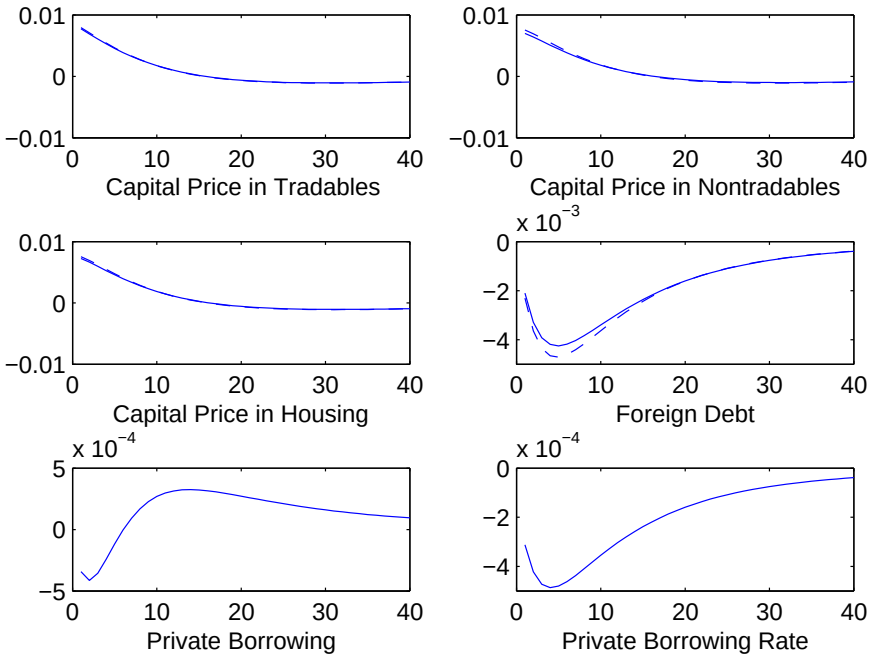


Figure 4. Effect of Decrease in the Price of Imports

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

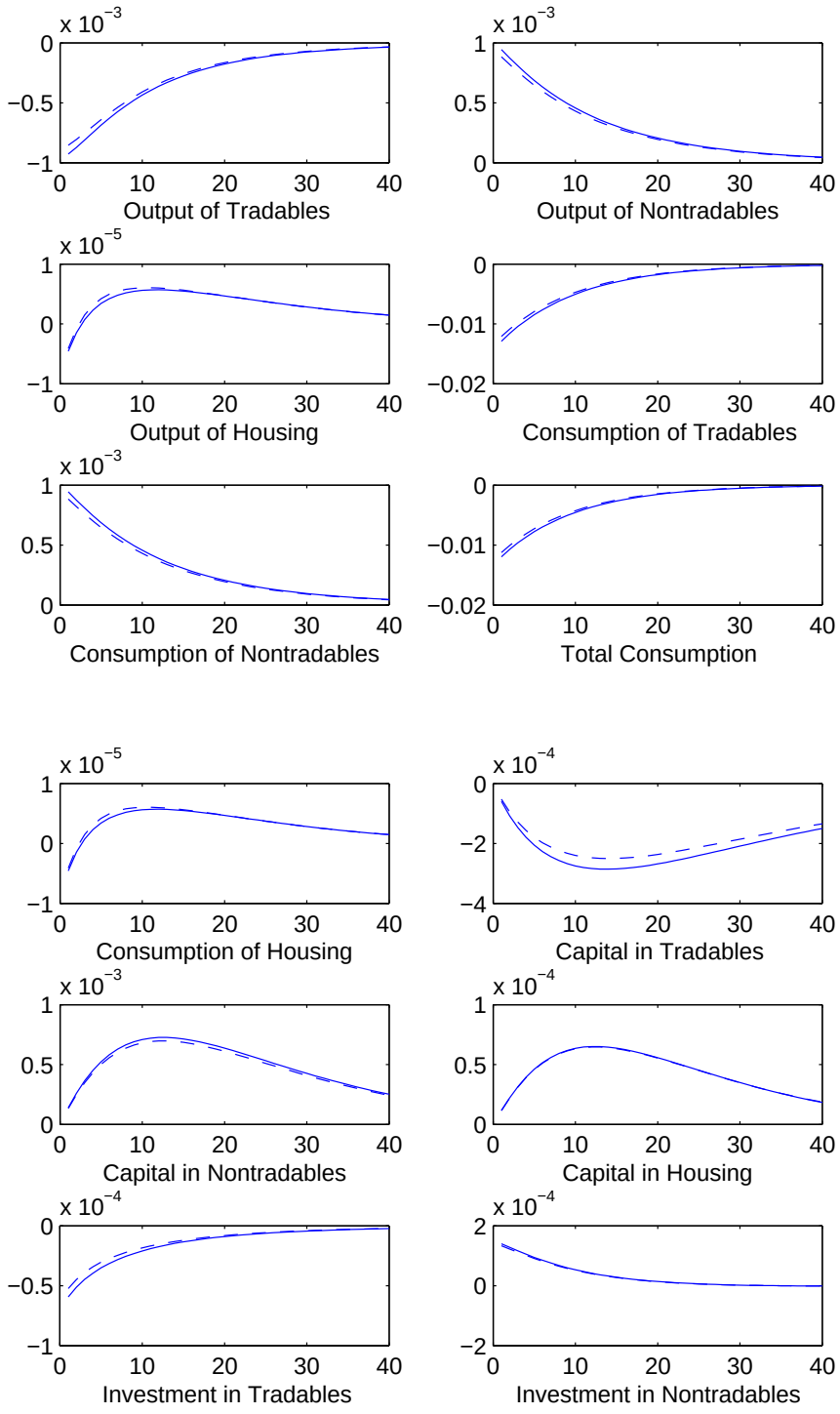


Figure 5. Effect of Decrease in the Price of Imports (continued)

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

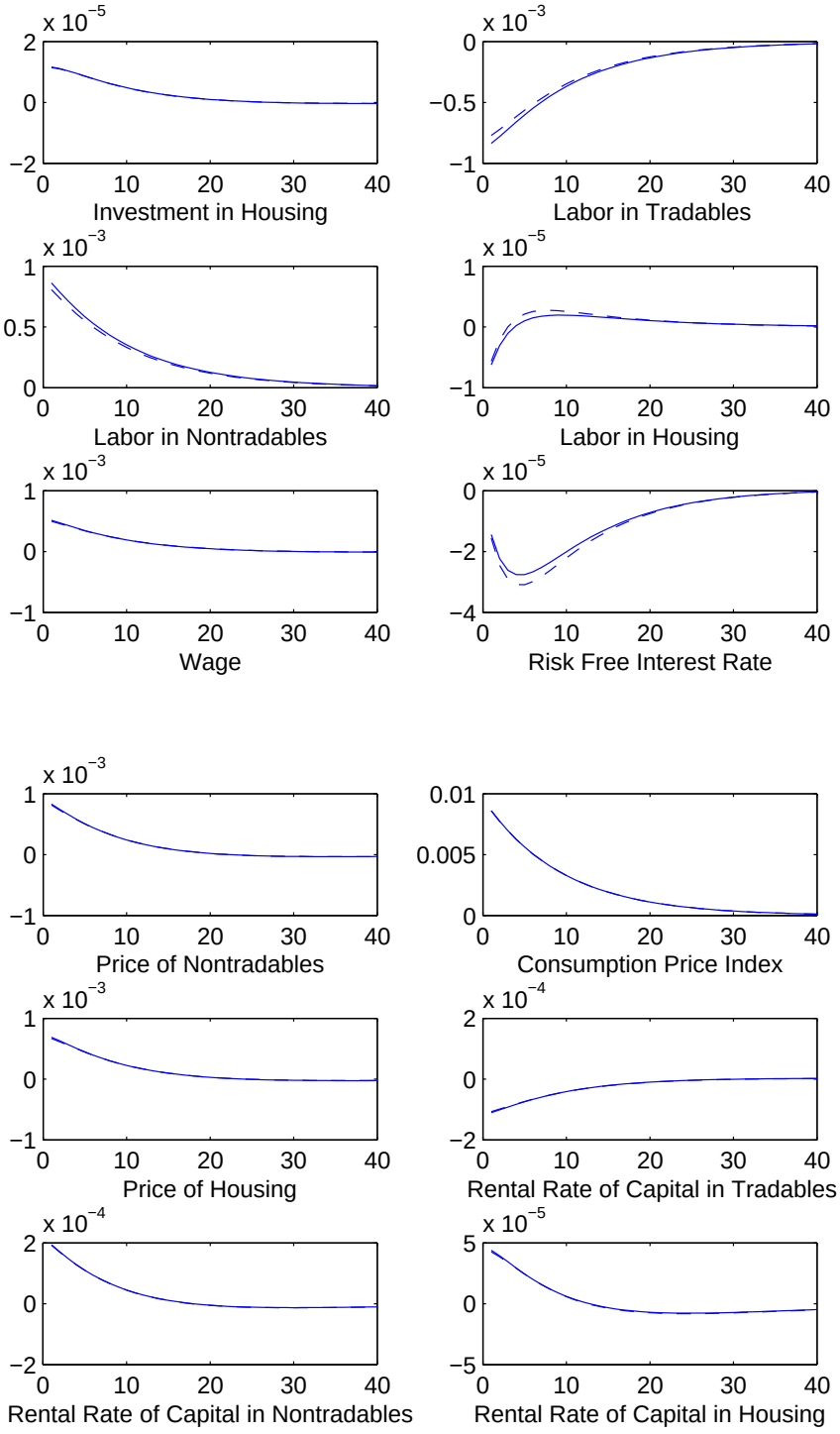


Figure 6. Effect of Decrease in the Price of Imports (continued)

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

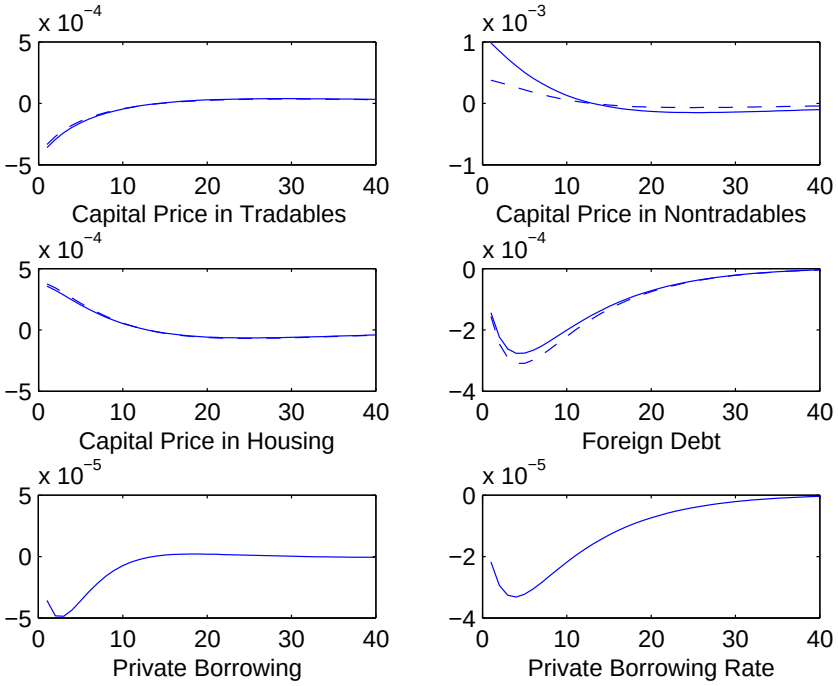


Figure 7. Effect of Foreign Risk Premium Shock

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

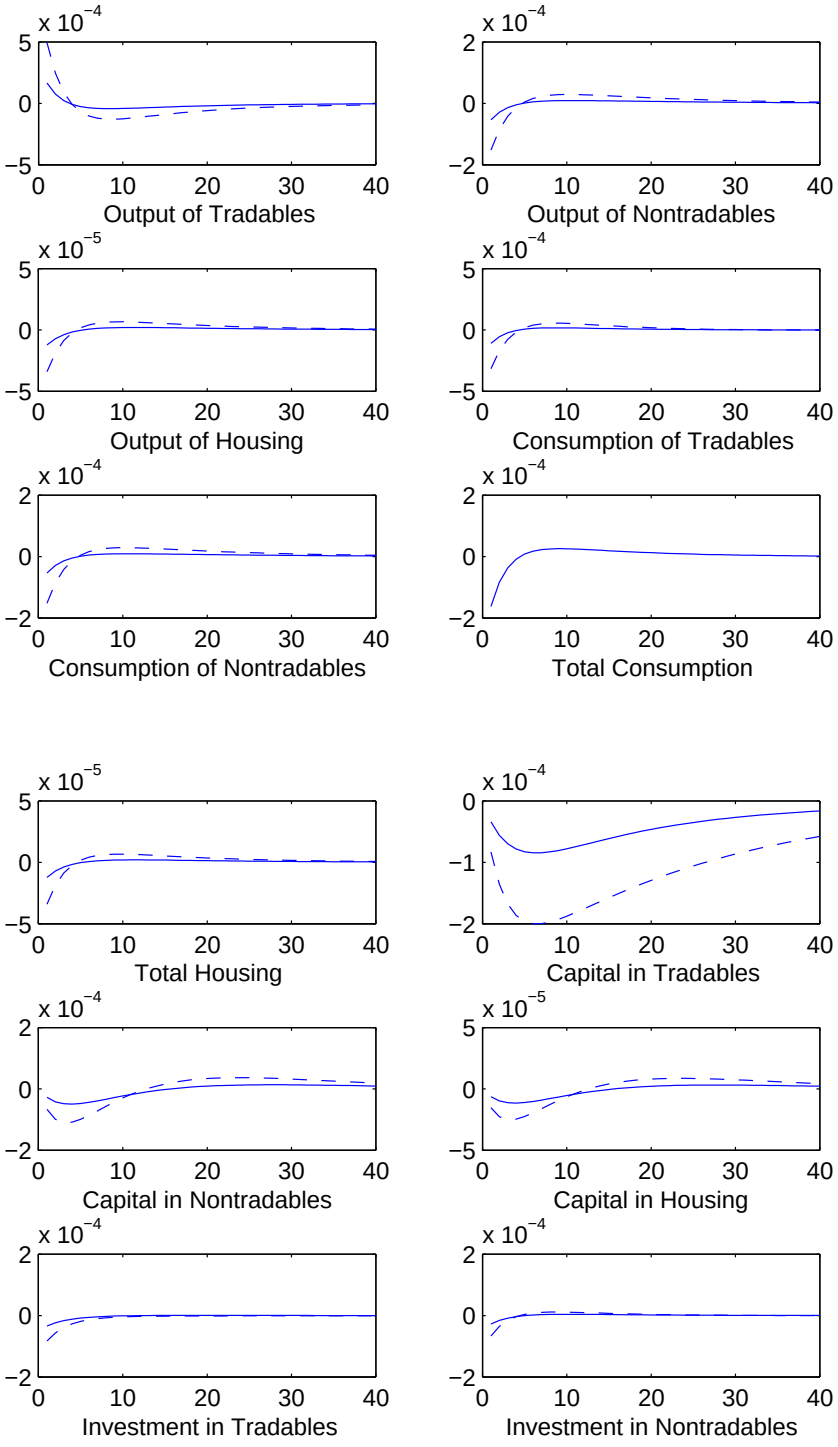


Figure 8. Effect of Foreign Risk Premium Shock (continued)

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

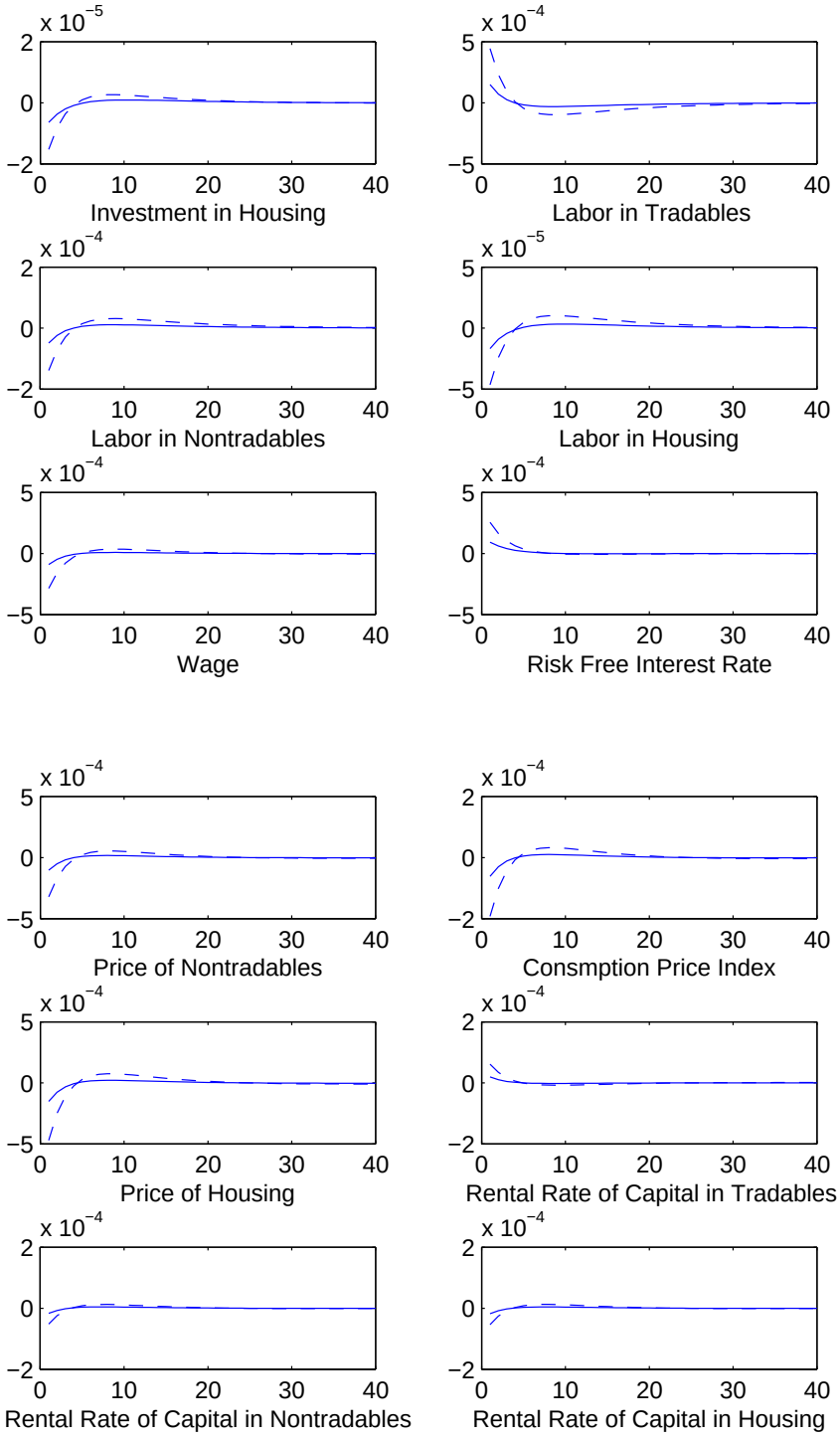


Figure 9. Effect of Foreign Risk Premium Shock (continued)

(a continued line denotes the economy with financial accelerator and a dashed line the baseline economy)

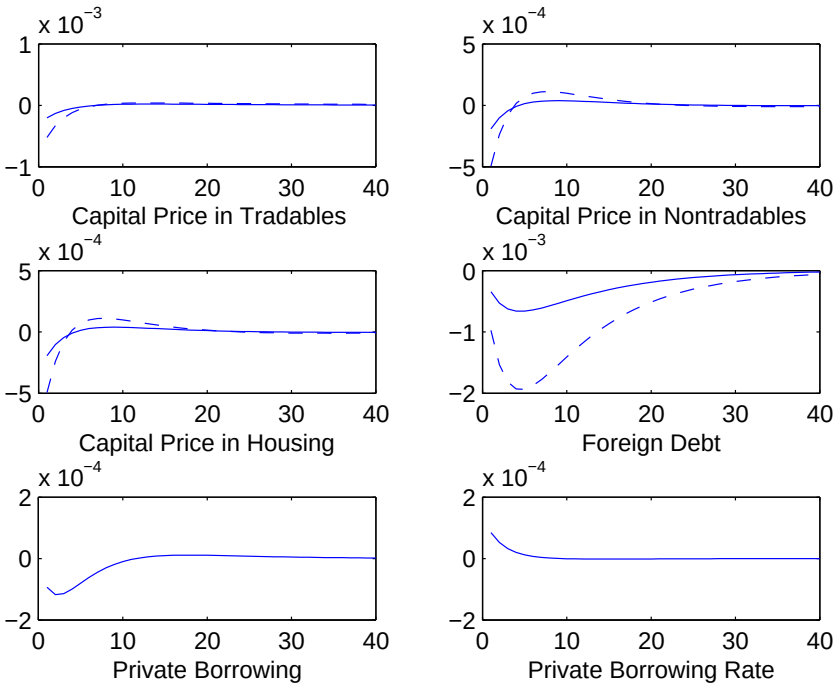


Figure 10. Effect of Borrowing Shock

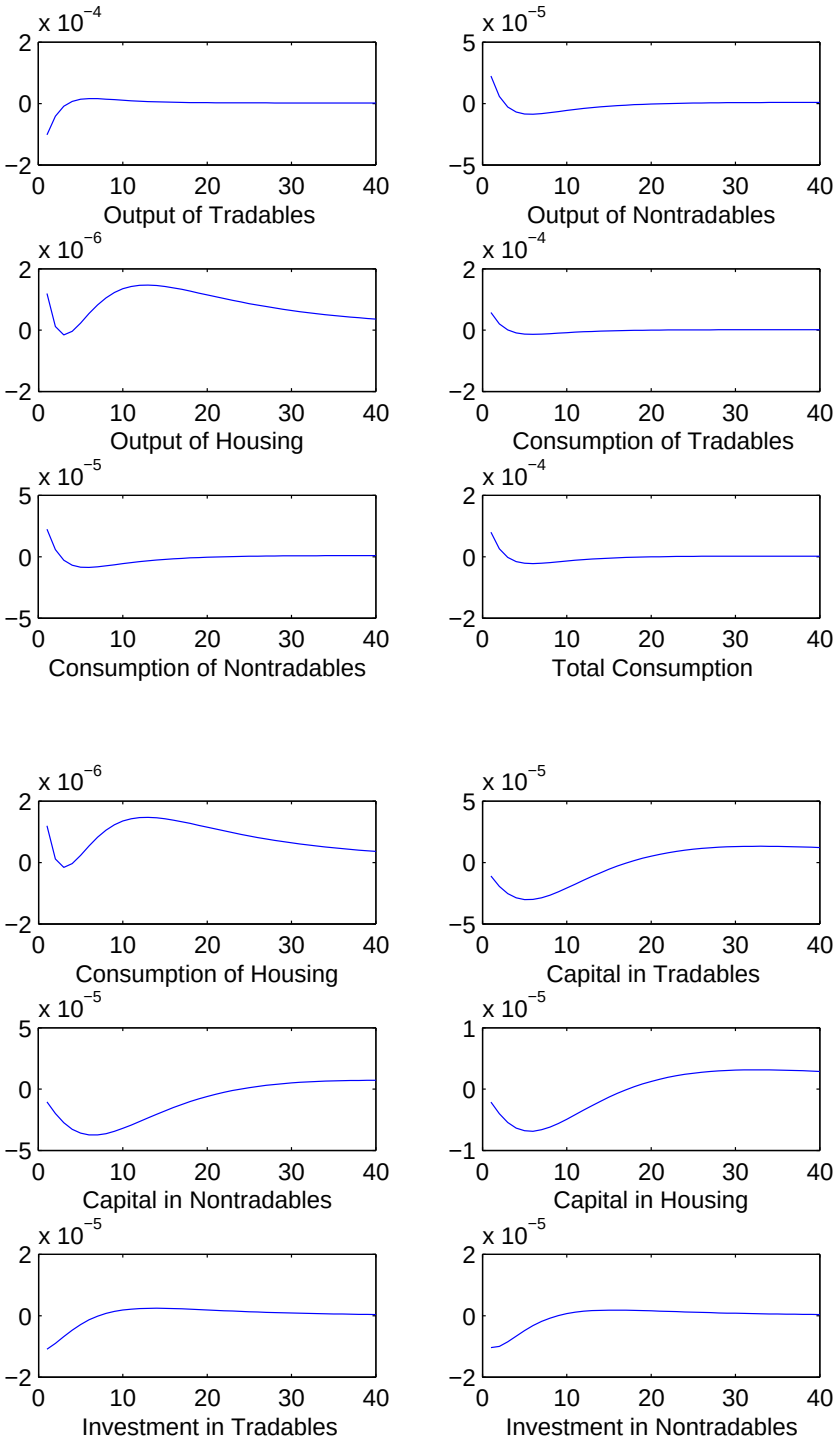


Figure 11. Effect of Borrowing Shock

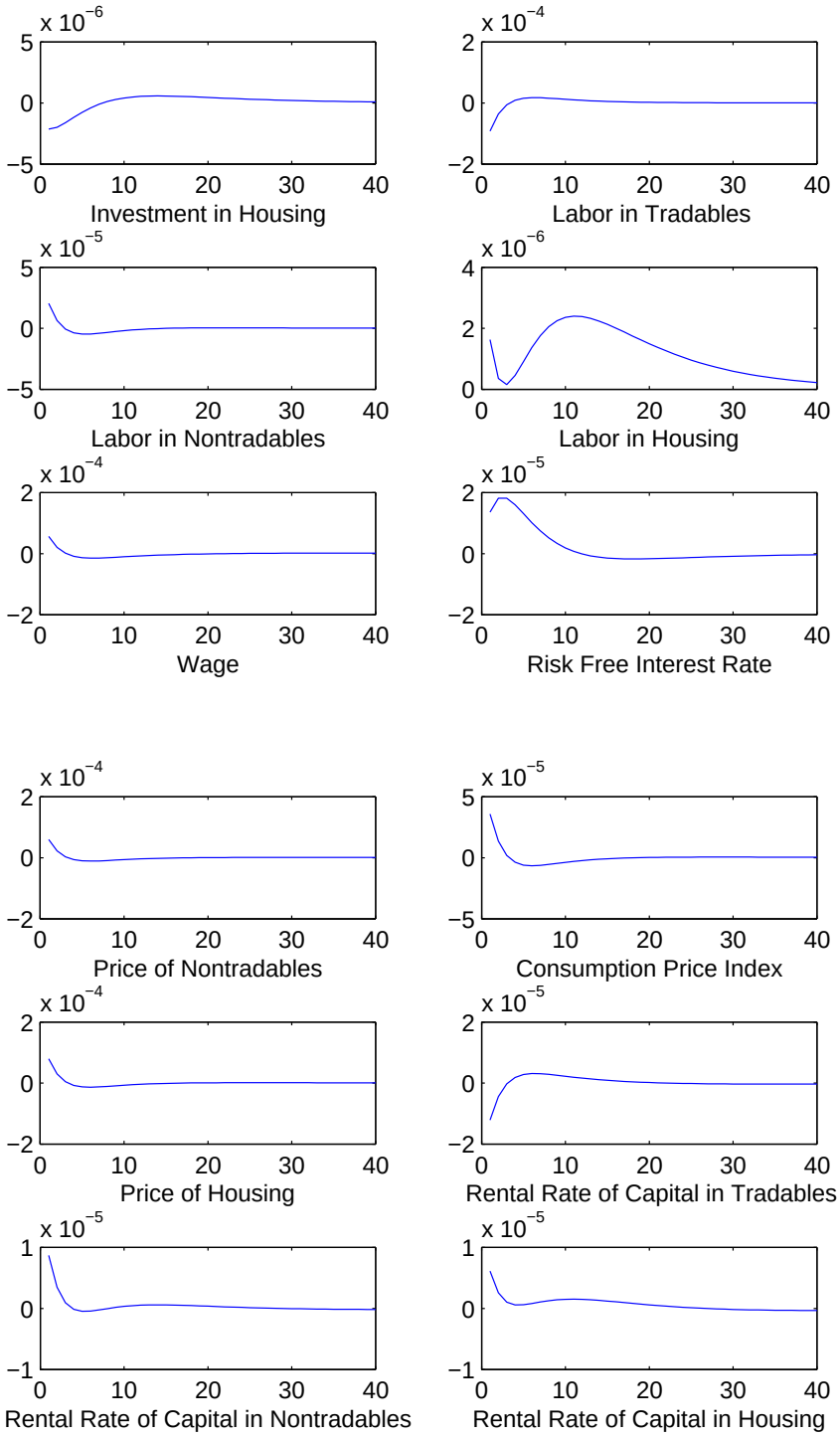


Figure 12. Effect of Borrowing Shock