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Financial Distress and Unconventional Monetary Policy in Financially Open Economies

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מצוקה פיננסית ומדיניות מוניטרית בלתי קונוונציונלית במשקים פתוחים לתנועות הון

דוד אלקיים ואליעזר בורנשטיין

תמצית

אנו בוחנים כיצד פתיחות המשק לתנועות הון – כיצד גישה לשווקים הבין-לאומיים – משפיעה על רגישות הכלכלה לזעזועים ועל האפקטיביות של מדיניות מוניטרית בלתי קונוונציונלית (רכישות נכסים) שנועדה למתֵן את השפעתם. לשם כך אנו מרחיבים את המסגרת שפיתחו Gertler and Karadi (2011) למשק קטן ופתוח לתנועות הון, מסגרת שבה ההון העצמי של הבנקים מגביל את כמות האשראי הבנקאי במשק ולכן לשינויים בהון זה יש השלכות ריאליות. אנו דנים בשני סוגים של זעזוע – ריאלי ופיננסי – וכן בשני סוגים של פתיחות פיננסית: בראשון השווקים הבין-לאומיים נגישים למשקי הבית ובשני הם נגישים לפירמות. אנו מוצאים כי הן לסוג הזעזוע והן לסוג הפתיחות יש השלכה משמעותית על מידת הרגישות לזעזועים. במקרה של זעזוע ריאלי (לפריון) שני הסוגים של פתיחות פיננסית ממתנים את השפעתו על הכלכלה יחסית למשק סגור. לעומת זאת, במקרה של זעזוע פיננסי, התפתחות שפוגעת ישירות בהון העצמי של הבנקים, התמונה מורכבת יותר. כאשר העולם פתוח רק למשקי בית והם יכולים להפקיד גם בבנקים זרים, לזעזוע פיננסי יש השפעה גבוהה יחסית להשפעתו על משק סגור. כאשר העולם פתוח לפירמות והן יכולות ללוות גם מבנקים זרים, לזעזוע פיננסי יש השפעה מזערית על הפעילות אך השפעה ניכרת על הפסדי הבנקים. אשר לאפקטיביות של מדיניות מוניטרית בלתי קונוונציונלית, נמצא כי במקרה של פתיחות למשקי הבית האפקטיביות גבוהה יחסית לאפקטיביות במשק סגור, ואילו במקרה של פתיחות לפירמות המדיניות אף עלולה להזיק.

Financial Distress and Unconventional Monetary Policy in Financially Open Economies

Eliezer Borenstein and David Elkayam

Abstract

How does financial openness of an economy facing domestic financial frictions change the propagation of shocks? How does it affect the potential effectiveness or desirability of unconventional monetary policy intended to mitigate the effects of adverse shocks? We analyze these questions by applying the setup of Gertler and Karadi (2011) to an open economy. Our results show that the answers to these questions depend on the openness structure of the economy: it matters which sector (households, firms, or both) has access to the global financial markets. In particular, we find that with regard to productivity shocks, financial openness generally mitigates the effects of the shocks relative to the closed economy. In contrast, with regard to financial shocks we find that financial openness can strongly exacerbate their effect: when the economy is open only to households' savings (so that they can deposit abroad as well), the effect of financial shocks is amplified relative to the closed economy case. When the economy is open to firms borrowing (so that they can borrow from abroad as well), the effect on the economy becomes ambiguous. As for the effectiveness of an asset purchase policy, we find that in some openness structures its effect is strengthened relative to the closed economy, while in others it could even be detrimental to the economy.

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1. Introduction

In this paper we apply the framework of Gertler and Karadi (2011) (henceforth: GK) to a small open economy. We analyze the effect of various shocks in a small open economy facing domestic financial frictions in comparison to a closed one. We also analyze the possible differences between the required responses of the government to these shocks. We find that the nature of openness of the economy can significantly change the way in which shocks affect the economy, particularly the financial sector, and the way in which the government should react.

GK present a model in which, due to an agency problem between depositors (households) and banks[1], the supply of banks' credit is tightly connected to the banks' net worth. The agency problem stems from an assumption that bankers can divert some of the assets they manage. This would be profitable for them as long as the amount they can divert exceeds their franchise value, which depends positively on both their net worth and their expected profitability. GK also assume that the level of banks' net worth is not enough to support the first best amount of intermediation so that the economy displays a positive spread between the interest rate for borrowers and the interest rate for savers (henceforth: spread).

In the GK model, when a shock lowers banks' net worth, banks are forced to reduce assets (a fire sale of assets). This reduces the demand for capital by production firms thereby also reducing the price of capital, which causes a further fall in banks' net worth and so on.[2] The situation described results in a deterioration in the banks' ability to transfer resources from savers (households) to borrowers (final good firms), which is reflected in a widening of the spread and in a further decrease in savings and production. In this situation of financial distress it might be beneficial to the economy for the government to replace some of the private intermediation, by borrowing from households and lending directly to the production firms.[3] Since, as GK note, the

[1] GK's idea applies to other financial intermediaries as well. However, due to their dominant role in the financial intermediation, and due to the fact that banks are usually highly leveraged, which is at the heart of GK's mechanism, they usually speak specifically about banks. We also speak here specifically about banks.

[2] According to the GK framework, the return that banks get on credit is tied to the price of capital. A decline in the price of capital thus causes a further fall in banks' net worth (this is actually an amplification of the shock due to the fire sale of assets).

[3] As long as the inefficiencies involved with it are not too large.

financial disruption is accompanied by an increase in the interest rate spread, the spread serves in their model as an indicator for the central bank as to when to intervene. In their framework, this intervention takes the form of a "credit rule" for the central bank which defines the amount of central bank intermediation as a function of the spread. This is the way in which their framework can justify the Federal Reserve's large-scale asset purchasing program launched in the midst of the last financial crisis. GK refer to this type of intervention as an "unconventional monetary policy".

The aim of our paper is to extend the framework of GK to a small open economy. There are few other papers that used open economy versions of the GK framework.[4] To our knowledge, none have focused on the differences in the basic GK mechanism that the openness of the economy entails, nor on the differences in the appropriate reaction of the government to shocks that affect banks' net worth. Highlighting those aspects is the main contribution of our paper.

In this work we consider an economy in which depositors (households) have access to a foreign risk-free bond that they can use as a saving device. We also allow the borrowers (final good firms) to gain access to the international capital markets by assuming they can borrow from abroad at a global given rate. We assume that the interest rate at which firms borrow is higher than the interest rate that households earn on their savings abroad.[5] We conduct our analysis for two different types of shocks—real shock and a financial shock. The real shock is a standard productivity shock. The financial shock is a direct shock to banks' net worth.[6] The analysis we conduct is based on the impulse response functions of the two aforementioned shocks which we construct for four cases: 1. A closed economy (as in GK) 2. An economy that is open to households (depositors) but closed to final good firms (borrowers). 3. Closed to households and open to final good firms. 4. Open to both households and final good firms.

[4] Among these papers are Garcia (2013), Akinci and Queralto (2014), Dedola, Karadi and Lombardo (2013) and Steffen (2015).

[5] This could be, for example, the result of assuming that the world is also characterized by a financial friction that yields an interest rate spread. Alternatively it could reflect a risk premium that the domestic economy has to pay for borrowing from abroad. The interest rates could be equal, as a private case.

[6] We shall expand on this shock in the next section.

In the case of a productivity shock, for the closed economy case we find similar results to GK: a large amplification of the shock due to the financial friction and a decline in banks' net worth and credit. However, when the economy is open, on either or on both sides, the net worth of banks is hardly impacted, and there is no amplification mechanism. In other words, we find that in an open economy, and in stark contrast to a close economy, the banks' situation is almost isolated from the effects of a technology shock[7], and the effect of that shock on the economy comes mainly through the standard real channel.

When the shock that hits the economy is a financial shock (that directly hits banks' net worth) the reaction of the economy depends on the nature of openness. When the economy is open only to households the amplification mechanism is at work, in sharp contrast to the case of the productivity shock, and it is stronger than that of the closed economy. The reason for the stronger amplification is that here, in response to the decline of banks' net worth households can increase their savings abroad thereby further decreasing their deposits in banks.

When the economy is open to borrowers they can replace bank credit with foreign credit (at a given world borrowing rate), and thus, in contrast to the case where the economy is closed to borrowers, there is no amplification mechanism with respect to banks' credit, investment and production. However, with respect to banks' net worth there is still the direct effect of the shock and, as we show later, in this case the shock has a negative long-lasting effect on banks' net worth. We should also note that since the firms have to rely more on foreign credit, the profit of the local banks decreases and this has negative welfare implications. We discuss this issue in a short "welfare implications" section (Section 4).

An interesting point that should be emphasized here is that in the case where the economy is not open to borrowers, there is an internal mechanism that causes the banking system to restore its initial situation. In this case, as long as banks' net worth is lower than usual, so is the capital stock. And, as long as the capital stock is lower

[7] We shall dwell on the reasons in Section 3. Here we just note that when the economy is open to households, the deposit rate is determined abroad and households react by decreasing foreign deposits. Local deposits do not change and banks' credit and net worth therefore stay the same. When the economy is open to borrowers, the borrowing rate is determined abroad and firms react by decreasing foreign credit. Banks' credit, deposits and net worth do not change.

than usual, the return on capital is higher than its usual level, and so is the spread, which affects banks' profitability. This enables banks to gradually rebuild their net worth. In contrast, when the economy is open to borrowers, this restoration mechanism is absent since the capital stock goes back to its usual level before banks' net worth has fully recovered. Hence, banks' profitability returns to its usual level before their net worth has fully recovered from the shock.

Regarding the response of the government (to a financial shock), when the economy is open only to households, credit intervention increases the price of capital thereby helping to mitigate the negative effects of the shock on banks' net worth, as in the closed economy. This is not the case when the economy is open to firms. Here the price of capital is determined by the world borrowing rate and so does not react to the government intervention. Furthermore, when the economy is open only to firms, government credit policy even worsens banks' situation. In this case the government's credit increases the deposit rate and hence reduces the spread, which eventually erodes the banks' net worth. However, even in this situation it might be beneficial for the government to intervene, as its intervention acts to lower the amount that the economy has to borrow from abroad, thereby reducing the resource loss.[8]

In models of a small open economy, it is usually assumed that the economy is open to households (Schmitt-Grohe and Uribe (2003), for example). That is, the sector that engages in the activity vis-á-vis the foreign economy is the household sector. However, had the assumption been different (e.g. that the firms engage in the activity vis-a-vis the foreign economy), the economy would behave the same. In contrast, as we show in this paper, when there is a financial friction (in our case between depositors and banks) it does matter which sector is the one that engages in this activity.

The papers that have used open economy versions of GK assumed that the sector engaging in the activity with the foreign market is either the banking sector or the household sector. However, it turns out that the implications of these different assumptions are identical, as the agency problem restricts banks' behavior exactly the same way in both cases. In other words, since households essentially control the credit

[8] Here and throughout the paper we ignore possible inefficiency in government credit intervention.

decisions of banks (by controlling the amount they deposit in banks), it does not matter whether households have access to the foreign credit market or the banks do.[9] To the best of our knowledge, none of the papers have explored the implications of access to foreign credit on the part of firms. As we show later, when assuming that the firms are the sector that engages in the foreign borrowing activity, the implications become different, since firms' decisions are not subject to the agency problem. Hence, the main insights of this paper, regarding the implications of different openness structures, are subsumed in the distinction between openness on the side of the depositors in the economy and openness on the side of borrowers (firms), as we do here.

Although GK presented their idea in a setup with nominal rigidities, the basic mechanism they present also pertains to a real business cycle setup. Hence, in order to simplify our model and to highlight the differences between closed economies and open economies, we use a real business cycle version of GK. Although in this setting there is no role for monetary actions per se, we maintain GK's terminology, and refer to government's credit provision as unconventional monetary policy.[10]

We will now describe the model and the parameters of calibration that we have used. In the third section we analyze the model by looking at the reaction of the main model variables to the technology, banks' net worth and government credit shocks. The fourth section discusses some welfare implications of the results, and the fifth section concludes. Additional figures are presented in the Appendix. The complete model equation and further technical details of the model are provided in a technical appendix.

2. The model

We use a standard small open economy real business cycle model[11], to which we add banks, as in GK. There are six types of agents in the model: households, banks, final

[9] We demonstrate this in Appendix 2.
[10] The mechanism that GK highlight regarding the Federal Reserve's LSAP program is basically a real one (its impact does not hinge on price stickiness although it has monetary implications). The entity which is most likely to conduct this kind of policy is the monetary authority. However, in GK's framework it does not matter whether it is the central bank or the government that conducts the asset purchases, so we use the terms "government" and "central bank" interchangeably.
[11] See for example Scmhitt-Grohe and Uribe (2003).

good producers, capital producers, government and an exogenous foreign economy as we shall describe later. We now describe the role of each type of agent.

2.1 Households

There is a continuum of identical households. Each household consumes, saves and supplies labor. Households save by lending funds to banks (financial intermediaries), to foreign borrowers and possibly also to the government. Within each household there is a constant fraction $1-f$ of workers and a fraction f of bankers. Workers supply labor to firms and return the wages to the household. Bankers manage a financial intermediary and transfer their earnings to their household. Each household deposits funds in the banks, apart from the banks that it owns. Each period a banker can become a worker with a probability of $1-\theta$. Thus, every period, $(1-\theta)f$ of bankers exit and become workers and a similar number of workers become bankers, keeping the relative proportion of bankers fixed.

The representative household has the following momentary utility function:

1. $\mathrm{U}_t = \frac{(C_t - hC_{t-1})^{1-\gamma_C}}{1-\gamma_C} - \chi \frac{L_t^{1+\omega}}{1+\omega}$

where C_t and L_t are consumption and hours of work, respectively, and $0 < \beta < 1$, $0 < h < 1$, χ and ω are parameters of time preference, habit formation, labor supply scale and the inverse of Frisch elasticity, respectively.

Households can lend (in the form of deposits) to local banks (B_t) or lend abroad (B_t^*). Both B_t and B_t^* are one-period bonds that pay real interest rate R_t and $R_t^{B^*}$ respectively. In each period the household faces the following budget constraint:

2. $C_t + B_t + B_t^* + \Phi(B_t^*) = W_t L_t + \Pi_t - \mathrm{T}_t + R_{t-1} B_{t-1} + R_{t-1}^{B^*} B_{t-1}^*$

where W_t, Π_t, T_t, stand for real wage, profit from banks and firms, and lump sum taxes, respectively. $\Phi(B_t^*)$ is a cost function for adjusting B_t^* of the form:

3. $\Phi(B_t^*) = \frac{\varphi_{B^*}}{2}(B_t^* - B_0^*)^2$

where φ_{B^*} is a positive parameter, and B_0^* is the steady state value of B_t^*. This cost of adjusting B_t^* can be interpreted as representing a kind of friction between the local economy and abroad.[12]

The consumer maximizes his lifetime expected utility $E_0 \sum_{i=0}^{\infty} \beta^i \mathrm{U}_i$ subject to the budget constraint (2). Let Λ_t be the Lagrange multiplier on Equation (2). The first order conditions of the consumer maximization for the choice of consumption, lending to banks, lending to overseas and the supply of labor services are (2) above and (4) to (7) ahead:

4. $\Lambda_t = U_{Ct} = (C_t - hC_{t-1})^{-\gamma_C} - \beta h(C_{t+1} - hC_t)^{-\gamma_C}$
5. $\mathrm{E}_t\left[\mathrm{M}_{t,t+1}\mathrm{R}_{B^*t}\right] = 1 - \Phi'(B_t^*) = 1 + \varphi_{B^*}(B_t^* - B_0^*)$
6. $\mathrm{R}_t = \frac{R_t^{B^*}}{1+\varphi_{B^*}(B_t^* - B_0^*)}$
7. $\Lambda_t \mathrm{W}_t = \chi L_t^{\omega}$

where $\mathrm{M}_{t,t+1}$ is the stochastic discount factor from t to $t+1$, that is:

8. $\mathrm{M}_{t,t+1} = \beta \frac{\Lambda_{t+1}}{\Lambda_t}$.

According to Equation 6 the household will increase its investment abroad until the effective rate of return on foreign bonds equals the return on bank deposits. In the simulation we shall use two extreme values for the cost parameter φ_{B^*}. One, describing an economy which is completely open to households, in which this parameter is assigned a value of zero, so that the deposit rate is always equal to the world's deposit rate; and a second one, describing an economy which is closed to households, in which the parameter is assigned a very large value so that households choose not to adjust B^*, and the domestic deposit rate is independent of the world's deposit rate.

2.2 Banks

Banks obtain funds from households and lend them to final good firms. In order to finance the capital needed for production, at the beginning of each period the final good firms issue S_{jt}^p financial claims to bank j that earn a stochastic return R_{t+1}^s in the next period. The balance sheet of the bank is given by:

[12] See Uribe and Yue (2006) for an extended discussion on this issue.

9. $Q_t^s S_{jt}^p = \mathrm{N}_{jt} + \mathrm{B}_{jt}$

where Q_t^s stands for the price of each claim, N_{jt} is the net worth of the bank and B_{jt} is households' deposits in that bank. Total net worth available for a surviving bank in $t+1$ is:

10. $\mathrm{N}_{jt+1} = R_{t+1}^s Q_t^s S_{jt}^p - R_t \mathrm{B}_{jt} = (R_{t+1}^s - R_t) Q_t^s S_{jt}^p + R_t \mathrm{N}_{jt}.$

The value of the bank has the form:

11. $\mathrm{V}_{jt} = \mathrm{E}_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \mathrm{M}_{t,t+1+i} N_{jt+1+i} =$

$= \mathrm{E}_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \mathrm{M}_{t,t+1+i} [(R_{t+1+i}^s - R_{t+i}) Q_{jt+i}^s S_{t+i}^p + R_{t+i} N_{jt+i}].$

The aim of the bank is to maximize its value. As long as the discounted risk-adjusted premium in any period, $\mathrm{M}_{t,t+1+i}(R_{t+1+i}^s - R_{t+i})$, is positive, the bank will want to expand its assets by borrowing from households.[13] To motivate a limit on its ability to do so, GK introduce a moral hazard/costly enforcement problem. At the beginning of each period the banker can divert a fraction λ of its funds and transfer it to his family. However, in such a case the depositors will force the banker into bankruptcy and recover the rest, $1-\lambda$, of the assets. The depositors will be willing to supply deposits to the bank as long as the value of the bank is larger than the gain from diverting a fraction of assets, that is, as long as:

12. $\mathrm{V}_{jt} \geq \lambda Q_t^s S_{jt}^p.$

The bank's final wealth can be written as:

13. $\mathrm{V}_{jt} = \upsilon_t Q_t^s S_{jt}^p + \eta_t \mathrm{N}_{jt}$

where:

14. $\upsilon_t = \mathrm{E}_t[\mathrm{M}_{t,t+1}\{(1-\theta)(R_{t+1}^s - R_t) + \theta \chi_{t,t+1} \upsilon_{t+1}\}]$
15. $\eta_t = E_t\{(1-\theta) + \theta M_{t,t+1} \zeta_{t,t+1} \eta_{t+1}\}$
16. $\chi_{t,t+1} = \frac{Q_{t+1}^s S_{t+1}^p}{Q_t^s S_t^p}$
17. $\zeta_{t,t+1} = \frac{N_{t+1}}{N_t}.$

From (12) and (13), if the constraint binds we get:

[13] We assume that in steady state, R_t^s is larger than R_t by a constant positive spread, that is: $R_0^s = \mathrm{R}_0 + spread$, where R_0^s and R_0 are the steady state values of R_t^s and R_t respectively.

18. $Q_t^s S_{jt}^p = \frac{\eta_t}{\lambda - \upsilon_t} N_{jt}$ or $\frac{Q_t^s S_{jt}^p}{N_{jt}} = \phi_t$ where: $\phi_t = \frac{\eta_t}{\lambda - \upsilon_t}$.

As noted by GK, under reasonable calibration the constraint always binds.

Now, since all the components of ϕ_t do not depend on bank-specific factors, we can aggregate Equation 18 across individual banks to get:

19. $Q_t^s S_t^p = \phi_t N_t$

where S_t^p and N_t stand for the aggregate quantities of bank assets and net worth respectively. The evolution of net wealth can now be written as:

20. $\mathrm{N}_{t+1} = (R_{t+1}^s - R_t)\, Q_t^s S_t^p + R_t \mathrm{N}_t = [(R_{t+1}^s - R_t)\phi_t + R_t]\mathrm{N}_t$

and:

21. $\zeta_{t,t+1} = \frac{N_{t+1}}{N_t} = (R_{t+1}^s - R_t)\phi_t + R_t$

22. $\chi_{t,t+1} = \frac{Q_{t+1}^s S_{t+1}^p}{Q_t^s S_t^p} = \frac{\phi_{t+1}}{\phi_t}\zeta_{t,t+1}$.

Total net worth of the banking sector is the sum of those who survive (N_{nt}) and of the new bankers(N_{et}):

23. $N_t = N_{nt} + N_{et}$.

Following GK we add a shock $(\in_t^N)$ to the net worth of banks, in order to analyze the direct effect of changes in banks' net worth on the economy, as will be detailed in the following section. Thus, using Equation 20 the funds of those who survive is:

24. $N_{et} = \{\theta[(R_t^s - R_{t-1})\phi_{t-1} + R_{t-1}]\mathrm{N}_{t-1}\}\, \in_t^N$.

The new bankers receive start-up funds from the households. Following GK we assume that the size of the funds is a fraction $\varpi/(1-\theta)$ of the value of the exiting bankers, so that in the aggregate:

25. $N_{nt} = \varpi Q_t^s S_{t-1}^p$.

Combining the last two, we get the law of motion of aggregate net worth of the banking system:

26. $N_t = \theta[(R_t^s - R_{t-1})\phi_{t-1} + R_{t-1}]\mathrm{N}_{t-1}\, \in_t^N + \varpi Q_t^s S_{t-1}^p$.

2.3 Government

Following GK we assume that the government can act as a bank: issue government debt to households (which pay the riskless rate R_t) and lend to non-financial firms at the market lending rate (R^s_{t+1}). Let S^g_t and S_t stand for the government and total amount of debt, respectively. That is:

$$27.\ S_t = S^g_t + S^p_t.$$

The government lends a fraction ψ_t of total debt:

$$28.\ S^g_t = \psi_t S_t.$$

Since $Q^s_t S^p_t = \phi_t N_t$, we have:

$$29.\ Q^s_t S_t = \frac{\phi_t}{1-\psi_t} N_t.$$

The government issues B^g_t=$Q^s_t S^g_t = Q^s_t \psi_t S_t$, and the earnings are:

$$30.\ (R^s_{t+1} - R_t) B^g_t = (R^s_{t+1} - R_t) Q^s_t \psi_t S_t.$$

The process of extending credit by the government incurs expenses, which reflect the assumption that the government is less efficient than the private sector in extending credit. These expenses could also be thought of as capturing all kinds of distortions that this government policy could create (moral hazard, etc.). The expenses are some proportion τ of B^g_t:

$$31.\ \tau B^g_t = \tau Q^s_t \psi_t S_t.$$

So the government budget constraint is:

$$32.\ \mathrm{G}_t + \tau Q^s_t \psi_t S_t = \mathrm{T}_t + (R^s_t - R_{t-1}) Q^s_{t-1} \psi_{t-1} S_{t-1}.$$

Following GK (2011) we assume that government expenditures remain constant and taxes (T_t) are adjusted to keep the budget balanced.

As for ψ_t we assume a feedback rule in the form of:

$$33.\ \psi_t = \bar{\psi} + \upsilon[(R^s_{t+1} - R_t) - (R^s_0 - R_0)].$$

That is, the government increases its lending in proportion to the gap between the actual spread and its steady state value.

2.4 Final good firms

We assume a sector of competitive firms that combine capital with labor to produce a final tradable product:

$$34.\ Y_t = A_t(\xi_t K_{t-1})^{\alpha} L_t^{1-\alpha}$$

where A_t is the productivity level, and ξ_t is a capital quality shock which, as GK note, is best thought of as reflecting some form of economic obsolescence.[14] After production takes place, the depreciated capital $(1-\delta)\xi_t K_{t-1}$ is sold to capital producers at the price Q_t^k and the new capital stock K_t is purchased for use in production in the next period.

To finance the new capital the firm issues shares to the banks (S_t^p) and possibly also to the government (S_t^g). We assume that the number of shares equals the number of capital units it intends to use in the next period (K_t), that is:

$$35.\ S_t = S_t^p + S_t^g = K_t.$$

In order to finance the capital stock, the firm can also get loans from abroad. Let D_t^* stand for the amount it borrows and $R_t^{D^*}$ stand for the world interest rate paid on those loans.[15] In addition to interest payments, the firm also has a borrowing cost in the form of:

$$36.\ \Phi(D_t^*) = \frac{\varphi_{D^*}}{2}(D_t^* - D_0^*)^2$$

where φ_{D^*} is a positive parameter, and D_0^* is the steady state value of D_t^*.

The total value of stocks and the loans from abroad equals the total value of the capital stock, that is:

$$37.\ Q_t^S S_t + D_t^* = Q_t^k K_t$$

where Q_t^S and Q_t^k stand for the price of one unit of stocks and of capital, respectively.

The profit function of the final good firms at time t is:

$$38.\ \Pi_t^F = \mathrm{Y}_t + Q_t^k(1-\delta)\xi_t K_{t-1} - W_t L_t - R_t^S Q_{t-1}^S S_{t-1} - R_t^{D^*} D_{t-1}^* - \frac{\varphi_{D^*}}{2}(D_t^* - D_0^*)^2.$$

[14] In the current version of the paper we do not activate the capital quality shock.

[15] We assume that $R_t^{D^*}$ is always greater than $R_t^{B^*}$.For ease of calculating the steady state of the model we assume that in steady state the spread abroad is equal to the local spread. That is: $R_0^{D^*} - R_0^{B^*} = R_0^S - R_0 = spread$, where $R_0^{D^*}$ and $R_0^{B^*}$ are the steady-state values of $R_t^{D^*}$ an $R_t^{B^*}$, respectively. This equality causes the level of firm borrowing from abroad to be zero in steady state.

Using Equation 37, Equation 38 can be written as:

$$39.\ \Pi_t^F = \mathrm{Y}_t + Q_t^k(1-\delta)\xi_t K_{t-1} - W_t L_t - R_t^s(Q_{t-1}^k K_{t-1} - D_{t-1}^*) - R_t^{D^*} D_{t-1}^* - \frac{\varphi_{D^*}}{2}(D_{t-1}^* - D_0^*)^2.$$

The firm has to maximize its lifetime profits. The FOC with respect to the choice of labor, capital and loans is:

$$40.\ Y'_{L,t} = W_t$$
$$41.\ E_t(M_{t,t+1}Y'_{K,t+1}) = E_t[M_{t,t+1}(-Q_{t+1}^k(1-\delta)\xi_{t+1} + R_{t+1}^s Q_t^k)]$$
$$42.\ E_t(M_{t,t+1}R_{t+1}^s) = E_t[M_{t,t+1}(R_{t+1}^{D^*} + \varphi_{D^*}(D_t^* - D_0^*))]$$

with:

$$43.\ Y'_{L,t} = (1-\alpha)A_t L_t^{-\alpha}(\xi_t K_{t-1})^{\alpha} = (1-\alpha)\frac{Y_t}{L_t}$$
$$44.\ Y'_{K,t+1} = \xi_{t+1}\alpha A_{t+1}(\xi_{t+1}K_t)^{\alpha-1}L_{t+1}^{1-\alpha} = \alpha\frac{Y_{t+1}}{K_t}.$$

Equation 41 can be interpreted as a pricing equation for the yield on stocks.[16] According to Equation 42 the firm will increase its borrowing from abroad until the effective cost of borrowing from abroad equals the cost of borrowing from domestic banks. In a similar way to the households sector, in the simulation we shall use two extreme values for the cost parameter φ_{D^*}: one, describing an economy which is completely open to firms, in which this parameter is assigned a value of zero, so that the cost of borrowing from banks is always equal to the world borrowing rate; and a second one, describing an economy which is closed to firms, in which the parameter is assigned a very large value so that firms choose not to adjust D^*, and the domestic borrowing rate is independent of, the world's borrowing rate.

2.5 Capital producers

We assume that capital is produced by a sector of competitive capital producing firms, which are owned by households. At the end of each period the capital producers buy the depreciated capital $(1-\delta)\xi_t K_{t-1}$ from the final good firms at market price Q_t^k. It then combines it with new investment (I_t) to produce new capital (K_t) and sells it to the final good firms at the market price for use in production during the following period. The transformation of new investment into installed capital is subject to adjustment costs $\Gamma\left(\frac{I_t}{I_{t-1}}\right)$ in the form presented below.

[16] This equation can be written as: $E_t M_{t,t+1}\frac{[\alpha\frac{Y_{t+1}}{\xi_{t+1}K_t}+(1-\delta)Q_{t+1}^k]\xi_{t+1}}{Q_t^k} = E_t(M_{t,t+1}R_{t+1}^S)$.

The profit function of the capital producers at time t is:

$$45.\ \Pi_t^C = Q_t^k \mathrm{K}_t - Q_t^k(1-\delta)\xi_t K_{t-1} - I_t - \Gamma\left(\frac{I_t}{I_{t-1}}\right) I_t$$

where capital is evolving according to:

$$46.\ K_t = I_t + (1-\delta)\xi_t K_{t-1}.$$

Using Equation 46 the profit can be written as:

$$47.\ \Pi_t^C = [Q_t^k - 1 - \Gamma\left(\frac{I_t}{I_{t-1}}\right)]I_t.$$

The firm maximizes its lifetime profits. The first order condition for investments is the following derived price of capital:

$$48.\ Q_t^k = 1 + \Gamma\left(\frac{I_t}{I_{t-1}}\right) + \Gamma'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}} + E_t[\mathrm{M}_{t,t+1}\Gamma'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2]$$

where $\Gamma'\left(\frac{I_t}{I_{t-1}}\right)$ is the derivative with respect to$\left(\frac{I_t}{I_{t-1}}\right)$, and $\Gamma(\frac{I_t}{I_{t-1}})$ is specified as:

$$49.\ \Gamma(\frac{I_t}{I_{t-1}}) = \frac{\gamma_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$$

where γ_I is positive.

Using Equation 49, Equation 48 gets the form:

$$50.\ Q_t^k = 1 + \frac{\gamma_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 + \gamma_I\left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}} - \mathrm{M}_{t,t+1}\gamma_I\left(\frac{I_{t+1}}{I_t} - 1\right)\frac{I_{t+1}^2}{I_t^2}$$

2.6 Aggregate resource constraint and market clearing

Summing up the budget constraints of the five sectors (households, banks, government, final good firms and capital producers) we get:

$$51.\ \mathrm{Y}_t = C_t + I_t + \Gamma(I_t, I_{t-1})I_t + G + \tau Q_t^S \psi_t K_t + \Phi(B_t^*) + \Phi(D_t^*) + NX_t$$

where NX_t is net export and is equal to:

$$52.\ NX_t = (B_t^* - R_{t-1}B_{t-1}^*) - (D_t^* - R_{t-1}^{D^*}D_{t-1}^*)$$

2.7 Exogenous processes:

1. $\ln(A_t) = \rho^A \ln(A_{t-1}) + \varepsilon_t^A$
2. $\ln(\in_t^N) = \varepsilon_t^N$

where both ε^N and ε^A are i.i.d with a mean of zero and given variance.

A complete list of the model's equations is presented in the technical appendix.

2.8 Parameters

To assign values to the parameters of the model we followed GK where possible. The list of the parameters and the values are presented in Table 1.

Table 1 – Parameter values

Households		
γ_c	1	Risk aversion of consumption
β	0.990	Discount factor
h	0.815	Habit formation in consumption
χ	3.409	Scale parameter of labor in the utility function
ω	0.276	Inverse of Frisch elasticity
φ_{B^*}	10^{-10} or 10^{+10}	Marginal cost of adjusting foreign deposits
B_0^*	0	Steady state value of households' foreign deposits
Banks		
λ	0.3802	Fraction of capital that can be diverted
ϖ	0.002	Proportional transfer to the entering bankers
θ	0.972	Survival rate of the bankers
Δ	0.0025	Steady state value of the spread (per quarter)
Final good firms		
α	0.33	Capital share in production
δ	0.025	Depreciation rate of capital
φ_{D^*}	10^{-10} or 10^{+10}	Marginal cost of adjusting foreign deposits
D_0^*	0	
Capital producing firms		
γ_I	1.728	Inverse elasticity of net investment to price of capital
Government		
$s_G = \frac{G_0}{Y_0}$	0.20	Steady state proportion of govt. expenditure
υ	0 or 100	Reaction coefficient of govt. credit to the spread

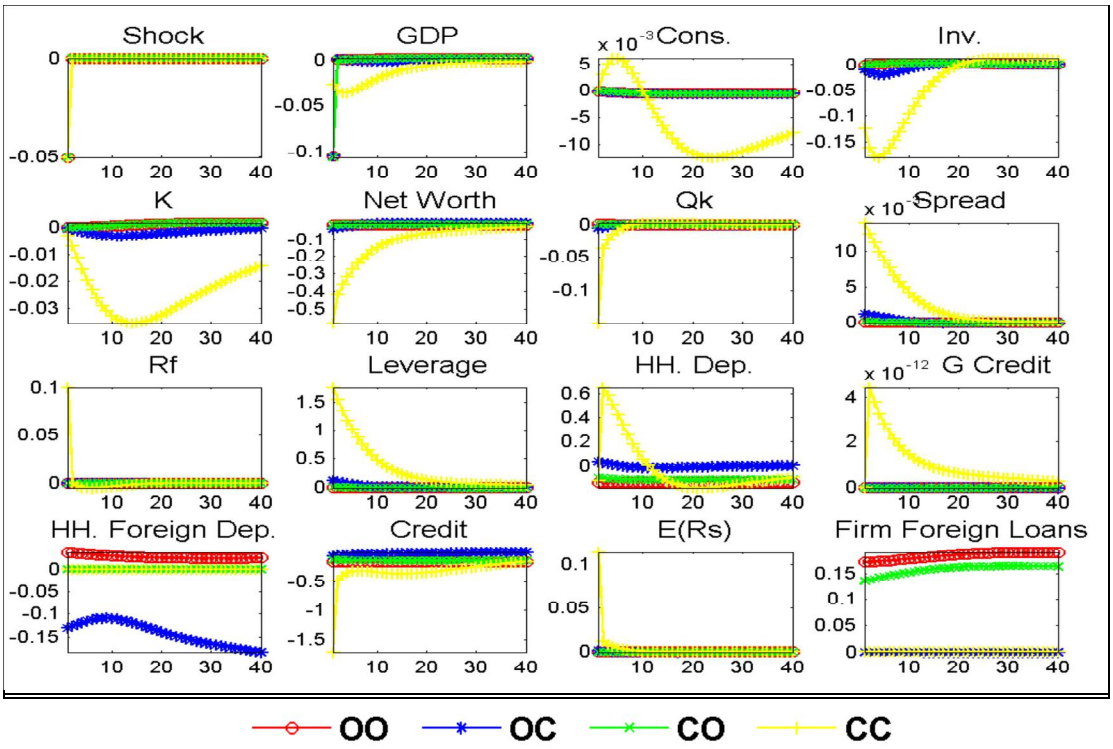
3. Model analysis

We now look at the development of the economy in response to external shocks and in response to policy shocks, and compare the results of a closed economy to those of an open economy.[17]

3.1 Productivity shock

We start the analysis by presenting the impulse response to a productivity shock of a magnitude of 5% of productivity's steady state level. For illustration purposes, we will present the IRF for the case where the shock has no serial autocorrelation. The results are shown in Figure 1. We distinguish among four possible cases: a closed economy (CC yellow), an economy that is open only to households (OC, blue), an economy that is open only to final good firms (CO, green) and an economy that is open both to households and firms (OO, red). The size of the shock appears in the upper left side, and is equal in all four cases.

Figure 1 – Productivity shock



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

[17] The IRFs were calculated using a 1st order approximation in DYNARE 4.4.

Let us look first at the closed economy case (yellow line). When the shock impacts the economy, output falls due the productivity decline, and hence households' income falls as well. Since households want to smooth consumption, they reduce their supply of savings (deposits) to the banks. The banks, facing a lower amount of deposits, must now lower their credit to firms, which causes the firms to reduce their demand for capital. Since demand for capital has fallen, so does its price, and with it banks' net worth, as the return that banks receive on the credit they extended is tied to the price of capital.[18] Since banks now become more leveraged they need to reduce credit, which results in an even lower demand for capital by the final good firms, and in a bigger decline in the price of capital, which further reduces banks' net worth, and so on. The fall in banks' net worth makes the economy more credit constrained, which is reflected in a rise in the interest rate spread (of roughly 1.5 percentage points). Regarding consumption, initially it rises (since banks' net worth is lower, and this lowers the amount of deposits that households want to hold in the banks[19]), but after the initial rise, it is lower than steady state for a long time. The process described here is similar to that described in GK, in which an asset fire sale results in an amplification of the initial shock.[20] To sum, in the closed economy, a temporary productivity shock has an amplified and a long-lasting effect.

In sharp contrast to the closed economy case, in the other cases there is almost no response of output (aside from the direct, temporary, effect of the productivity shock) on banks' net worth, investment and the price of capital. The reason for this depends on the type of openness structure. When the economy is open to firms (either exclusively—represented by the green line, or when it is open for households as well—represented by the red line), the firms face a totally elastic supply of credit. Hence, the amount of capital they choose to purchase does not change. Specifically, when the economy gets hit with a negative productivity shock and banks reduce the amount of credit to firms, this has no effect on firms' demand for capital, as they can

[18] Their return is also impacted directly by the lower productivity, but to lesser degree.

[19] The agency problem places a limit on households' deposits, and in the absence of alternative instruments for saving they have to decrease their savings, i.e. increase their consumption. However, the actual amount of deposits increases as result of the shock, since banks' leverage decreases and they have to replace net worth with deposits, for which they are willing to pay a higher interest rate.

[20] Here, for example, banks' net worth drops by nearly 50% and the price of capital drops by nearly 20%, in response to a 5%, temporary, decline in productivity. Furthermore, the shock affects the economy long after it has faded, since as long as banks' net worth is lower the amount of credit banks can supply is lower, hence, investment is lower as well.

replace domestic credit with foreign credit at no cost. The fact that firms do not lower their demand for capital means that there is no further decline in the price of capital, and therefore almost no decline in banks' net worth. When the economy is open only to households (represented by the blue line), the mechanism is slightly different, but with similar results. The decline in productivity entails a reduction in households' income, just like in the closed economy. Here, however, in order to smooth consumption households don't have to reduce their deposits at banks. Now they can and will reduce their foreign asset holdings instead.[21] Since households now do not reduce their deposits, the banks don't have to reduce credit and the price of capital barely falls. The effect of the shock on banks' net worth is thus very mild. To sum, the openness of the economy, either on the side of the depositors (households) or on the side of the borrowers (final good firms) isolates the financial sector (specifically, banks' net worth) from the effect of the productivity shock, by weakening the reaction of the price of capital to the shock. Thus, the openness highly reduces the negative effects of the productivity shock on the economy, both in terms of magnitude and in terms of duration.

3.2 A shock to the net worth of banks

We now turn to look at a shock that directly impacts the net worth of banks. Following GK we applied a redistribution shock which transfers wealth from banks to households such that banks' net worth declines and households' current income increases by the same amount.[22] As GK stress, this redistribution of wealth has effect only because of the financial friction (the agency problem between households and banks).

The results are shown in Figure 2. The size of the shock appears in the upper left side, and is equal in all four cases (the shock is of a magnitude of 40% of the steady state value of net worth). We will look first at the results under a closed economy (yellow line). As can be seen, the decline in the net worth of the banks leads to a decline in bank credit and thus in investments and output.[23] This leads to a

[21] When households reduce their deposits at banks the deposit rate increases so it is always worthwhile for them to decrease foreign deposits (for which the interest rate is given).
[22] This shock can be thought of either as a financial shock, originating in the financial sector, or as depicting the financial channel of a nonfinancial shock (a productivity shock for example).
[23] Since, in order to satisfy the leverage constraint, the banks are forced to sell assets.

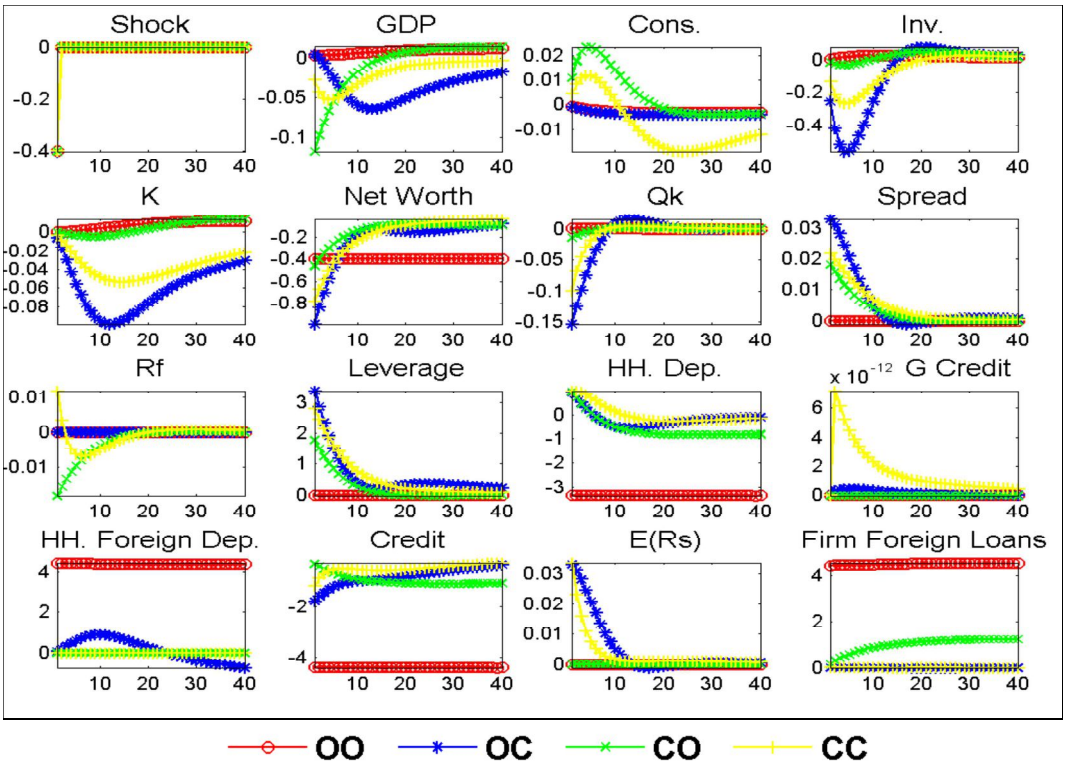
decline in the price of capital (and to an increase in the spread), which leads to a decline in the (actual) return on capital, which leads to a further fall in the net worth of the banks, which leads to a further decline of the bank's credit, and so on. As a result, net worth declines by 80%, much more than the initial effect of the shock.[24,25] The increase in the spread is an expression of the fact that the economy is now in a state where households cannot transfer to firms all the resources they would have like to (in the absence of the financial friction). That is, households have to reduce savings (so the banker does not divert assets), and final good firms must reduce investment, as they now face a lower amount of funding. Lastly, after the shock, the spread is higher than usual and hence banks are more profitable than usual and are thus able to rebuild their net worth. In this sense, we can say that the closed economy has an inherent mechanism that causes the banking system to eventually recover back to its original level. As we will shortly see, in an open economy this is not necessarily always the case.

When the economy is open only to households (blue line), we obtain an amplified reaction of the various variables.[26] The reason is that households now have the ability to invest abroad and so when banks' net worth gets hit by a negative shock, households transfer some of their savings abroad. The result of this is a stronger fall in the price of capital[27] and a stronger amplification process (i.e. a stronger fire sale)—a stronger decline of banks' net worth and of credit, investment, and so on. We can see that the cumulative decline in the net worth of banks, and therefore in (bank) credit, investment, the capital stock, the price of capital stock and output, is much larger than in the closed economy case. In addition, since in this case households can invest in foreign bonds there is no increase in consumption, even initially.[28] Finally, it is worth noting the effect of the shock when labor supply is fixed. We present this case in

[24] These results are similar to those of GK. In their paper they present the IRF of only the output, investments and the spread. We ran their model ourselves and verified that the rest of the variables react similarly to the results in our model.
[25] Regarding the reaction of the risk-free rate, the decline in the bank's net worth increases its demand for deposits, while at the same time the increase in households' income leads to an increase in the supply of deposits. The outcome is an increase in deposits. The effect on the risk-free interest rate will depend in general on the relative strength of the movement of the supply and demand curves. Here the risk-free rate initially increases and later decreases.
[26] Except consumption, which households are now able to smooth via the foreign capital market.
[27] Since the supply of credit, and thus the demanded amount of capital, decline more in this case.
[28] Consumption slightly decreases, as should be expected, in light of the decrease in households' permanent income.

Figure A1.a in Appendix 1. When labor is fixed the amplification mechanism (when the economy is open to households) is much stronger, since there is no offsetting effect of an increase in the labor supply in response to the negative shock.

Figure 2 - Shock to banks' net worth



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

We now look at the case where the economy is open only for final good firms (green line). In this case the firms can borrow any amount from abroad at a given borrowing interest rate. The decline in the net worth of banks forces them to reduce credit to firms, but this does not change total credit to firms since the firms can replace bank credit with foreign credit at no cost. Hence, in this case, the decline in investment, capital stock and the price of capital is much lower than in the two former cases.[29] As for the banks, since the price of capital declines only modestly, the decline in the net worth is close to the direct effect of the shock. That is, in contrast to the two previous cases, here there is almost no amplification of the shock. However, in this case the net

[29] This modest decline is only due to a decline in labor supply which is related to the lack of another route for saving. Holding labor constant (see figure A1.a Appendix 1) the shock has no effect on the capital stock or on output.

worth of the banks never completely recovers.[30] In the first few quarters, as long as the deposit rate is lower than its value in the steady state, the spread is higher than the steady state level and hence banks' profits, along with net worth, increase. But, at some stage the deposit rate returns to its steady state level while the net worth is still below the steady state. From this moment on, the spread remains in its steady state value (because the return on capital is constant). As a result, bank credit never recovers and the firms' borrowing from abroad remains high.

An even more extreme case is when the economy is open to both households and final good producers (red line). In this case the spread is always equal to the spread abroad and therefore does not rise in response to the shock. Thus, banks cannot rebuild their net worth, and it stays stuck at the level to which it fell when it was hit by the shock. Since banks' net worth is lower, the credit they extend is lower and so the firms borrow more from abroad and households save more abroad. The cost of credit, and thus total credit to firms, hardly change, and the capital stock, the price of capital and total output therefore hardly change. In other words, as opposed to the first two cases, when the economy is open to final good firms there is no mechanism that causes the banking system to restore its initial situation. In this case, temporary shocks have a long-term impact on the banks' situation.

To sum, the results for the net worth shock show that when the financial sector is hit by a shock, the financial openness of the economy does not necessarily reduce the effect of the shock on the economy, as was the case for the productivity shock, and the effect depends on the exact nature of openness. When the economy is open only to households the effect on the economy is much larger than in the closed economy case. When the economy is open (also or only) to borrowing firms, the effect on the economy is lower than that in the closed economy case but the effect on the banks is much more persistent.

[30] Technically, the net worth does recover eventually, but it takes a very long time. The fact that it does recover eventually is because we set the cost parameter to be very small, but not exactly zero. In order not to obscure our message with technical issues, we refer to the behavior of net worth here as "never recovering". A further question that this case might raise, regards the validity of the log linearization of the model around the steady state, since the model, in effect, exhibits a non stationary behavior (as Schmitt-Grohe and Uribe 2003 discuss). We don't deal with those questions, as we are only interested in depicting the reaction of the economy to shocks, around its "normal" steady state, and not in calculating the moments of the variables in the model, for example. In Figure A1.b in the appendix, we show this IRF for the case in which the adjustment costs are slightly higher, and there the net worth does converge back to its steady state level, straight from the beginning.

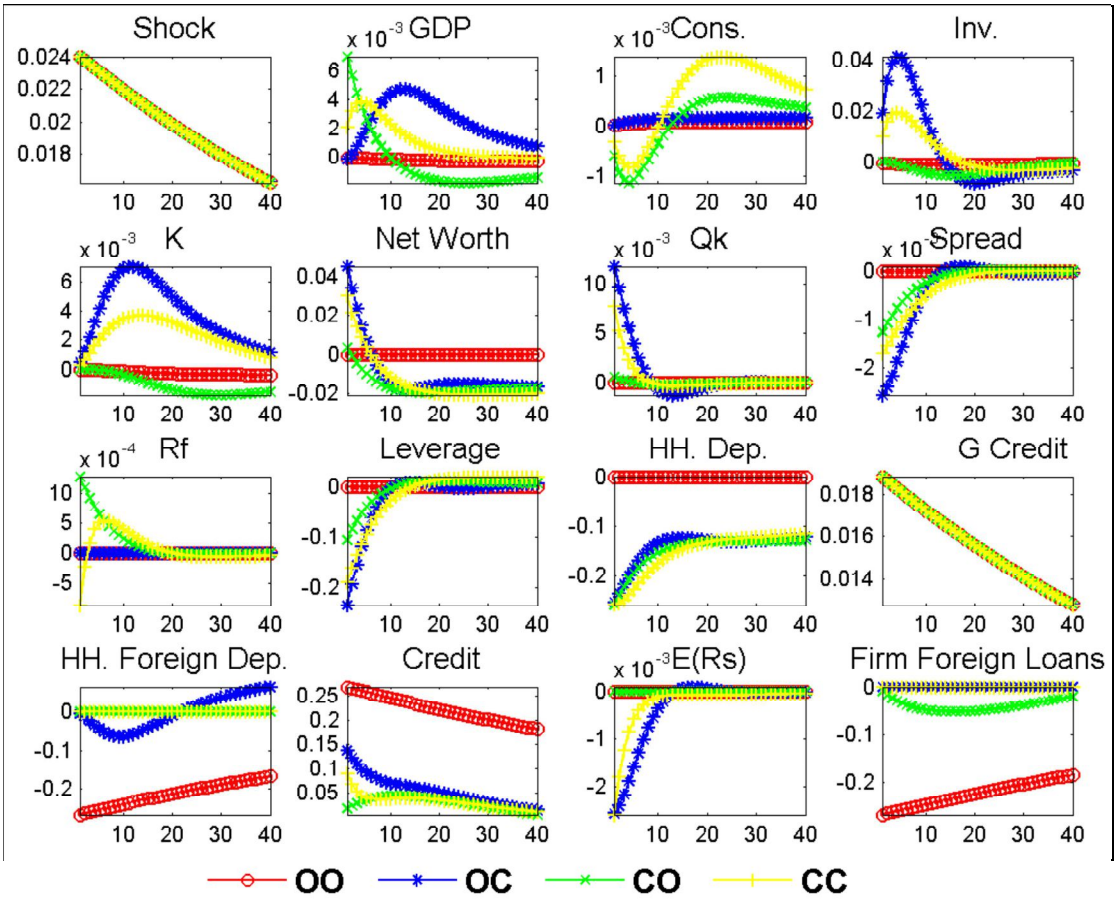
3.3 The role of asset purchases

Now we turn to the effect of asset purchases by the government, under the four different versions of the economy. First we look at the effect of a shock to government purchases and then we look at the reaction of the government to a net wealth shock.

3.3.1 Shock to government purchases

We start by presenting the IRF to a government asset purchase shock, in which the government buys assets from the final good firms. The initial size of the asset purchase is calibrated to be in the magnitude of 2% of output and then it gradually declines according to its serial correlation. The results are presented in Figure 3.

Figure 3 - Shock to government purchases



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

Let us look first at the closed economy version (yellow line). In this case, the response of the variables essentially mirrors those of the net worth shock. The government purchases increase the demand for capital thereby increasing the price of capital. A higher price of capital increases the actual total return on bank credit thereby contributing to a higher net worth of banks and thus to higher bank credit. Total credit is higher leading to higher investments, capital stock and production. As for private consumption, in the first few periods it declines, because households' ability to save improves, but then moves higher than its steady state level for a while. When the economy is open only to households the effect on the economy is also much stronger, which indicates that in this kind of an economy, the effectiveness of unconventional monetary policy is potentially much stronger.

When the economy is open only to firms (the green line) we get results that at first might seem strange. Under this economic structure, government intervention worsens the banks' situation: It lowers banks' net worth, thereby negatively affecting the level of capital. The reason for this is that since firms face a perfectly elastic supply of foreign loans, government credit does not result in a higher amount of total credit to firms, but just in a crowding out some of the foreign credit. Hence, firms' demand for capital does not change and neither does the price of capital. Furthermore, the government intervention reduces the profitability of banks, since it increases government borrowing, which is reflected in the rise of the risk-free rate.

In the case where the economy is open to both households and firms (red line), like in the former case, the credit that the government supplies to firms just crowds out the foreign credit, and it has no effect on the price of capital. However, in this case the government action does not reduce banks' profitability, as the risk-free rate does not rise. The government asset purchases encourage households to reduce their foreign deposits and lend the resources domestically, keeping the risk-free rate constant.

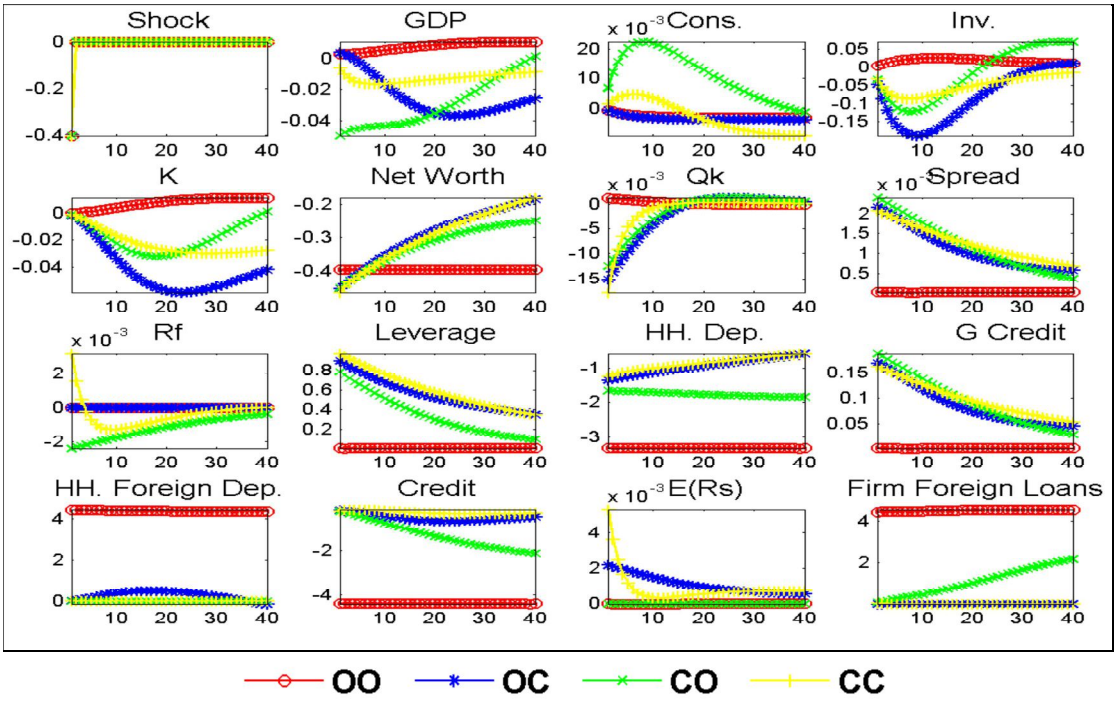
3.3.2 Government credit policy in response to a net worth shock

We now turn to look at the way that government purchases change the reaction of the economy to the net worth shock.[31] This exercise mimics the way in which the government (or the central bank) might choose to react in a case of financial distress in the economy. As in GK, this reaction takes the form of a "credit rule" (Equation 33), which determines the government's asset purchase amount as a function of the increase in the interest rate spread, which serves as an indicator of financial distress in the economy.

The results are presented in Figure 4.[32] With the exception of the fully open economy (OO), all paths of government purchases are quite similar: The government starts with a purchase of about 15% of GDP and in the following periods the amount of purchases declines with the declining spread. When the economy is fully open, there is no response by the government, since there is no increase in the spread. This indicates that in general, it may be better for the government to respond to the financial situation of the banking system (specifically, to the level of net worth), instead of to the spread, as the spread isn't always a good indicator of the level of financial distress in the economy. When the government does purchase assets, we can see that the effect is as shown in Figure 3: When the economy is closed to firms, the government intervention has a stabilizing effect on the economy, and when it is open to firms and closed to households, the intervention has a negative effect on banks' net worth.

[31] This exercise could be done with respect to the productivity shock as well, of course. We focus here on the net worth shock as it better highlights the attributes of a financial distress.
[32] Figure A1.c in Appendix 1 plots the difference between Figure 2 and Figure 4 in the text, for a more convenient comparison.

Figure 4 - Shock to Banks' net worth, with govt. reaction to spread opening



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

4. Welfare implications

In the previous section we showed that the dynamics of the economy in response to exogenous shocks, or to government asset purchases, can be very different depending on its openness structure. In this section we will briefly discuss some welfare implications related to the different openness structures of the economy. We shall concentrate on a shock to banks' net worth. In order to highlight the main effects of the shock, in this section we shall assume a fixed labor supply. The results are summarized in Table 2, where for each of the four possible structures of openness we present the cumulative change for several key variables and for lifetime utility.

Table 2 – Cumulative effect of a net worth shock on key variables

	Y	C	I	U
CC	-0.3825	-0.1282	-0.2543	-0.0230
OC	-0.9322	-0.5066	-0.6198	-0.0643
CO	0.0000	-4.2691	0.0000	-0.1102
OO	0.0000	-11.5041	0.0000	-1.4610

The cumulative effect is calculated as the sum of the variables over 1,000 periods after the shock. The cumulative effect on utility is calculated as the discounted stream of utility over the same time span.

We start with the closed economy case. The negative shock to banks' net worth lowers production, thereby reducing the resources available to the economy, which obviously reduces welfare.[33] When the economy is open to household savings, the effect of the shock on banks' net worth, and through it on output, is much stronger. Table 2 shows that in this case the welfare loss is three times the welfare loss of the closed economy case.

When the economy is open to firms (either exclusively, or when it is open to households as well) their access to the global capital market enables them to overcome the reduced supply of local bank credit, so that the level of output is not affected by the reduction in the supply of bank credit. Yet, the deterioration in the state of the banking sector still has a strong negative effect on households' welfare: The lower net worth of banks causes households to divert more of their savings abroad, and causes firms to borrow more from abroad. As firms must now rely more heavily on foreign credit, more of the resources of the economy are now being transferred abroad instead of being used domestically (as the profits of domestic banks decline and the profits of foreign banks increase by the same amount). Hence, even though firms have access to the foreign market, the negative shock to banks' net worth implies negative welfare consequences. Furthermore, as we saw in the previous section, in these cases (where the economy is open to firms' borrowing) the recovery of banks might take a very long time (or even never happen) and thus the welfare costs stemming from the positive spread might accumulate to large losses. Table 2 shows that under our calibration in both of these cases the decline in welfare is much larger than in the former two cases (in which the economy is closed for firms). When the economy is open on both sides, the effect on welfare is much larger than in all other cases, which is the result of the very large, negative, and long-lasting effect that the net worth shock has on banks' net worth.

Regarding asset purchases by the government, our results showed that when the economy is open to firms' borrowing, asset purchases have no direct effect on output.[34] However, in a manner similar to the discussion above, as long as the interest

[33] There is also a negative effect, of a second order of magnitude, on households' welfare since now their ability to smooth consumption is hampered.
[34] When the economy is open to borrowers and closed to depositors, they have an indirect effect on production via households' labor decisions.

rate spread is positive, they still have positive welfare implications, as they replace households' foreign savings with domestic savings.

5. Conclusions

We applied the framework of Gertler and Karadi (2011, 2013) to a small open economy, real business cycle model. We showed that the financial openness of an economy highly mitigates the effects of productivity shocks. With regard to a shock that directly affects the net worth of banks, its effects depend on the kind of openness. When the economy is open only to household savings the reaction of the economy is amplified, and when the economy is open (also or only) to final good firms' borrowing the reaction of the economy is mitigated. However, in this case the shock still might have strong negative welfare implications. Our results highlight two aspects that should be taken into account in this context. First, when households have an alternative saving device other than domestic savings, the response of the price of capital to financial shocks is larger and the effect on the financial sector is stronger. Second, when the economy is open to the final good firms, banks' net worth recovers very slowly (or even never recovers at all) after a financial shock. In cases where the spread (between borrowing and deposit rates) is large this could have a large detrimental effect on banks' profitability and hence on households' welfare, since a larger part of the financial intermediation is now transferred abroad.

Regarding the effectiveness of an unconventional monetary policy in the form of asset purchases, our results showed that it has a stabilizing effect on the financial sector only when the economy is closed to borrowers. In the case where it is open only to borrowers, asset purchases exacerbate the financial distress of banks. However, even in this case asset purchases are welfare enhancing and the benefit increases with the spread. Another point concerning policy is that when the economy is open to both households and firms the situation of the banking sector is not reflected in the spread and the government must therefore monitor and react to the net worth of the banks.

Our findings indicate that it is important to identify the nature of the openness of an economy. This is necessary in order to assess the possible effects of financial

shocks and in order to assess whether or not an unconventional monetary policy should be implemented.

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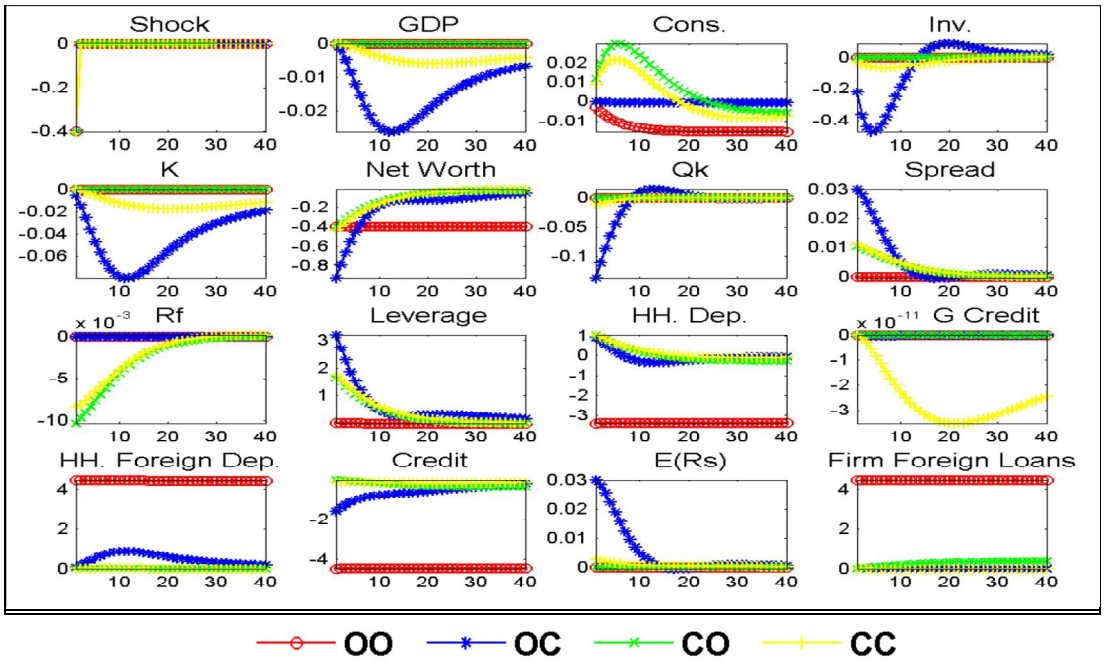
6.1 Appendix 1

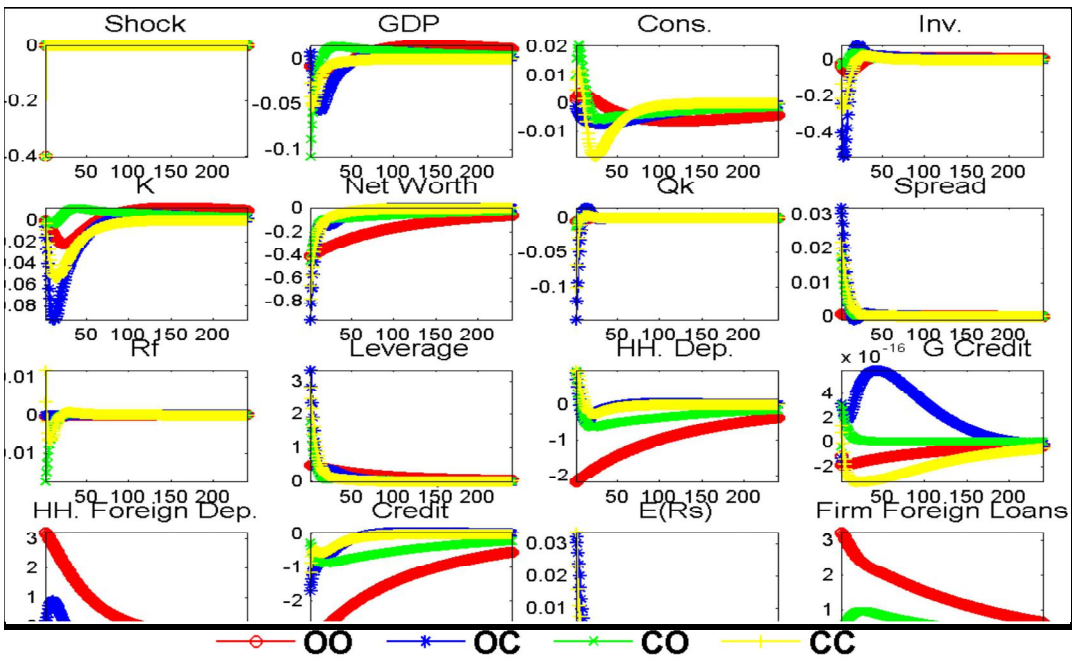
Additional figures

Figure A1.a - Shock to net worth with fixed labor



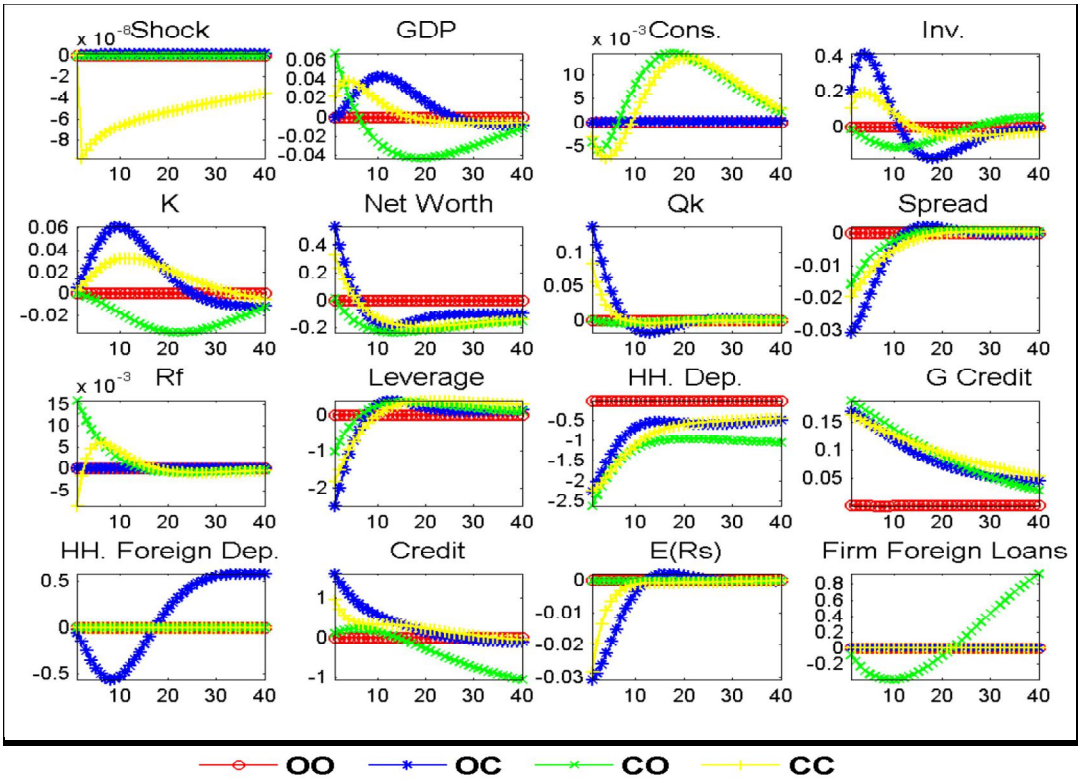
* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

Figure A1.b - Shock to net worth when debt adjustment costs are slightly above zero



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

Figure A1.c - Shock to net worth with and without government reaction (difference)



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

6.2 Appendix 2

In this appendix we demonstrate the equivalence of the assumption that the economy is open to households and the assumption that it is open to banks. For the case in which the openness is through the banks, we have to modify several equations of the model presented in Section 3 as follows.

The balance sheet of the banks, Equation 9 in Section 3, is modified to allow banks to raise foreign deposits:

9.1 $Q_t^s S_{jt}^p = \mathrm{N}_{jt} + \mathrm{B}_{jt} + \mathrm{F}_{jt}$

where F_{jt} stands for foreign deposits, and $R_t^{F^*}$ is the deposit rate on foreign deposits.[35] Equation 6 is modified to:

6.1 $R_t = R_t^{F^*}$

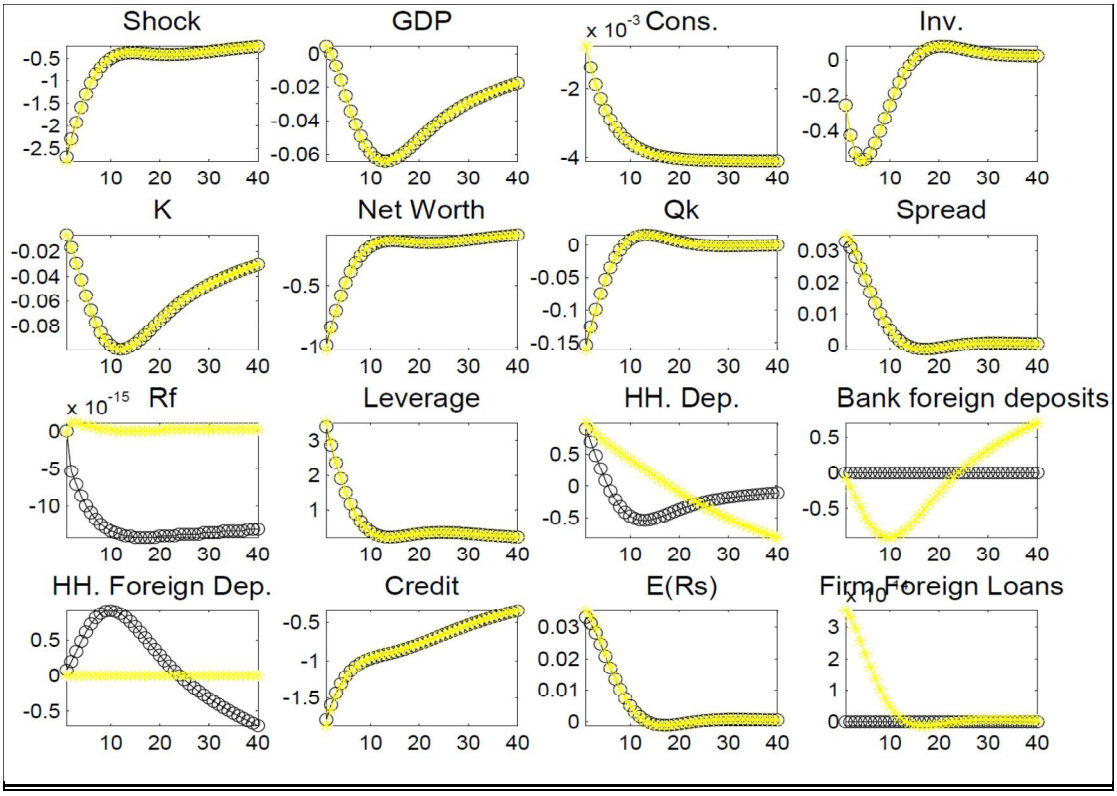
And equation 52 for net exports is modified to:

52.1 $NX_t = (B_t^* - R_{t-1}B_{t-1}^*) - (D_t^* - R_{t-1}^{D^*}D_{t-1}^*) - (F_t^* - R_{t-1}^{F^*}F_{t-1}^*)$

[35] In the simulation we assume that $R_t^{F^*}$ is equal to $R_t^{B^*}$.

In Figure A2.a we demonstrate the equivalence of the two assumptions by presenting the IRF of a net worth shock. The figure compares the case that we discussed in Section 3.2 of an economy which is closed to firms and open to households (black line) to the case where the economy is closed to firms and open to banks (yellow line). The figure shows that the reaction of almost all of the variables is identical in both cases. The only differences are regarding the composition of foreign deposits between banks and households: When the economy is open to households, they increase their deposits abroad in response to the shock.[36] When the economy is closed to households but open to banks, households cannot lend abroad. As such, they do not reduce their deposits in the local banks to the same extent. The local banks now have a higher amount of deposits relative to the former case, but they cannot use the additional deposits to extend credit since their leverage ratio prohibits them from doing so. Hence, they use the additional deposits to replace some of the foreign deposits ("bank foreign deposits"), thereby, in effect, increasing the economy's net exports on behalf of the households.

Figure A2.a - Shock to net worth – openness to households (black) vs. openness to banks (yellow)



* Impulse responses are reported as deviations from the model's steady state except for GDP, consumption, investments, capital and net worth which are reported as percentage deviations from steady state.

[36] The differences in the response of the risk free rate and in firms' foreign loans are nearly zero.