Financial Factors and International Spillovers

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Abstract

This paper explores how financial factors affect the international transmission mechanism. We look at how financial frictions affect the international transmission of country specific productivity shocks. We then explore how two types of shocks that affect the external finance premium are propagated across countries. We build a two country DSGE model with financial frictions to explore the size and nature of international spillovers. Our main findings are that financial frictions magnify movements in international relative prices. In addition, external finance premium shocks can generate significant and persistent international spillovers but they depend on the type of shock. A shock to the dispersion of the productivity of entrepreneurs results in a shift in the foreign aggregate supply curve. A shock to the survival probability of entrepreneurs generates a shift in the foreign aggregate demand curve.

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1 Introduction

Two striking features of the Great Recession are the speed and synchronicity with which real activity collapsed across the world. Following adverse developments in the US subprime mortgage market global financial markets became severely disrupted. Moreover, the effect of this disruption was not limited to the financial sector; global real output and trade declined dramatically and central banks took unprecedented coordinated action, in part, to alleviate the adverse impacts of the financial market shocks on real activity. Many economies entered the longest contraction of output seen since the Great Depression. And the proportion of economies entering recession was higher than at any point since the Great Depression. The exceptional degree of global interdependence in financial and real variables suggests a strong international transmission mechanism of shocks originating in the financial sector.

Understanding the inter-linkages between financial and real variables has been given increased attention by policy makers and academics following the financial crisis. There is a new and growing literature aimed at understanding how country specific financial market shocks are transmitted internationally. This paper contributes to the literature by addressing two questions; first it examines how financial frictions affect the international transmission mechanism. Second, it explores the international spillovers from country-specific credit spread shocks.

To answer these questions we build a two country DSGE model with financial frictions. The impacts of financial frictions are examined by looking at the dynamic responses of foreign country variables to a productivity shock in the home country with financial frictions turned on, compared to the case without. Then two types of credit spread shocks are introduced to the home economy and the dynamic response of foreign variables are analyzed. Our examination of the type of credit spread shock and its impact on international spillovers is an addition to the literature.

A number of studies look at how the financial sector propagates shocks originating in the real sector (Gertler and Kiyotaki (2010), Goodfriend and McCallum (2007)). But one explanation for the Great Recession is that financial market shocks actually drove declines in investment and activity, meaning there may be a role for financial factors in driving domestic and foreign business cycle fluctuations. For example, empirical evidence from Cetorelli and Goldberg (2011) documents a strong relationship between adverse liquidity shocks to advanced economies banking systems and shocks to credit supply in emerging economies, with knock on effects on real activity. In contrast there are relatively few studies which investigate the macroeconomic impact of direct disturbances to financial factors and the role played by the financial sector as a source of business cycle fluctuations particularly in an open economy framework. Smets and Wouters (2007) and Gilchrist et al. (2009) look at the role of financial factors in driving business cycle fluctuations but these are in closed economy frameworks. A new area of literature has begun to look at international spillovers from financial shocks by extending open economy models to incorporate international linkages between investor's balance sheets (Paustian and Søndergaard (2010)). In a similar framework Dedola and Lombardo (2010) stress the importance of international spillovers through the equalization of credit spreads. However, few have examined the importance of the nature of the financial shock for international propagation channels and the impact on the real economy.

To examine these issues we extend Faia (2007)'s two country DSGE model with financial frictions to allow for shocks to the financial sector. The benefit of using a simple framework is that it allows us to explore the size and nature of international spillovers with clearly defined propagation channels and international linkages. We particularly focus on the propagation of credit spread shocks which are excluded from Faia's original analysis.

Financial frictions are introduced via a financial accelerator mechanism along the lines of Bernanke et al. (1999). Investors pay an external finance premium (EFP) to borrow funds from households via financial intermediaries. The cost of borrowing varies over the business cycle which means when the economy is hit by a negative shock the cost of borrowing increases. Krugman (2008) described the global diffusion of the recent financial crisis as evidence of an international financial multiplier at work. Borrowers highly exposed to foreign lenders were subject to collapsing asset values. Falls in asset values undermined their credit worthiness and reduced net worth restricting leveraged investors access to credit. Krugman (2008) suggests this had an impact on lending behavior in the foreign economy since it adversely affected foreign credit spreads and more general asset prices, with knock on consequences for real activity.

Collateral constraints, of the type introduced by Kiyotaki and Moore (1997), have also been used to capture financial accelerator effects in open economy DSGE models (Devereux and Yetman (2010)). Whilst these may be better suited to capture balance sheet effects associated with the process of financial deleveraging there is some new evidence to suggest a credit spread equalization channel is important in the propagation of financial shocks from one country to another which may be missed with collateral constraints (Dedola and Lombardo (2010)). In addition we are interested in finding a model which replicates data observations. l Brzoza-Brzezina et al. (2010) suggest EFP type constraints outperform collateral constraints in data, whereas collateral constraints deliver better co movement and qualitative results. For this reason we favor using an EFP to introduce financial frictions to our model.

Our paper introduces two types of credit spread shock. The first affects the elasticity of credit spreads with respect to the net worth of borrowers and the second affects financial agent's net worth directly. Few studies have looked explicitly at the impact of different shocks that affect credit spreads. Dedola and Lombardo (2010) and Christiano et al. (2010) examine the consequences of a shock to the elasticity of external financing which is equivalent to the first type of credit spread shock that we introduce to our model. They find significant and persistent effects on real variables from such shocks. In contrast, as far as we are aware, there are few studies which have looked at the impact of a shock which operates more directly via net worth. Considering the patterns of international propagation from such shocks is particularly interesting in the context of the current juncture, characterized by large and synchronized declines in asset prices and macroeconomic variables, driven by negative developments in financial markets. And in a time of significant changes to financial market regulations which may impact on the value of financial agents collateral thereby more directly affecting their net worth.

Results suggest that financial frictions magnify movements in international relative prices. In addition, external finance premium shocks can generate significant and persistent international spillovers. Crucially the international spillover depends on the way the credit spread shock is modeled. A "risk" shock to the dispersion of the productivity of entrepreneurs results in a shift in the foreign aggregate supply curve. A "net worth" shock to the survival probability of entrepreneurs generates a shift in the foreign aggregate demand curve.

In our model the labor supply response of foreign households plays a crucial role in the transmission of the shocks from one country to the other. A significant labor supply response of the foreign household to both a domestic productivity and "risk" shock drives output and consumption co-movement across countries. This resolves some of the well known output correlation puzzle seen in standard open economy models (see Backus et al. (1994)). However, the degree of output co-movement crucially depends on the strength of this channel. We find with a shock to the net worth this channel is less significant.

This paper is structured as follows: Section 2 contains an overview of the model and methodology while section 3 has the model simulations. Section 4 concludes.

2 Model and Methodology

The economy is a two-country, two traded good dynamic stochastic general equilibrium (DSGE) model. The Home (H) and Foreign (F) country are symmetric. Variables for the F country are denoted with an asterisk. There are 6 agents in each country: households, final good producers, intermediate producers, entrepreneurs, a financial intermediary and a central bank. As a result, the economy contains 10 markets. Each country contains markets that are in autarky, including a capital market where entrepreneurs supply capital to intermediate goods firms, a labor market where households work for the intermediate producers, an intermediate inputs market where intermediate producers supply inputs to final goods firms, and a market for loanable funds coordinated by a financial intermediary which obtains deposits from the households and extends loans to entrepreneurs. Entrepreneurs are not directly linked to the entrepreneurs and financial intermediaries in the other country. Our model contains the standard international linkages of open economy DSGE models. Final goods firms in each country produce and sell a continuum of domestic varieties to the households and entrepreneurs in both countries and households engage in international trade of risk-free real bonds denominated in foreign currency. The central bank acts mechanically according to a Taylor rule.

Our model contains inefficiencies which impact the markets for final goods, international bonds, capital and loanable funds. Final goods producers are monopolistically competitive and set prices in Calvo fashion. International risk free bonds are not perfectly mobile across countries because domestic households pay a premium when they purchase foreign currency bonds. The production of capital is subject to adjustment costs. The market for loanable funds is subject to asymmetric information between the borrower and the lender. This last inefficiency is not standard for New Keynesian open economy models because it introduces a financial friction which affects international spillovers in two ways. First, it provides a channel through which financial shocks spillover to the international real sector and second, it amplifies movements in international prices and net international flows.

2.1 Model

2.1.1 Household Problem

The household maximizes the expected discounted sum of utilities that it obtains from consumption and hours worked

$$\max E_t\{\sum_{i=0}^{\infty} \frac{C_{t+i}^{1-\sigma}}{1-\sigma} - \frac{H_{t+i}^{1+\phi}}{1+\phi}\}, \tag{1}$$

where β, is the discount factor, σ the parameter of risk aversion, ϕ is the Frisch elasticity of wages to labor supply, H_t is total hours and C_t is final goods consumption consumption basket. The utility function is continuous, differentiable, and separable in consumption and hours and increasing and concave in consumption and decreasing and convex in hours. The household faces the following nominal budget constraint

$$P_t C_t + D_t + P_t \frac{B_{h,t}^*}{e_t^r} \leq W_t H_t + R_{t-1}^n D_{t-1} + P_t R_{t-1}^F \frac{B_{h,t-1}^*}{e_t^r} + \Pi_t \tag{2}$$

The left hand side is household expenditure on consumption and saving in the form of nominal domestic deposits D_t and risk-free real foreign-currency bonds $B_{h,t}^*$. The international bonds are debt contract denominated in foreign currency that are signed between home and foreign households where one country is usually the lender and the other the borrower. The two countries are symmetric in everything but international bond trade. The debt contracts are denominated in foreign currency and due to exchange rate risk the home households have to pay a premium for trading them. The right hand side is the income households receive as a wage W_t from working hours N_t, as a nominal $R_{t-1}^n$from holding deposits D_{t-1} last period , as a real return $R_{t-1}^F$from investing in real international bonds $B_{h,t-1}^*$ last period, and dividend income from owning firms. The international bonds are converted into real domestic currency units by dividing by the real exchange rate, defined as the relative price of domestic consumption goods relative to foreign consumption goods:

$$e_t^r \equiv \frac{e_t P_t}{P_t^*} \tag{3}$$

The household maximizes the present value of its utility subject to its budget constraint in order to choose quantities

$\{C_t, B_t, D_t, H_t\}_{t=0}^{\infty}$. taking prices $\{P_t, R_t, R_t^n, W_t\}_{t=0}^{\infty}$ and the initial wealth endowments D_{t-1}, B_{t-1} as given. Its optimal conditions include equation (4), which is a labor supply condition equating the marginal rate of substitution between leisure and consumption to the real wage, equation (5), an Euler equation with respect to the nominal deposits and equation (6), an Euler equation with respect to the real international bonds

$$\frac{H_t^{\phi}}{C_t^{-\sigma}} = \frac{W_t}{P_t} \tag{4}$$

$$\beta E_t \frac{R_t^n}{P_{t+1}/P_t} \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} = 1 \tag{5}$$

$$\beta E_t (\frac{C_{t+1}}{C_t})^{-\sigma} (\frac{e_t^r}{e_{t+1}^r}) R_t^F = 1. \tag{6}$$

The first order conditions of the foreign household are identical, except for the optimality condition with respect to the foreign bond purchases which is:

$$\beta E_t (\frac{C_{t+1}^*}{C_t^*})^{-\sigma} R_t^* = 1. \tag{7}$$

Domestic households pay a spread between the interest rate on the foreign currency portfolio R_t^F and the foreign interest rate R_t^* which is an increasing function of the real value of its net foreign asset position $\frac{B_t^*}{e_t^r}$:

$$\frac{R_t^F}{R_t^*} = \exp(-pr(\frac{B_{h,t}^*}{e_t^r} - \frac{B_h^*}{e^r})) \tag{8}$$

This spread may reflect a country specific risk or imperfect international capital mobility. It is necessary in order to achieve a stable steady state and ensure that the net foreign asset position is a stationary variable. A necessary condition that ensures that the uncovered interest parity holds is that:

$$E_t\{(\frac{C_{t+1}}{C_t})^{-\sigma} (\frac{e_t^r}{e_{t+1}^r}) \exp(-pr(\frac{B_{h,t}^*}{e_t^r} - \frac{B_h^*}{e^r}))\} = E_t\{(\frac{C_{t+1}^*}{C_t^*})^{-\sigma} R_t^*\} \tag{9}$$

The household at home consumes a basket of the two traded goods

$$C_t = [(1-\gamma)^{\frac{1}{a}} C_{f,t}^{\frac{a-1}{a}} + \gamma^{\frac{1}{a}} C_{h,t}^{\frac{a-1}{a}}]^{\frac{a}{a-1}} \tag{10}$$

$C_{h,t}$ and $C_{f,t}$ are the amounts of the domestic good and imported foreign good that the household consumes. γ is the home bias parameter that determines the share of domestic goods in the consumption basket and a is the elasticity of substitution between the two goods. The expenditure minimization problem of the domestic household implies a demand for domestic goods $X_h, t = \gamma(\frac{P_{h,t}}{P_t})^{-a} X_t$, a demand for imports $X_{f,t} = (1-\gamma)(\frac{P_{f,t}}{P_t})^{-a} X_t$, and a consumer price index $P_t = [(1-\gamma)(P_{f,t})^{1-a} + \gamma(P_{h,t})^{1-a}]^{\frac{1}{1-a}}$. Foreign households have an identical set of conditions, including $X_{f,t}^* = \gamma^*(\frac{P_{f,t}^*}{P_t^*})^{-a} X_t^*$, $X_{h,t}^* = (1-\gamma^*)(\frac{P_{h,t}^*}{P_t^*})^{-a} X_t^*$ and $P_t^* = [\gamma^*(P_{f,t}^*)^{1-a} + (1-\gamma^*)(P_{h,t}^*)^{1-a}]^{\frac{1}{1-a}}$ which are domestic demand, demand for imports and CPI, respectively.

2.1.2 Producers

There are several stages of production in each country. Intermediate firms use labor and capital in order to produce an identical input which final producers differentiate at no cost to obtain a tradable final good that can be sold to households for consumption and to entrepreneurs for consumption or investment in capital.

Intermediate Producers Intermediate producers rent capital K_t from entrepreneurs at a rental rate R_t^k and hire labor N_t at a nominal wage W_t in order to produce an intermediate good Y_t^w and sell it at a price P_t^w. The labor that the intermediate firms employ is a function of hours H_t worked by the household and hours H_t^e worked by the entrepreneur:

$$N_t = (H_t^e)^{1-\eta} (H_t)^{\eta}, \tag{11}$$

where η is the fraction of household labor used by the intermediate firms. They use a constant returns to scale technology:

$$Y_t^w = A_t {K_t}^{\alpha} {N_t}^{1-\alpha} \tag{12}$$

where A_t is TFP shock which follows an AR(1) process with persistence parameter ρ_A and standard deviation σ_A. Intermediate producers operate in a perfectly competitive environment in which profit maximization implies the following capital and labor demand optimal conditions:

$$\frac{R_t^k}{P_{h,t}} = \frac{P_t^w}{P_{h,t}} \alpha (\frac{Y_t}{K_t}) \tag{13}$$

$$\frac{W_t}{P_{h,t}} = \frac{P_t^w}{P_{h,t}} \eta (1-\alpha) (\frac{Y_t}{H_t}) \tag{14}$$

$$\frac{W_t^e}{P_{h,t}} = \frac{P_t^w}{P_{h,t}} (1-\eta)(1-\alpha) \frac{Y_t}{H_t^e} \tag{15}$$

We assume that the entrepreneurs supply labor inelastically and normalize the total amount of labor that the entrepreneur is supplying H_t^e to one. This implies that $N_t = (H_t)^{\eta}$ In the calibrations below we keep the share of income going to entrepreneurial labor small (on the order of .01), so that this modification of the standard production function does not have significant direct effects on the results.

Final good producers Final goods producers operate in monopolistically competitive environment and set their prices in Calvo fashion. Each period only a fraction $1-\omega$ of producers are allowed to adjust prices. The optimization problem is standard and delivers the following rule for the optimal price:

$$P_{h,t}^o(i) = \frac{b}{(b-1)} E_t \frac{\sum_{i=0}^{\infty} \omega^i \beta^i C_{t+i}^{-\sigma} P_{t+i}^w (P_{h,t+i})^b (X_{ht+i} + X_{ht+i}^*)}{\sum_{i=0}^{\infty} \omega^i \beta^i C_{t+i}^{-\sigma} (P_{h,t+i})^b (X_{ht+i} + X_{ht+i}^*)} \tag{16}$$

Note that each firm produces a different variety which enters the consumption function as a domestic composite good which is symmetric for H and F

$$X_{ht} = (\int_0^1 X_{ht}(i)^{\frac{b-1}{b}})^{\frac{b}{b-1}} \tag{17}$$

$X_{ht}(i) = C_{ht}(i) + C_{ht}^e(i) + I_{ht}(i)$ is the total demand for variety i for household and entrepreneurial consumption and investment. b is the elasticity of substitution between varieties. This implies the following demand function for each variety:

$$X_{ht}(i) = (\frac{P_{h,t}(i)}{P_{h,t}})^{-b} X_{ht} \tag{18}$$

where the domestic producer price index.

$$P_{h,t} = (\int_0^1 P_{h,t}^{1-b}(i))^{1-b} \tag{19}$$

An identical set of equations applies to Foreign. The law of one price holds for each variety

$$P^*_{h,t}(i) = e_t P_{h,t}(i) \tag{20}$$

which can be aggregated to a similar conditions which hold for the home and the foreign good sectors, $P^*_{h,t} = e_t P_{h,t}$ and $P^*_{f,t} = e_t P_{f,t}$.

2.1.3 Entrepreneurs

There are a continuum of entrepreneurs indexed by j who act as financial agents. Each period they rent out capital to intermediate firms at a rate R^k_t and finance the production of new capital $K_t(j)$ by buying investment goods at price Q_t.Each period a random and time varying fraction of entrepreneurs exits the market, denoted by $1 - s_t\chi$ and an equal fraction enters. s_t is a financial shock that follows an AR(1) process with a persistence parameter ρ_s and a standard deviation σ_s. A positive shock increases the survival probability of the entrepreneurs. With a survival probability lower than one, entrepreneurs face a fixed horizon problem, which reduces their effective discount factor, making them more impatient and ensures that they do not accumulate enough wealth to become fully self-financing. Entrepreneurs also work and receive a wage W^e_t from the intermediate firms. This wage guarantees that entrepreneurs always have enough resources to finance capital production and the economy never stops producing. Entrepreneurs finance capital production partly with their own financial wealth $NW_t(j)$ and partly with loans $L_t(j)$ from a bank.

$$L_t(j) = Q_t K_t(j) - NW_t(j) \tag{21}$$

Each entrepreneur is a subject to an idiosyncratic productivity shock which converts his capital to $a_{e,t}(j)K_t(j)$, where $a_{e,t}$ is a random variable, distributed independently across time and across entrepreneurs with a cumulative density function $F(a_{e,t}(j))$. It follows log normal distribution with a zero mean and a time varying standard deviation $f_t\sigma_{a^e}$. f_t is a second financial shock which follows an AR(1) process with persistence ρ_f and standard deviation σ_f. This shock preserves the average productivity across entrepreneurs but changes the dispersion of productivity distribution. A positive realization makes the tails of the a_e distributions fatter and increases the number of entrepreneurs with very low and very high productivity. Entrepreneurs observe the realization of their productivity before deciding how much capital to produce. They produce capital subject to a depreciation rate δ and capital adjustment costs:

$$K_t = (1-\delta)K_{t-1} + I_t - \frac{\Phi}{2}(\frac{I_t}{K_{t-1}} - \delta)^2 K_{t-1} \tag{22}$$

This set up implies the following optimal conditions that determine the price of capital and ex-post return to capital:

$$Q_t = (1 - \Phi(\frac{I_t}{K_t} - \delta))^{-1} \tag{23}$$

$$R^e_t \equiv \frac{Q_t(1-\delta) + \frac{R^k_t}{P_t}}{Q_{t-1}} \tag{24}$$

where the rate of return of an individual entrepreneur is $a_{et}(j)R_{et}$.

2.1.4 Financial Intermediary and Optimal Contract

An asymmetric information problem arises between the bank and entrepreneur because the idiosyncratic productivity shock a_e is privately observed by the entrepreneurs. The bank has to pay a monitoring cost μK_t to observe the shock. The asymmetric information creates a moral hazard problem because the entrepreneur has the incentive to misreport the

true value of a_e in order to borrow at a lower rate. The bank and the entrepreneur face a principal agent problem which delivers the conditions for the optimal contract between two parties. The optimal financial contract lasts one period and is renegotiated every period. It is affected by the business cycle through the net worth NW_t and the price of capital Q_t and treats these two variables as given. Its purpose is to eliminate the moral hazard problem and ensure that the entrepreneurs always report their productivity level truthfully. Both the capital production technology and the monitoring technology are linear and have constant returns to scale, which means that the marginal costs are constant and makes aggregation possible. The entrepreneurs net worth is sufficiently small in order to make external financing necessary. Then, the contract is risky debt.The contract can be described in terms of the amount of produced capital and the cut-off level of productivity at which entrepreneurs start to default. The entrepreneurs default if the productivity shock is lower than their return on capital $Q_{t-1}R_t^e a_t^e K_t < R_t^L(Q_t K_t - NW_t)$ or if their productivity is lower than some cut-off productivity level $\bar{a}_{t+1}^e$, defined as

$$\bar{a}_{t+1}^e = \frac{R_{t+1}^L(Q_t K_t - NW_t)}{R_{t+1}^e Q_t K_t} \tag{25}$$

The bank monitors the project only if the entrepreneurs default, in which case it seizes all the returns. The net entrepreneurial income is the expected return on capital $\int_{\bar{a}_{t+1}^e}^{\infty}[R_{t+1}^e Q_t K_t a_{et+1}]dF(a_{et+1})$ less the amount of loan repayment $\int_{\bar{a}_t^e}^{\infty} R_{t+1}^L L_t dF(a_{et+1})$ Substituting from the condition for the cutoff productivity level, the net share of income attributed to the entrepreneur is

$$\Gamma_{t+1} R_{t+1}^e Q_t K_t \tag{26}$$

where $\Gamma_t = [1 - \int_0^{\bar{a}_{t+1}^e} a_{et+1} dF(a_{et+1}) - \bar{a}_{t+1}^e(1 - \int_0^{\bar{a}_{t+1}^e} dF(a_{et+1}))]$ is the fraction of expected net capital received by the entrepreneurs The expected net income of the lender on such contract is

$$\Omega_{t+1} R_{t+1}^e Q_t K_t \tag{27}$$

where $\Omega_{t+1} = [(1-\mu)\int_0^{\bar{a}_{t+1}^e} a_{et+1} dF(a_{et+1}) + \bar{a}_{t+1}^e(1 - \int_0^{\bar{a}_{t+1}^e} dF(a_{et+1}))]$ is the fraction of net capital received by the Bank. The sum of the two fractions is lower than one $\Gamma_{t+1} + \Omega_{t+1} = 1 - \mu \int_0^{\bar{a}_{t+1}^e} a_{et+1} dF(a_{et+1})$, so that on average $\mu \int_0^{\bar{a}_{t+1}^e} a_{et+1} dF(a_{et+1})$ of the capital is destroyed by monitoring and the rest is split between the borrower and the lender. The zero profit condition for the lender implies that the return from lending to the entrepreneurs has to be equal to the cost of raising loanable funds which is the *real* deposit rate

$$\int_{\bar{a}_t^e}^{\infty} R_{t+1}^L L_t dF(a_{et+1})) + (1-\mu)\int_0^{\bar{a}_{t+1}^e}[R_{t+1}^e Q_t K_t a_{et+1}]dF(a_{et+1}) \geq \left(\frac{R_t^n}{1+E_t\pi_{t+1}}\right) L_t$$

We can rewrite it as

$$\Omega_{t+1} R_{t+1}^e Q_t K_t \geq \left(\frac{R_t^n}{1+E_t\pi_{t+1}}\right)(Q_t K_t - NW_t) \tag{28}$$

The optimal contract specifies a pair of $\{\bar{a}_{t+1}^e, K_{t+1}\}$ which maximizes the entrepreneur's expected return subject to the zero profit conditions which is effectively the participation constraint for the bank. Define the external finance premium efp_t as the spread between the gross return to the entrepreneurs and the risk free real interest rate

$$efp_t \equiv E_t\left[\frac{R_{t+1}^e}{\left(\frac{R_t^n}{1+E_t\pi_{t+1}}\right)}\right] \tag{29}$$

The optimal contract problem implies that the EFP is an increasing function of the monitoring cost and cut-off productivity level:

$$efp_t = \frac{1}{(\Omega_{t+1} - \frac{\Omega'_{t+1}}{\Gamma'_{t+1}}\Gamma_{t+1})} \tag{30}$$

Define the τ_t as the leverage ratio of entrepreneurial assets to net worth:

$$\tau_t \equiv \frac{Q_t K_t}{NW_t} \tag{31}$$

Combining equations (30) and (31) delivers a condition which shows that the EFP is an increasing function of the leverage ratio and, hence, a decreasing function of the net worth of the entrepreneurs:

$$efp_t = -v_{t+1}\frac{1}{\tau_t} \tag{32}$$

where $v_{t+1} = \frac{1}{\Gamma_{t+1}}\frac{\Gamma'_{t+1}}{\Omega'_{t+1}}$ is the elasticity of the external finance premium with respect to the leverage ratio. This elasticity is a decreasing function of the default probability of the entrepreneurs. If a positive shock hits the standard deviation of the productivity distribution of entrepreneurs, the distribution will become more dispersed with fatter tails and the likelihood of default perceived by the banks will rise. The banks will become more inelastic in their willingness to extend a loan for a given level of net worth.

Define V_t as the the net capital gain that the entrepreneurs obtain from investing in capital:

$$V_t = R^e_t Q_{t-1}K_{t-1} - \left(\frac{R^n_{t-1}}{1+\pi_t}\right) efp_{t-1}\left(Q_{t-1}K_{t-1} - NW_{t-1}\right) \tag{33}$$

Then the net worth at the end of period t is a sum of the net capital gain of the entrepreneurs who survive plus the wage received by all the entrepreneurs:

$$NW_t = s_t\chi V_t + \frac{W^e_t}{P_t} \tag{34}$$

The fraction of entrepreneurs who die consume their net capital gain:

$$C^e_t = (1 - s_t\chi)V_t \tag{35}$$

A shock s_t that lowers the fraction of surviving entrepreneurs would decrease the aggregate net worth in the economy but would also raise aggregate consumption because a larger fraction of entrepreneurs consume instead of investing in capital.

2.1.5 Monetary Policy

Monetary policy is conducted based on Taylor rules which target inflation and output growth and contains an interest rate smoothing term and allows for interest rate smoothing term:

$$\frac{R^n_t}{R^n} = \left(\frac{R^n_{t-1}}{R^n}\right)^{\gamma_r}\left[\left(\frac{1+\pi_t}{1+\pi}\right)^{\gamma_\pi}\left(\frac{Y_t}{Y_{t-1}}\right)^{\gamma_y}\right]^{1-\gamma_r} \tag{36}$$

where γ_r is the persistence of nominal interest rate changes and γ_π and γ_y are the weights that the central bank puts on inflation and output volatility. An identical condition describes the monetary policy of the foreign country

2.1.6 Market Clearing

Net trade in international bonds must be zero in equilibrium which implies

$$B^*_{ft} + \frac{B^*_{ht}}{e^r_t} = 0 \tag{37}$$

Market clearing conditions for the home final good and the foreign final good imply the following pair of resource constraints:

$$X_{h,t} + X^*_{ht} + \mu \int_0^{\bar{a}^e_t} a_{et} dF(a_{et}) Q_{t-1} R^e_t K_{t-1} = Y_t \tag{38}$$

$$X_{f,t} + X^*_{ft} + \mu^* \int_0^{\bar{a}^{*e}_t} a^*_{et} dF(a^*_{et}) Q^*_{t-1} R^{*e}_t K^*_{t-1} = Y^*_t \tag{39}$$

Market clearing of the loanable fund market requires that the real quantity of deposits equals the volume of loans, both at Home$\frac{D_t}{P_t} = L_t$,and at Foreign $\frac{D^*_t}{P^*_t} = L^*_t$.

2.2 Methodology

2.2.1 Calibration

Most parameters are calibrated based on Faia (2007). The values of the structural parameters are reported in table 1. There are some parameters that are calibrated differently and some parameters that are new. Our set up differs slightly from Faia's because the entrepreneurs in our economy work and receive a wage. We will assume that the fraction of hours η of entrepreneurial labor in total labor employed by intermediate firms is 1%, a value taken from Bernanke et al. (1999). We assume a lower survival probability of entrepreneurs χ 0.95 because it lowers the persistence of our impulse responses to very persistent shocks. This does not alter the dynamics and allows us to report impulse responses more clearly and over a shorter time horizon. The elasticity of the international spread with respect to the net foreign asset position is 1% which is in accordance with estimates ofLane and Milesi-Ferretti (2004).

We assume that the Calvo fraction of firms allowed to adjust prices every period is 0.6. The persistence and the standard deviations of the financial shocks are calibrated based onl Brzoza-Brzezina et al. (2010) who perform a similar exercise but in a closed economy setting.

2.2.2 Steady state and linearization

The steady state values that we use in our simulations are reported in table 2. The nonlinear model is log-linearized around the deterministic steady state up to the first order. The first order linearization does not detract from the dynamic analysis of responses to financial shocks because the financial accelerator mechanism creates first order effects which spillover from the external finance premium to the net worth of entrepreneurs, hence from the financial to the real sector of the economy. The list of equations describing the log-linear version of the model can be found in the appendix.

3 Results

3.1 International transmission mechanism

3.1.1 Productivity shock

Before looking at the effects of financial shocks, we examine how financial frictions alter the international transmission mechanism observed in standard open economy DSGE models. In similar frameworks, Gilchrist (2003) and Faia (2007)

find that the presence of a financial accelerator help to resolve the well known output co movement puzzle and increase business cycle synchronization. Financial frictions do this by amplifying the international spillovers which increase co movement and dampens those that decrease it.

Figures 2a-d report the impulse responses to a one standard deviation negative productivity shock in the home country. We focus first on the black line simulations which show the responses with financial frictions turned off in our model. As expected a negative productivity shock at home shifts the home aggregate supply curve left which results in a fall in output and a rise in inflation. The fall in wealth, associated with the fall in output, reduces investment and consumption spending.

In our model the international transmission mechanism is dominated by movement in the terms of trade which means the home productivity shock spills over to the foreign country as a negative aggregate supply shock. Foreign output falls and inflation rises (Figure 2C). Foreign investment and consumption also fall due to the fall in wealth. The foreign supply curve shifts left, like the home country, because of the effect the movement in the terms of trade has on the relative price of factors of production in the foreign country.

The behavior of the markets for factors of production is critical for understanding the international transmission mechanism in our model. Both capital and labor markets are experiencing simultaneous shifts in demand and supply. Figure 2A shows that the factor markets in the home country are dominated by supply side shocks, as prices and quantities are moving in different directions. The fall in investment indicates that capital supply shifts left resulting in an increase in the rental rate and a fall in the stock of capital. The fall in consumption raises the relative price of leisure which via a substitution effect leads to a rightward shift in labor supply resulting in a rise in the hours worked and a fall in the real wage. Figure 2C indicates that foreign factor markets are dominated by demand side shocks because factor prices and quantities are moving in the same direction. These shifts are driven by the increase in the terms of trade (Figure 2B) that makes foreign goods relatively less valuable. As a result, the value of the marginal products of capital and labor falls and the demands for both foreign factors of production shift left. Figure 2C shows that the negative labor demand shift results in a fall in labor hours and the real wage while the negative capital demand shift leads to a fall in the foreign rental rate and stock of capital.

The introduction of the financial accelerator dampens the response of output in the home country while it increases the response of output in the foreign country. The more subdued fall in the home country is mainly due to a smaller fall in capital. The financial accelerator mechanism is associated with a more inelastic capital supply as the rental rate of capital becomes more responsive to changes in the level of capital. This explains why movements in the rental rate of capital are amplified and movements in the capital stock are dampened. Less fluctuations in capital imply dampened movements in investment and output.

The presence of financial frictions amplifies the international transmission mechanism because it increases the movements in international prices. Figure 2B shows that the impact on the terms of trade and the real exchange rate is larger. Since domestic demand has a more muted response due to the presence of financial frictions, home imports fall by less and more of the adjustment happens through a rise in international prices. This in turn amplifies the terms of trade effect that lowers the value of the marginal products of labor and capital in the foreign country. As a result, the shift in labor demand in the foreign economy is greater and both the real wage and labor fall by a greater amount. As financial frictions lower the elasticity of capital supply, fluctuations in the foreign rental rate are amplified while the change in the capital stock is dampened. However, lower demand for capital reduces the price of capital which lowers foreign net worth and raises the foreign external finance premium. A higher premium raises the cost of borrowing and further reduces investment and output. Thus, the shift in the foreign aggregate supply curve is larger with financial frictions because the international terms of trade effect is magnified by the presence of the financial accelerator mechanism.

3.1.2 Financial shocks

Shock to elasticity of the external finance premium Figure 3 illustrates the positive relationship between the leverage ratio and the external finance premium generated by the introduction of a financial accelerator mechanism. The first credit spread shock that we introduce is an increase to the volatility of the productivity distribution of entrepreneurs which makes the curve in Figure 3 pivot anti clockwise. This means for a given leverage ratio the external finance premium is higher. This is because the shock to the volatility of the productivity distribution of entrepreneurs increases the banks perception of the probability of default and increases the level of productivity required for banks to lend since they are less willing to monitor entrepreneurs. We call it a "risk" shock because it increases the default risk of financial agents. The shock that we introduce to the dispersion of entrepreneurs is calibrated so that it results in a one standard deviation shock to the credit spread; it raises the credit spread proportionately by 0.0011. The actual spread increases from around 1.003 in steady state to 1.004.

Figures 4a-d display the impulse responses to this shock. We focus first on the impact on the domestic economy. As expected we find a strong financial multiplier effect which operates mainly through the capital market. The shock acts to reduce capital and investment because credit conditions tighten as the external finance premium charged by domestic financial intermediaries is rising. This reduces the quantity of capital demanded and lowers its price. Domestic entrepreneurs leverage ratios fall because the cost of purchasing capital is falling and net worth is rising. Over time the excess returns required by banks help to increase the net worth of entrepreneurs so the shock to the external finance premium falls as both the leverage ratio declines and the shock begins to unwind. There is a reduction in domestic aggregate demand because the fall in investment is large and outweighs a shift towards higher consumption by domestic entrepreneurs and households. Entrepreneurs consumption is rising as their net worth increases and household consumption is rising because real interest rates are falling. The reduction in demand acts to reduce costs and therefore domestic and CPI inflation which the policy maker reacts to by reducing real rates.

What are the spillover effects to the second country? Our results suggest that the international transmission is dominated by changes in the terms of trade. There is terms of trade appreciation since domestic prices fall by less than foreign prices denominated in domestic currency. This means there is a real appreciation of the domestic currency and a substitution of demand away from domestic goods towards foreign goods. As a result the foreign economy benefits from traditional expenditure switching effects and domestic net exports fall. These increase demand for foreign output over time.

But there is output co-movement across the two countries in the first few periods. This is because the appreciation of the terms of trade is having an effect on supply in the foreign economy. The appreciation of the terms of trade lowers the real output value of the marginal products of foreign capital and labor in terms of domestic output. As a result the demands for foreign capital and labor fall and overall foreign output falls. This fall in output has knock on consequences for foreign consumption and investment spending.

However, we find little evidence of co-movement between cross country financial variables. There is a muted response of the foreign external finance premium and correspondingly small response erosion of foreign capital in comparison to the domestic responses. There is also little evidence of co-movement across financial variables as the external finance premium is falling in the foreign economy compared to the rise in the external finance premium in the domestic economy. So in our framework the main international spillover seems to be dominated by the effects of movements in the terms of trade.

Shock to the survival probability of entrepreneurs The second credit spread shock that we introduce is a negative shock to the survival rate of domestic entrepreneurs. The spillover effects of this shock are mainly driven by changes to the net worth of domestic financial agents. The fall in the fraction of surviving entrepreneurs lowers aggregate net worth because entrepreneurs become more impatient and choose to consume more today given the higher probability that they will not survive to the next period. Therefore this type of shock acts like a "net worth" shock which provides an interesting comparison to our "risk" shock. We are now able to compare whether different types of credit spread shocks have different

real economy spillovers in our framework.

Figures 5a-d report the impulse responses to this type of shock. The shock to the survival rate of domestic entrepreneurs acts to reduce domestic investment and capital. Entrepreneurs falling net worth has two direct effects; first it leads to an increase in the external finance premium, second it increases the leverage ratio of borrowers. Over time there is a fall in the price of capital because the demand for investment goods is falling and net worth rises as the shock dies away both of these helps to reduce the external finance premium. Unlike the "risk" shock, here the fall in investment is outweighed by the rise in entrepreneurs consumption. This means that in the first few periods following the shock there is a rise in domestic output and inflation driven by the increase in overall aggregate demand. Consumption by the financial agent crowds out households consumption but domestic households increase their supply of labor because the rise in consumption means the price of leisure is higher which means output rises to meet increased demand from domestic entrepreneurs. Essentially since dying entrepreneurs demand more final goods the aggregate demand curve shifts right and home inflation rises.

The international spillovers are similar to the "risk" shock which highlights the importance of the terms of trade on international spillovers. There is terms of trade appreciation because the rise in domestic inflation is greater than the rise in foreign inflation. This means there is a real exchange rate appreciation of the domestic currency and expenditure switching towards the foreign economy. So domestic net exports fall and these act like a positive demand shock for the foreign economy where output and inflation rise.

There is also not much evidence of co-movement across financial variables with the shock to the survival rate of entrepreneurs. The response of foreign financial variables to the domestic financial shock as muted and there is a fall in the external finance premium in the foreign economy whilst it is rising in the domestic economy.

Comparison of financial shocks The impact of the survival probability shock is not only different in direction but also in magnitude. Figures 6a-d show the relative impulse responses to the two financial shocks where the impulse responses of the variables are scaled by the standard deviation of each shock. The impact of the survival probability shock is significantly larger and lasts longer than the impact of the external finance premium shock. This is true in both countries. These suggest that a "net worth" shock might be more important for international business cycle fluctuations than a "risk" shock.

4 Conclusion

We build a two-country DSGE model with a financial accelerator in order to analyze international spillovers from credit spread shocks originating in the foreign country. We find that the international transmission mechanism is amplified by the presence of financial frictions because movements in international prices are larger. We look at the international spillovers of two types of credit spread shocks, a "risk" shock and "net worth" shock. Our results indicate that the international spillovers resulting from the two types of shocks are significant and persistent but differ both qualitatively and quantitatively. A shock that raises the riskiness of entrepreneurs raises the credit spread and results in negative aggregate demand shift in the home economy due to a fall in investment spending. The spillover to the foreign economy is in the form of a rising terms of trade that lowers the relative values of the marginal products of capital and labor, induces a negative shift in capital and labor demand and leads to a leftward shift in the foreign aggregate supply curve. A shock that lowers the fraction of surviving entrepreneurs leads to a fall in the quantity of home net worth and a fall in consumption and investment spending. However, it results in a higher fraction of entrepreneurs consuming and shifts the aggregate demand curve to the right. The spillover to the foreign country is in the form of a rising terms of trade that makes foreign goods relatively cheaper and leads to a rightward shift in the foreign aggregate demand curve. The impacts of the two shocks also differ in magnitude. A "net worth" shock has a relatively larger impact than a "risk" shock. Our findings imply that shocks to the net financial wealth contribute more to international business cycle fluctuations than "risk" shocks.

Our short-term agenda is to extend our model in a way that helps think about international financial contagion. Currently, the entrepreneurs' balance sheets are not exposed to foreign financial assets or liabilities. The financial shocks spill over to the foreign country only through standard trade channels. We intend to add an international financial channel and see whether it enhances international spillovers. We plan to open the balance sheets of entrepreneurs in a number of ways and analyze how international spillovers change. We aim to compare how different types of financial exposure affect international spillovers. The exposure could be on the liabilities side by allowing entrepreneurs to borrow from a foreign bank, or it could be on the asset side by letting the entrepreneurs rent out capital to foreign intermediate firms.

5 Tables and Figures

5.1 Table 1 Calibration of structural parameters

Parameter	**Description**	**Baseline Value**
γ	Home Bias	0.7
ε	Substitution elasticity of varieties	6
ϕ	Inverse of Frisch labor supply elasticity	0.33
β	Discount factor	0.99
δ	Depreciation rate	0.025
α	Capital share in production	0.35
η	Entrepreneurial share in total hours	0.01
ε_{ik}	Elasticity of capital price to investment capital ratio	0.25
pr	Elasticity of foreign bond spread	0.01
χ	Survival probability	0.95
μ	Monitoring cost	0.12
σ_{a^e}	Volatility of E shock	0.28
υ	Elasticity of EFP to leverage ratio	0.05
a	Elasticity of substitution between home and foreign goods	1.5
ω	Fraction of firms not allowed to adjust every period	0.6
ϖ	Sensitivity parameter of ν to σ_{a^e}	0.12
γ_{r^n}	Persistence of nominal interest rate in monetary rule	0.8
γ_π	Weight on inflation	1.5
γ_y	Weight on output	0.5
ρ_A	Persistence of productivity shock	0.9
ρ_f	Persistence of financial shock to E riskiness	0.83
ρ_s	Persistence of survival probability shock	0.84
σ_A	Standard deviation of productivity shock	0.008
σ_f	Standard deviation of E productivity distributions shock	0.012
σ_s	Standard deviation of the survival probability shock	0.06

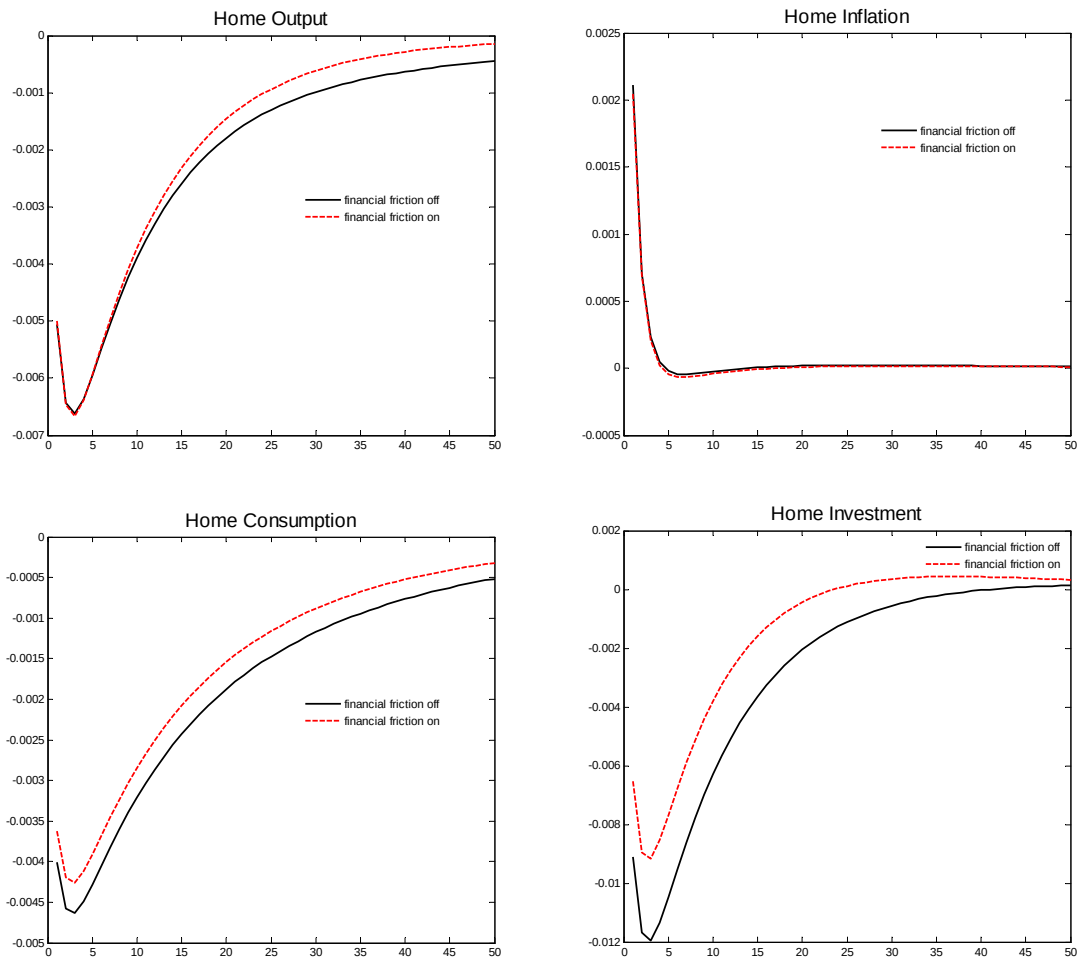
5.2 Table 2 Calibration of steady state values

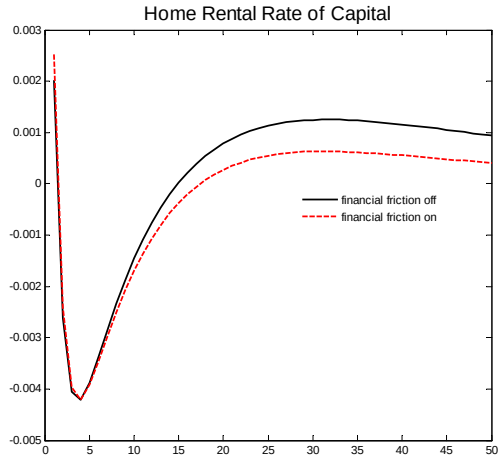
Steady State Variable	Description	Value
$\frac{B^*}{e^r}$	Net foreign asset position	0
Y	Output	1
X	Aggregate demand	1
R^F	Gross real interest rate on foreign bonds	1.01
K	Capital stock	7.116
N	Labor	0.348
I	Investment	0.178
$\frac{R^k}{P}$	Rental rate on capital	0.0381
$\frac{W}{P}$	Real wage	1.8699
R^e	Entrepreneurial return on capital	1.0131
τ	Leverage ratio	2.1
NW	Net worth	3.3886
L	Real value of loans	3.7274
$\frac{D}{P}$	Real value of deposits	3.7274
C	Consumption	0.768
C^e	Entrepreneurial consumption	0.0541
W^e	Wage of entrepreneurs	0.0065
e^r	Real exchange rate	1
TOT	Terms of trade	1
a^e	Cut-off productivity of entrepreneurs	0.52

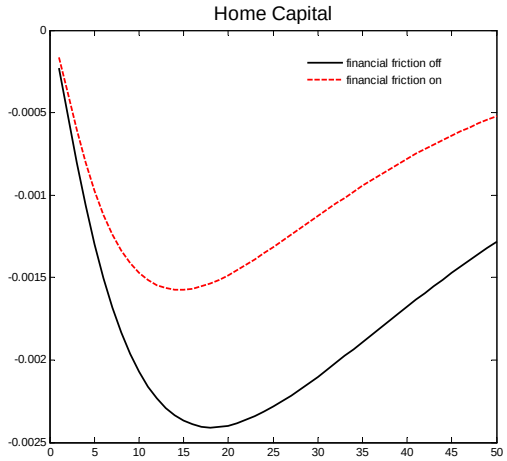
5.3 Figure 1 Diagram of international financial linkages in the model

5.4 Figure 2 Impulse responses to a one standard deviation negative productivity shock in the home country

Figure 2A




Home Rental Rate of Capital
financial friction off
financial friction on


Home Capital
financial friction off
financial friction on

Home Real Wage
financial friction off
financial friction on

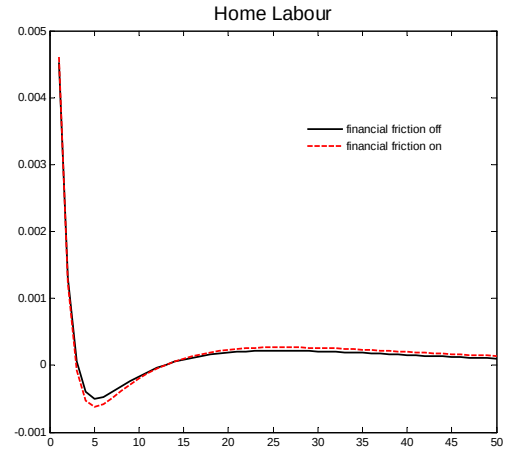

Home Labour
financial friction off
financial friction on

Figure 2B

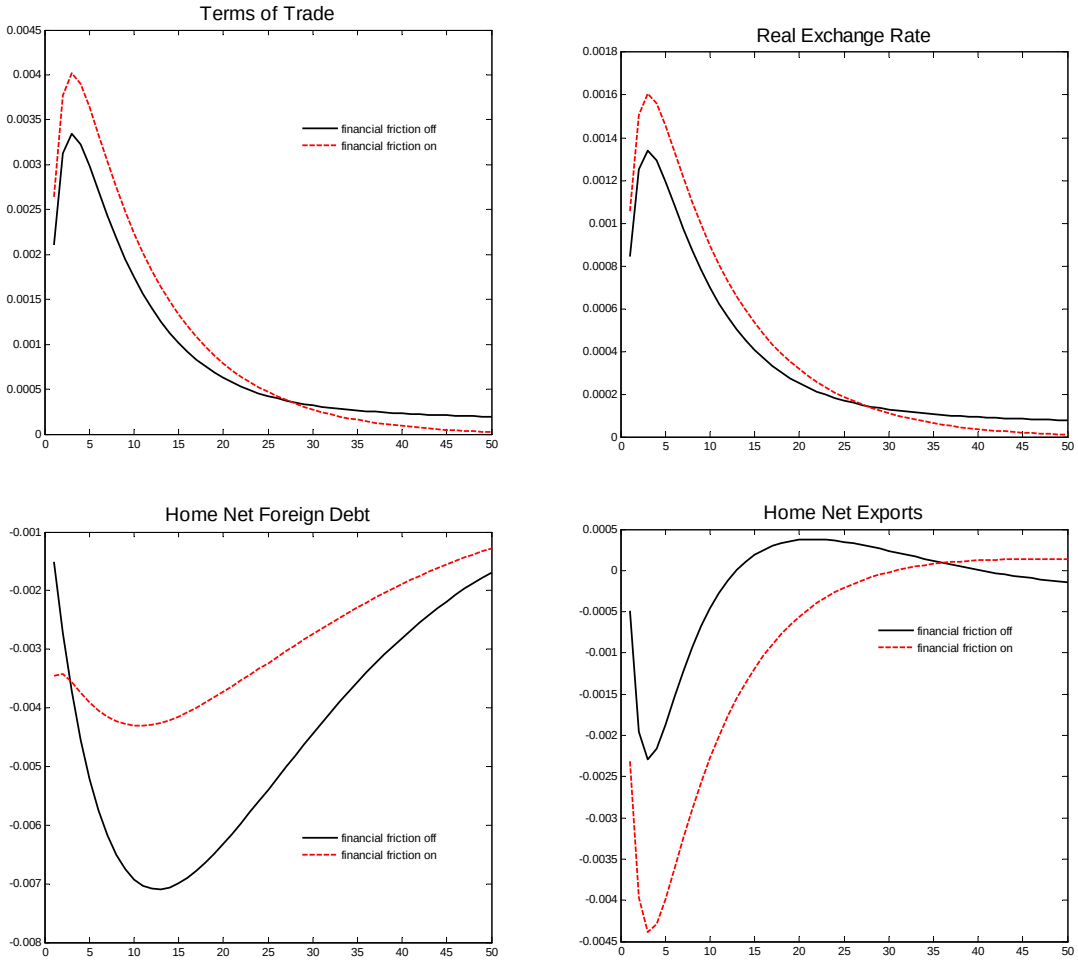
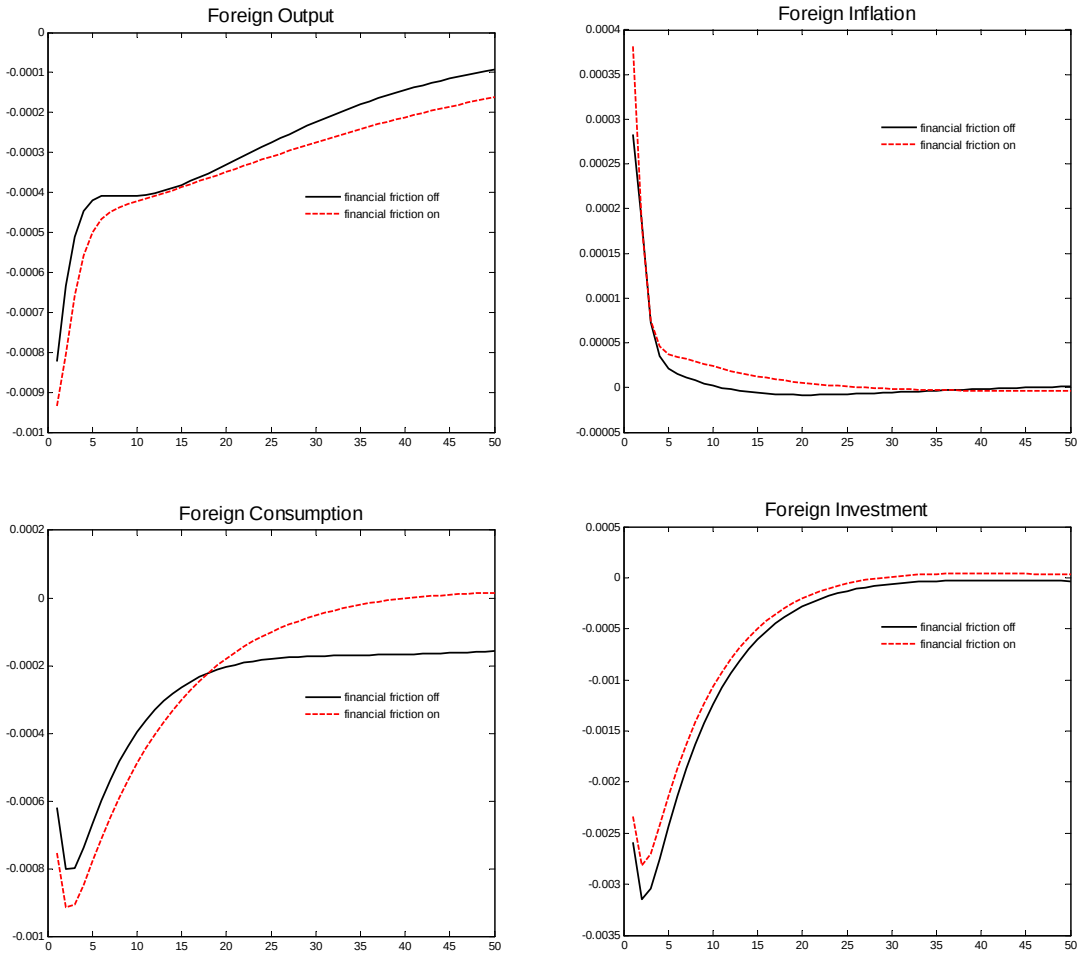
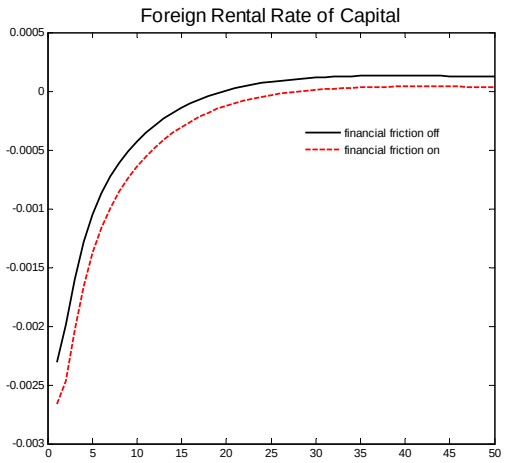
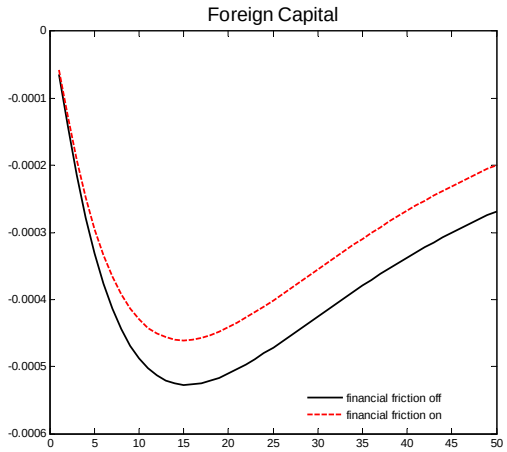
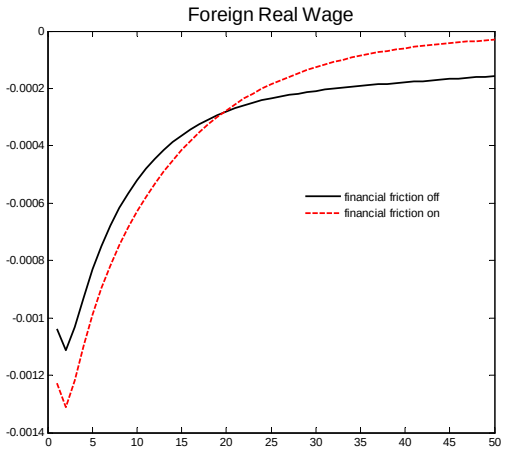

Terms of Trade
financial friction off
financial friction on
Real Exchange Rate
Home Net Foreign Debt
financial friction off
financial friction on
Home Net Exports
financial friction off
financial friction on

Figure 2C


Foreign Output
financial friction off
financial friction on
Foreign Inflation
financial friction off
financial friction on
Foreign Consumption
financial friction off
financial friction on
Foreign Investment
financial friction off
financial friction on


Foreign Rental Rate of Capital
financial friction off
financial friction on


Foreign Capital
financial friction off
financial friction on


Foreign Real Wage
financial friction off
financial friction on

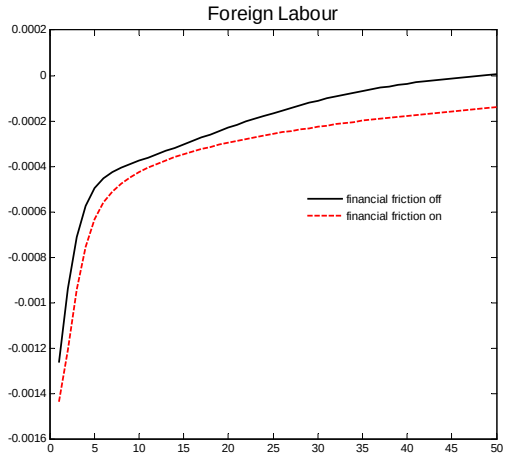
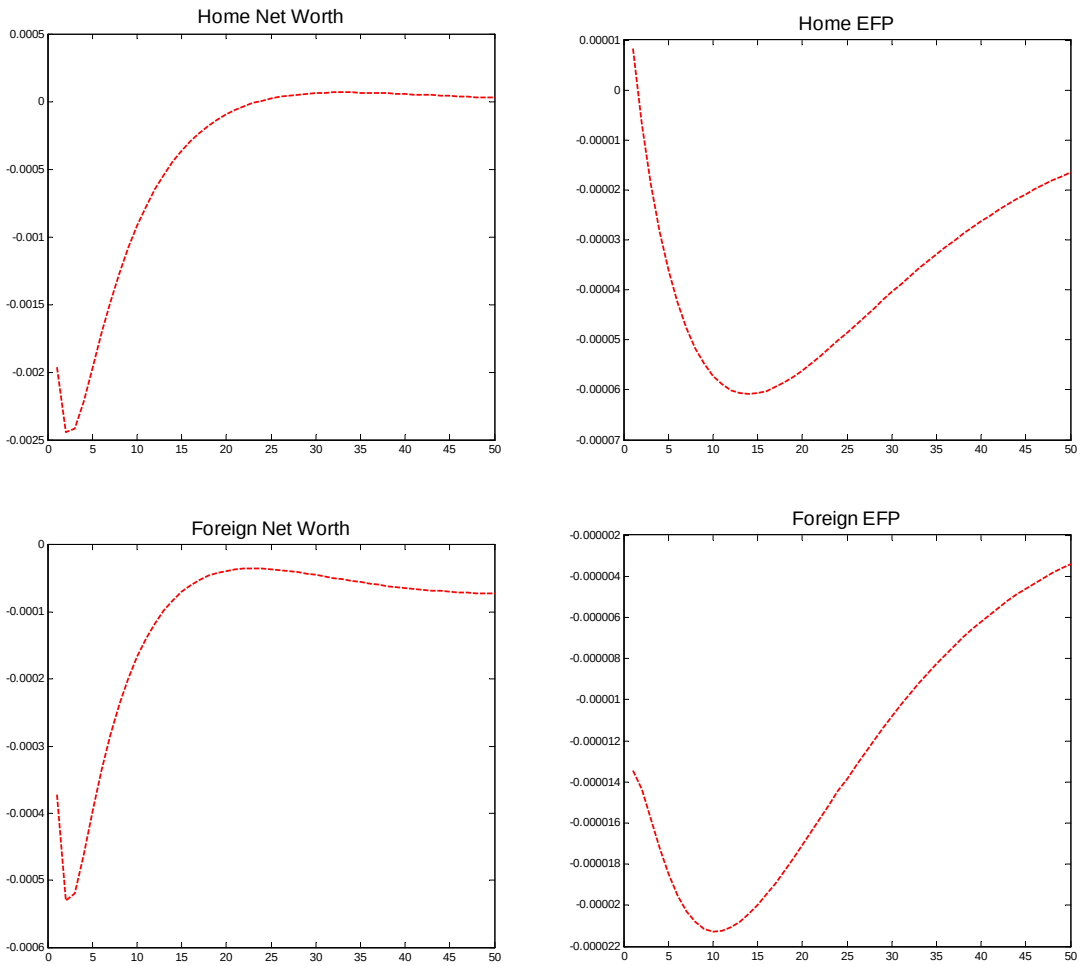
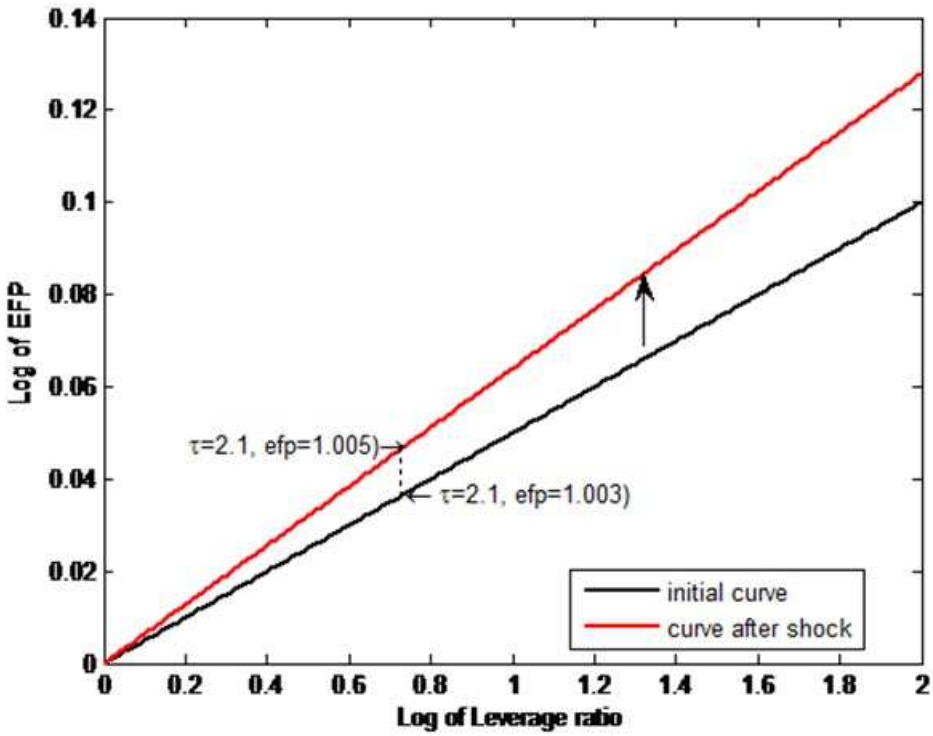

Foreign Labour
financial friction off
financial friction on

Figure 2D


Home Net Worth
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
0 5 10 15 20 25 30 35 40 45 50
Home EFP
0.00001
0
-0.00001
-0.00002
-0.00003
-0.00004
-0.00005
-0.00006
-0.00007
0 5 10 15 20 25 30 35 40 45 50
Foreign Net Worth
0
-0.0001
-0.0002
-0.0003
-0.0004
-0.0005
-0.0006
0 5 10 15 20 25 30 35 40 45 50
Foreign EFP
-0.000002
-0.000004
-0.000006
-0.000008
-0.00001
-0.000012
-0.000014
-0.000016
-0.000018
-0.00002
-0.000022
0 5 10 15 20 25 30 35 40 45 50

5.5 Figure 3 Effect of "risk" shock



5.6 Figure 4 Impulse responses to a negative one standard deviation "risk" shock in the home country

Figure 4a

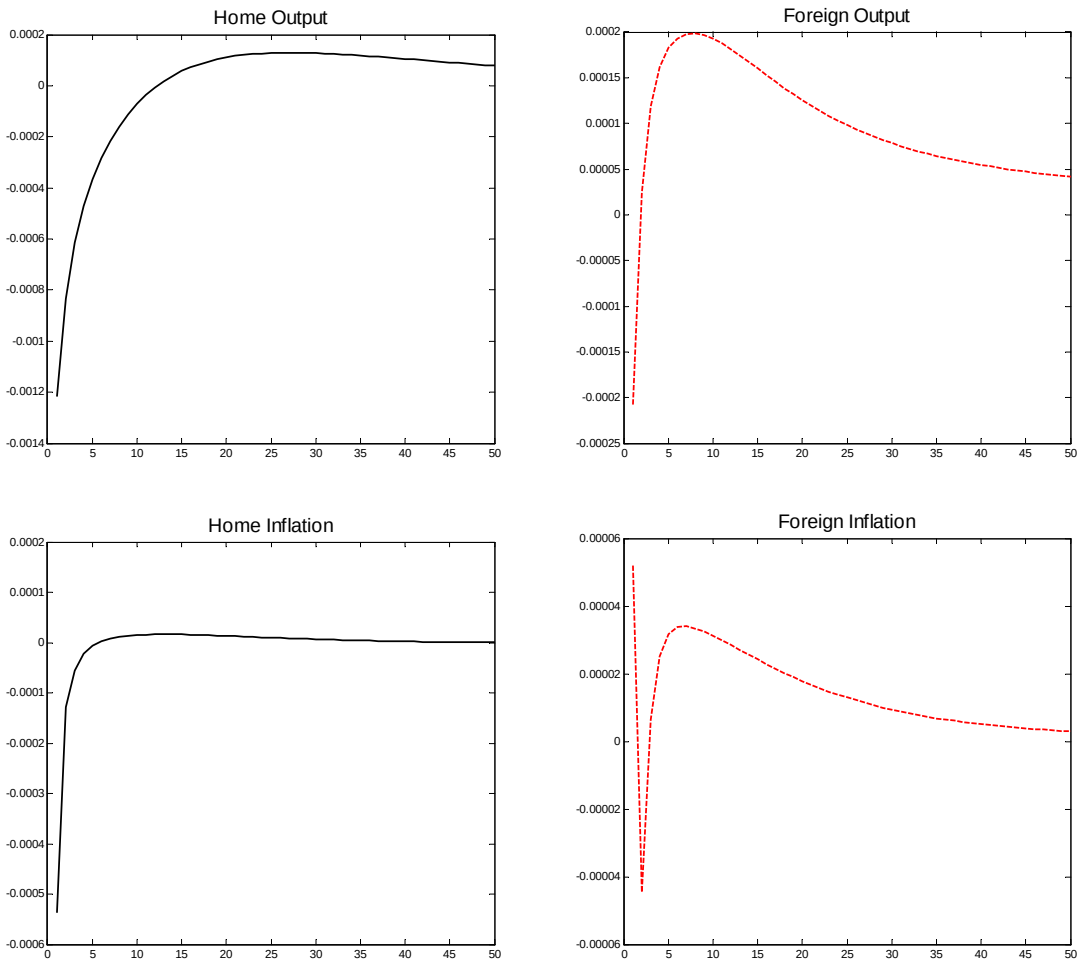


Figure 4b

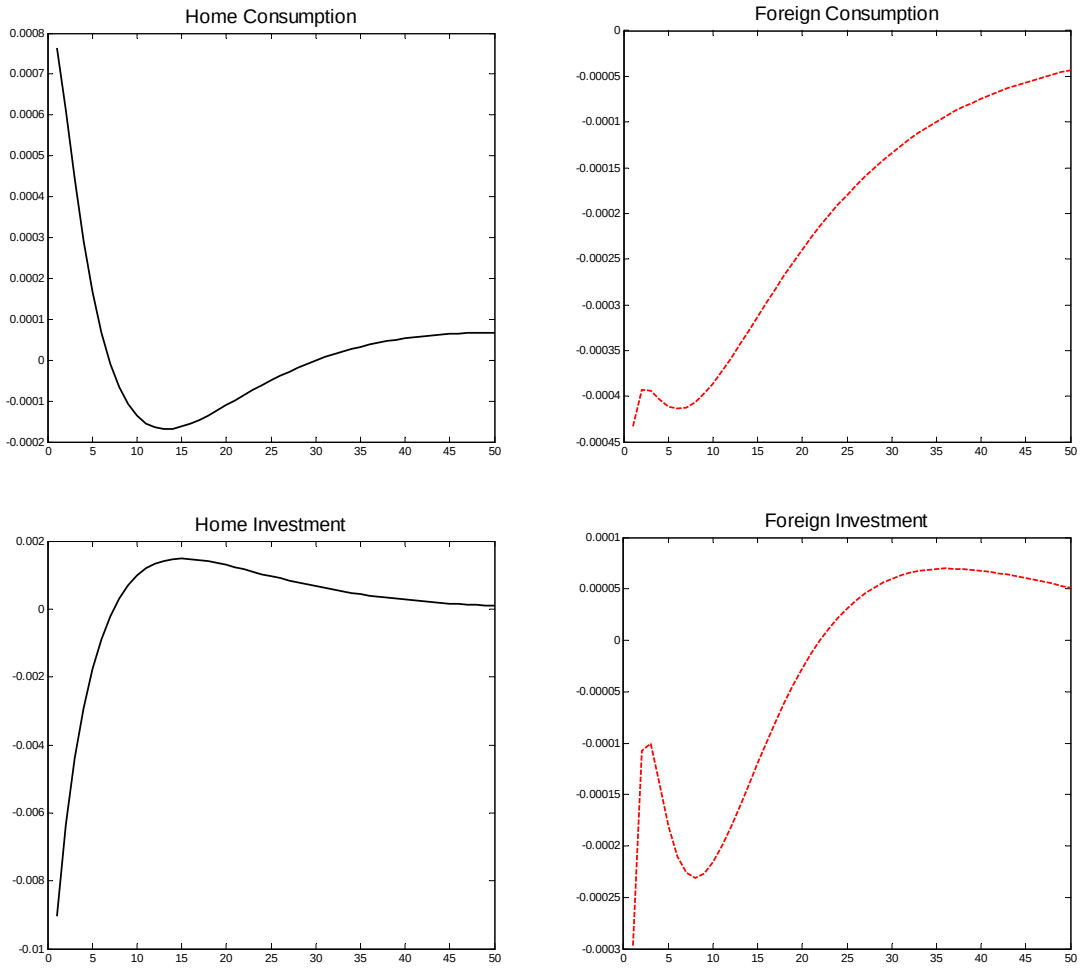

Home Consumption
Foreign Consumption
Home Investment
Foreign Investment

Figure 4c

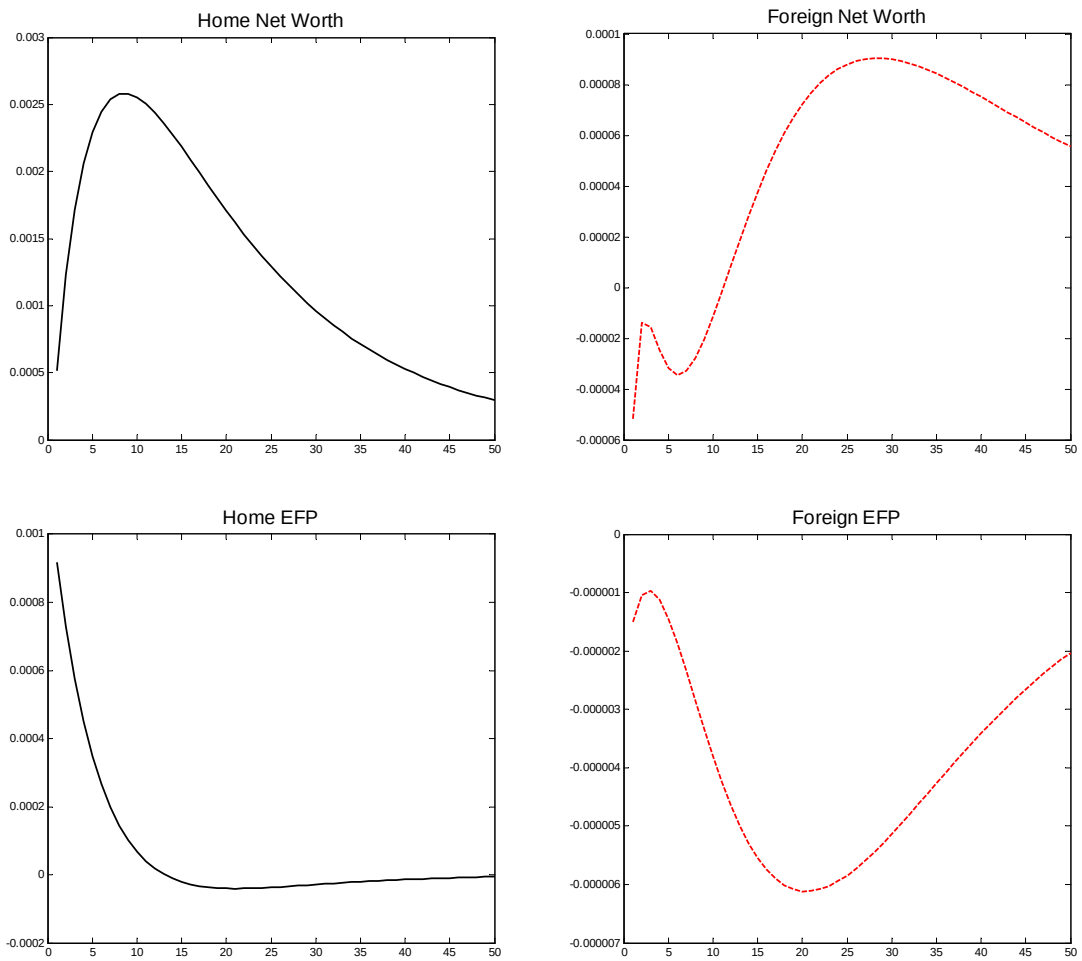
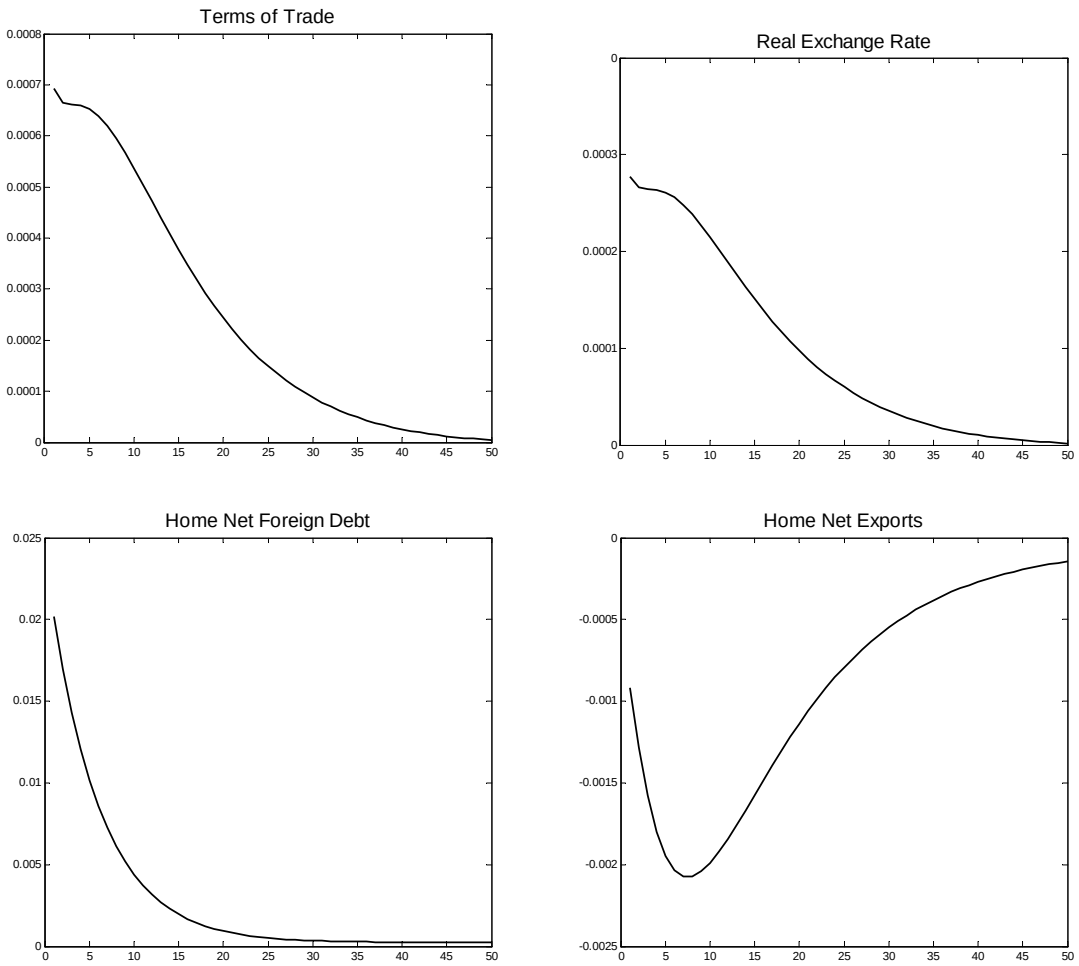


Figure 4d


Terms of Trade
Real Exchange Rate
Home Net Foreign Debt
Home Net Exports

5.7 Figure 5 Impulse responses to a negative one standard deviation survival shock in the home country

Figure 5a

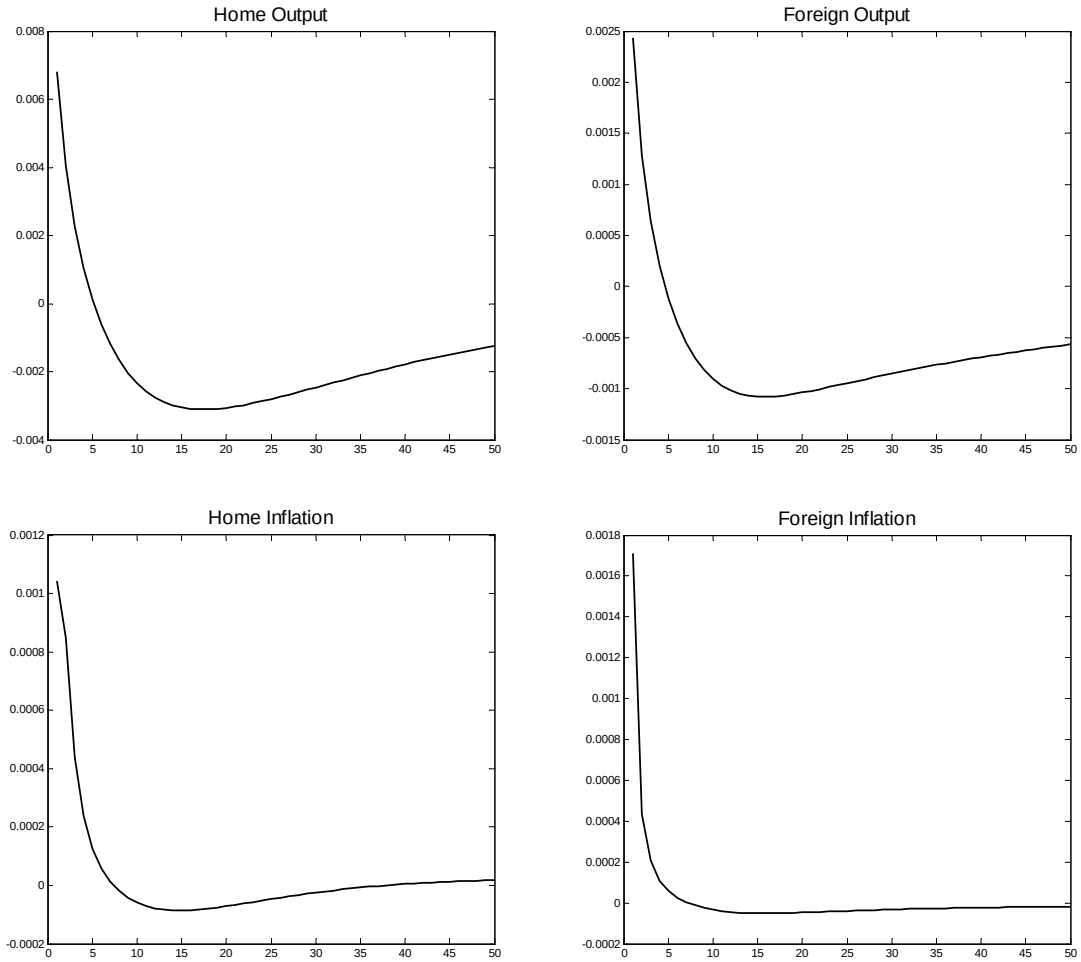


Figure 5b

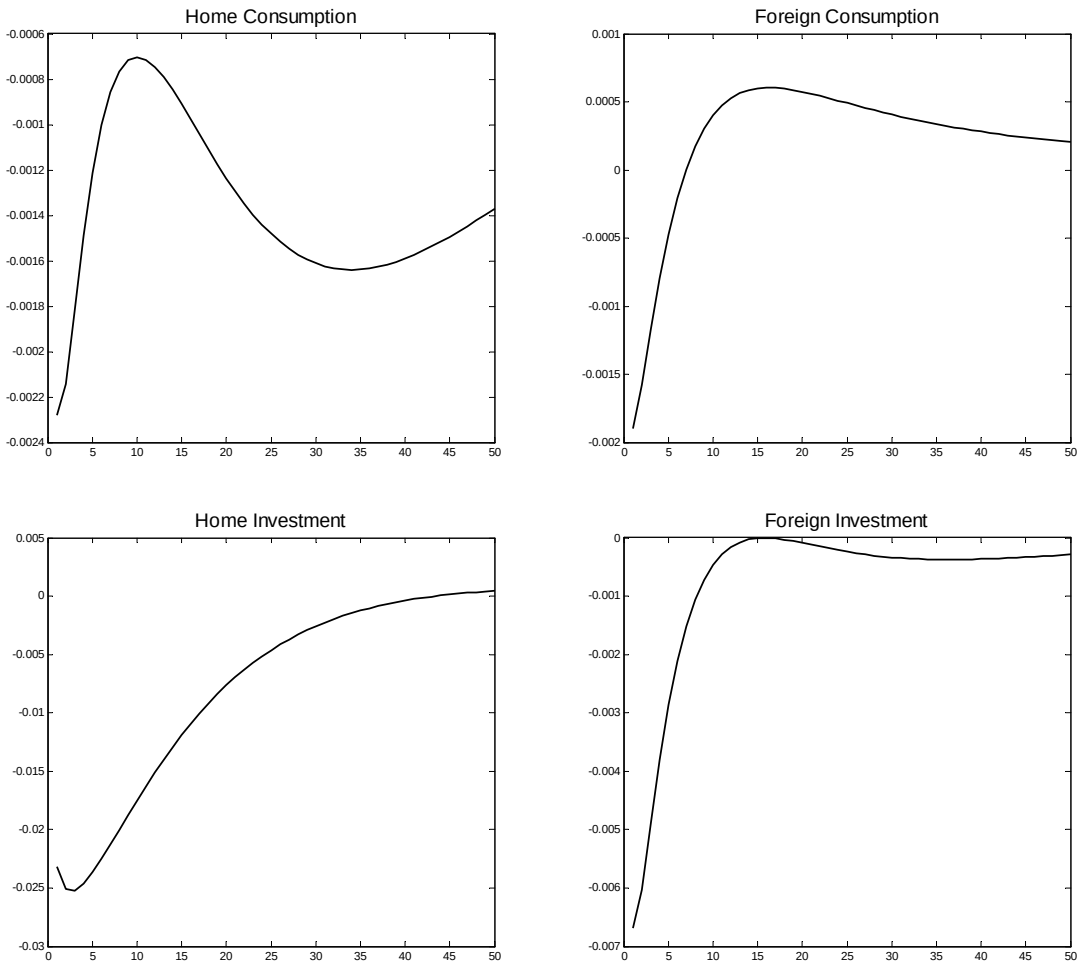

Home Consumption
Foreign Consumption
Home Investment
Foreign Investment

Figure 5c

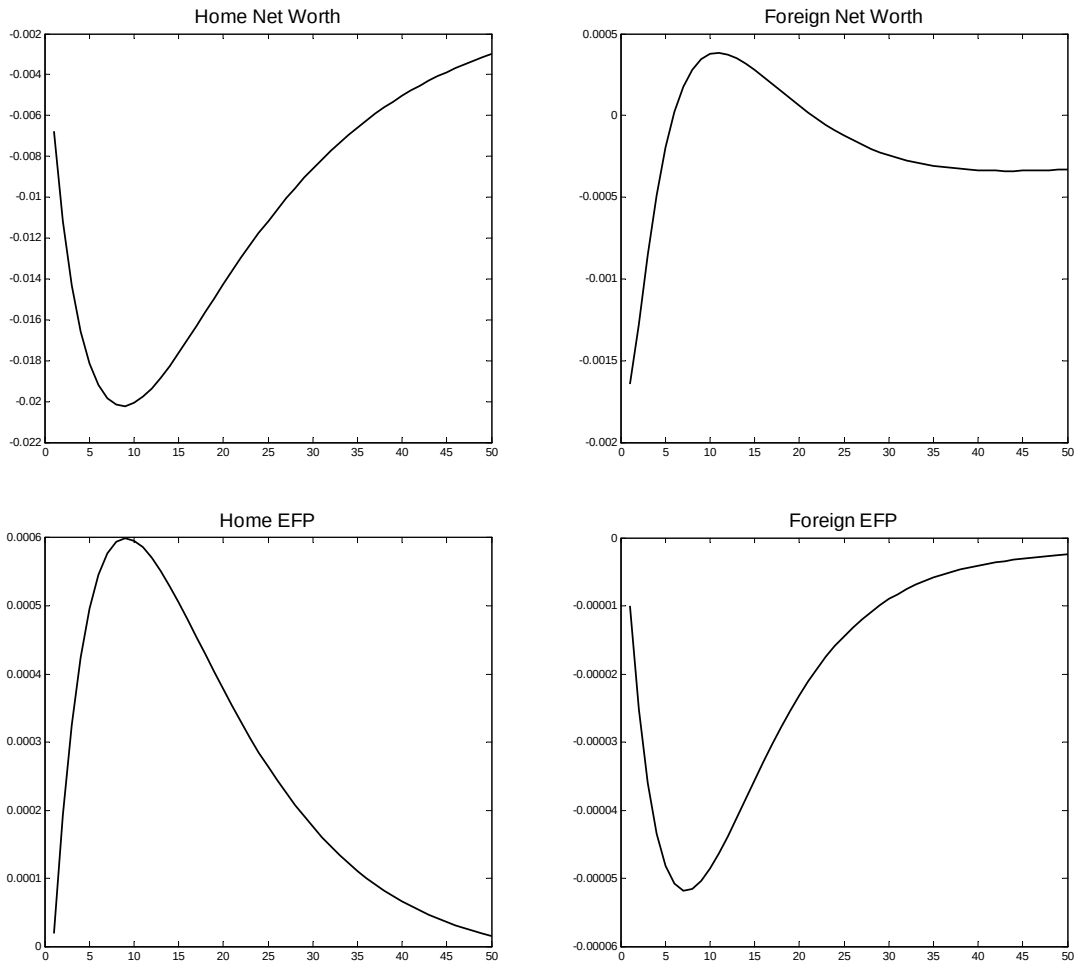
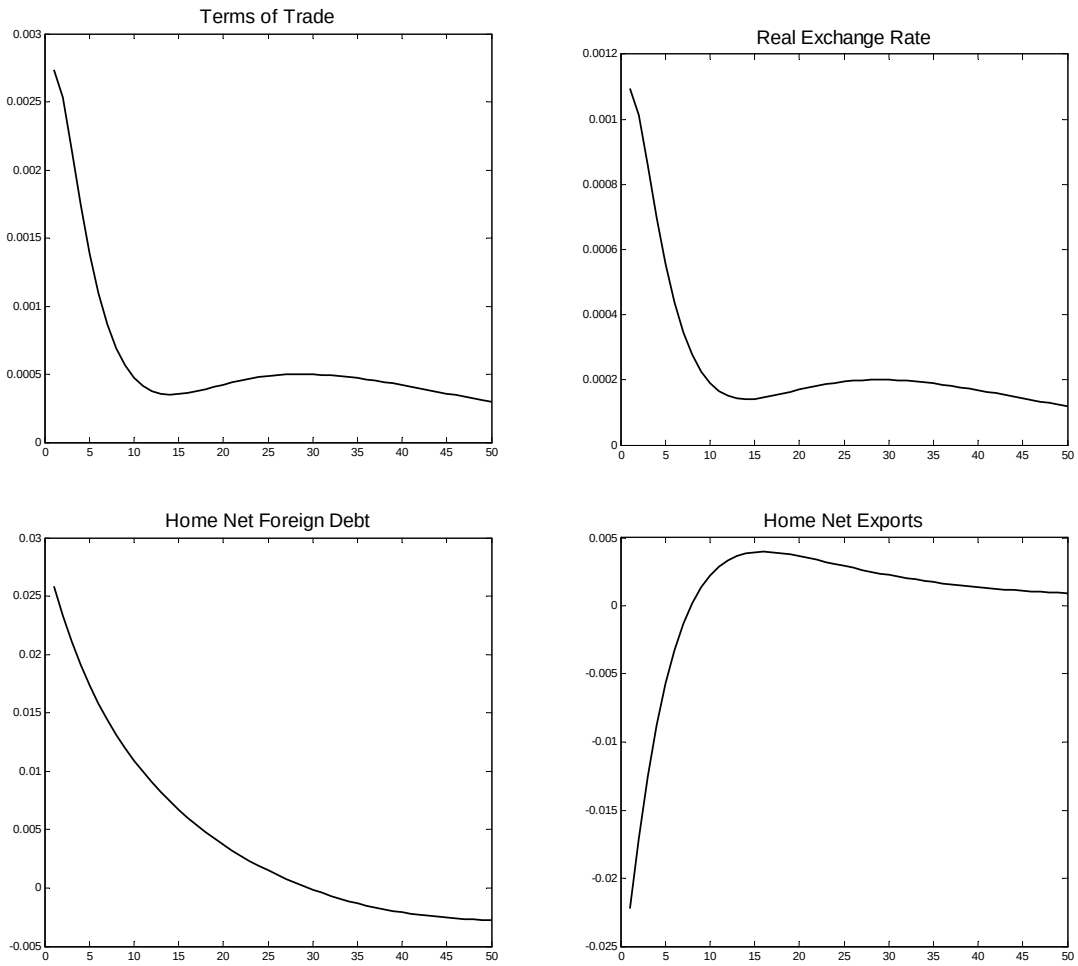


Figure 5d


Terms of Trade
Real Exchange Rate
Home Net Foreign Debt
Home Net Exports

5.8 Figure 6 Relative impulse responses to negative one standard deviation credit spread shocks in the home country

Figure 6a

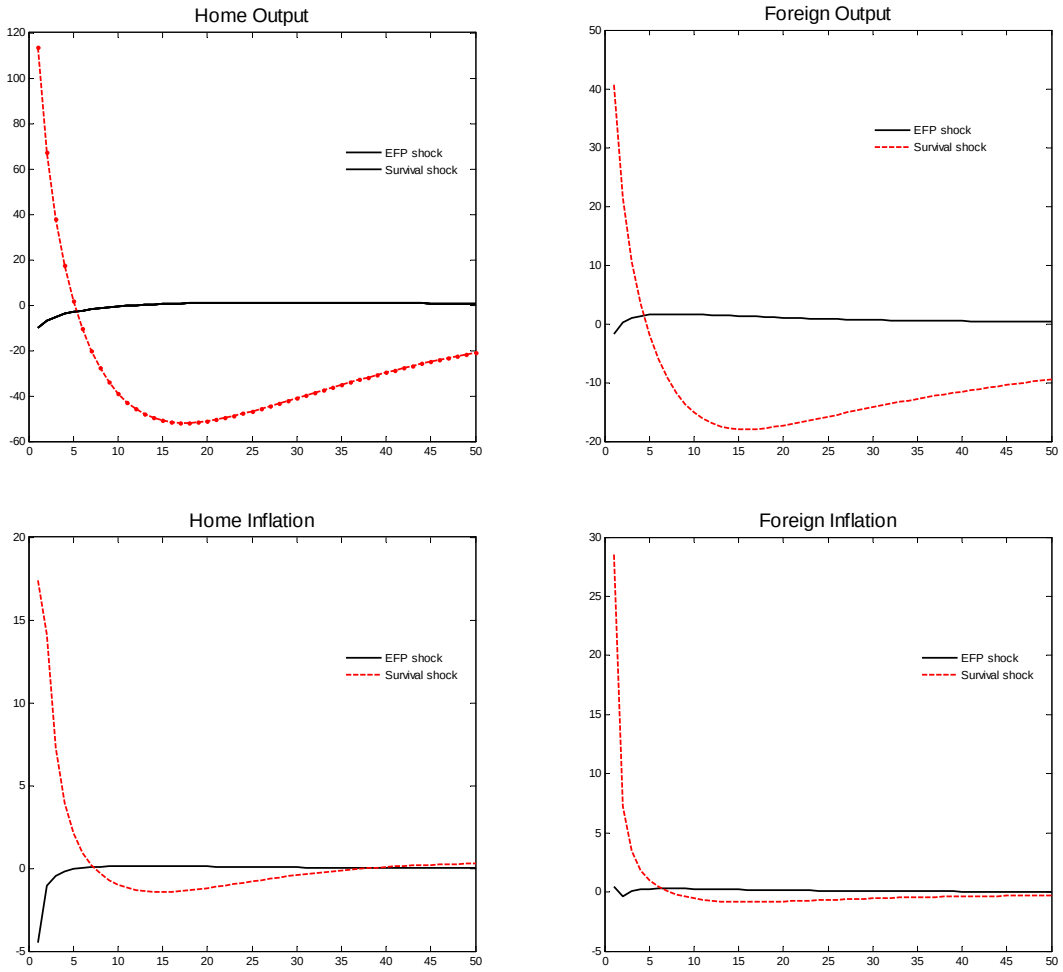


Figure 6b

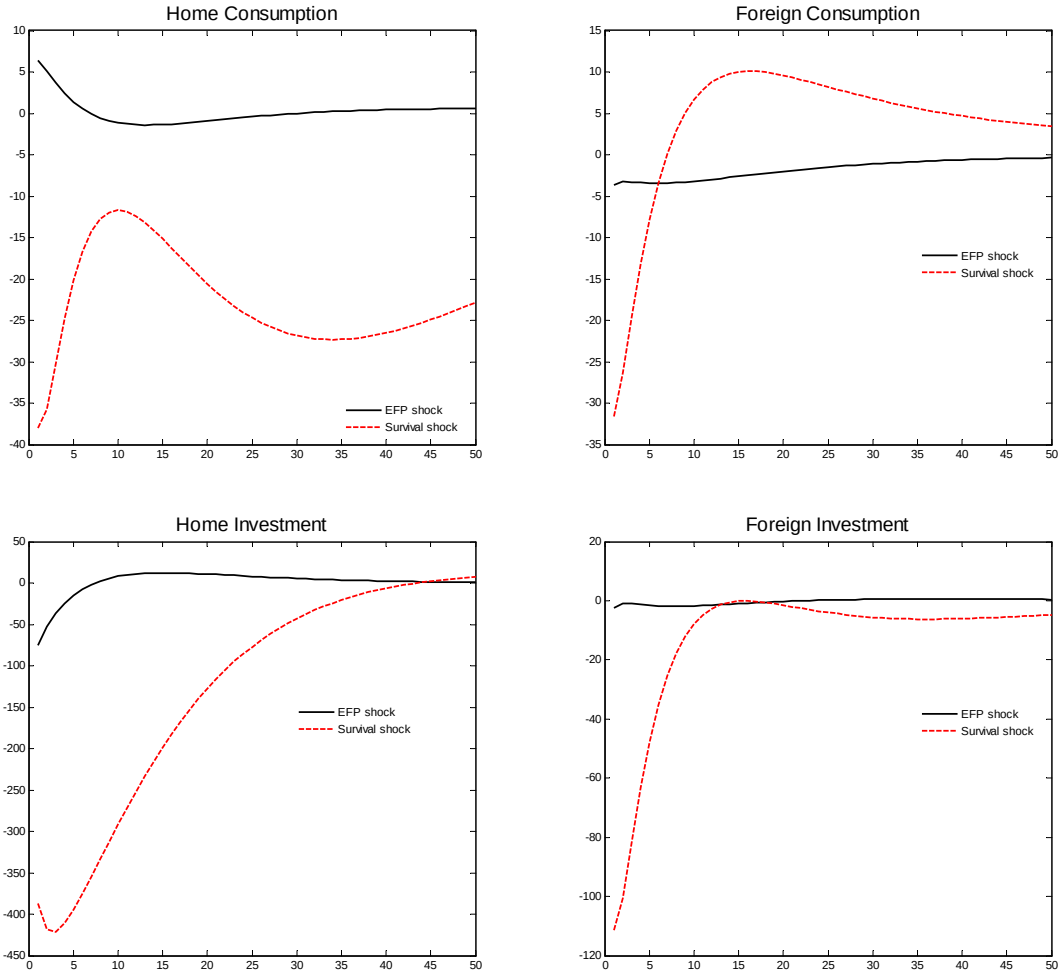

Home Consumption
EFP shock
Survival shock
Foreign Consumption
EFP shock
Survival shock
Home Investment
EFP shock
Survival shock
Foreign Investment
EFP shock
Survival shock

Figure 6c

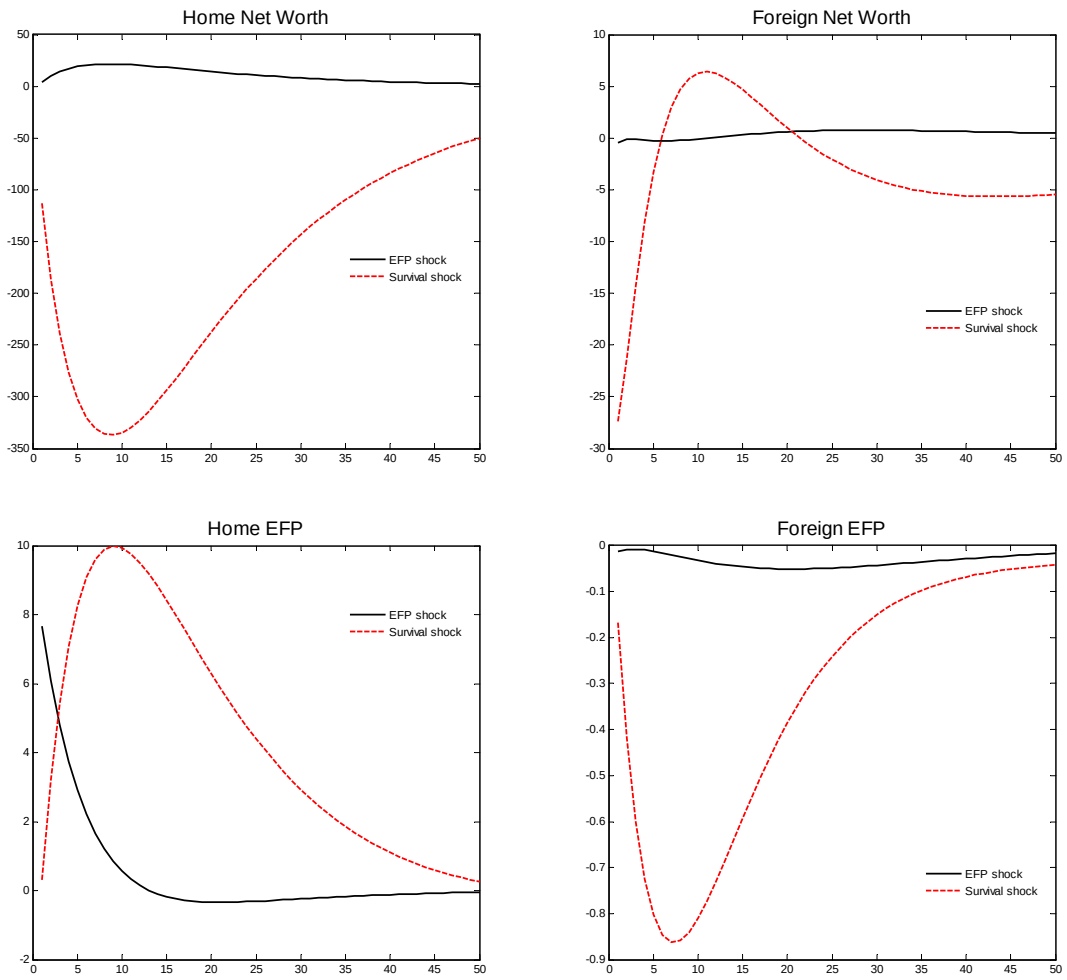
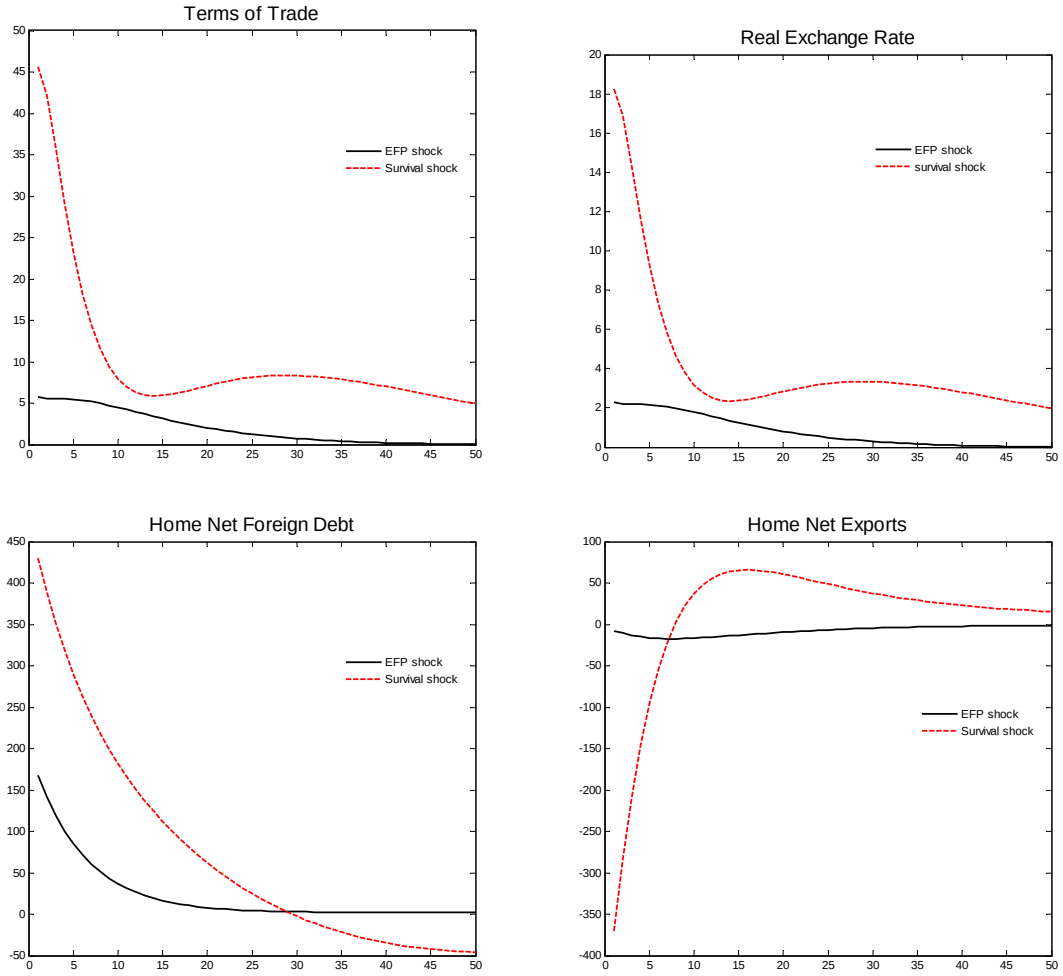

Home Net Worth
EFP shock
Survival shock
Foreign Net Worth
EFP shock
Survival shock
Home EFP
EFP shock
Survival shock
Foreign EFP
EFP shock
Survival shock

Figure 6d


Terms of Trade
EFP shock
Survival shock
Real Exchange Rate
EFP shock
survival shock
Home Net Foreign Debt
EFP shock
Survival shock
Home Net Exports
EFP shock
Survival shock

6 Appendix

6.1 Log linear model with a financial accelerator.

Variables with a hat and a time subscript are in log deviation from the steady state, or $\hat{x}_t = \log X_t - \log X$. Foreign country variables are denoted with an asterisk

$$g_t = \rho_g \, g_{t-1} + \varepsilon_{gt} \tag{40}$$

$$A_t = \rho_A A_{t-1} - \varepsilon_{At} \tag{41}$$

$$s_t = \rho_s \, s_{t-1} - \varepsilon_{st} \tag{42}$$

$$f_t = \rho_f f_{t-1} + \varepsilon_{ft} \tag{43}$$

$$ef\hat{p}_t = r^e_{t+1} - (r^n_t - \pi_{t+1}) \tag{44}$$

$$\hat{\tau}_t = \hat{q}_t + \hat{k}_t - n\hat{w}_t \tag{45}$$

$$\hat{q}_t = \varepsilon_{ik} \left(\hat{\imath}_t - \hat{k}_{t-1} \right) \tag{46}$$

$$r^e_{t+1} - (r^n_t - \pi_{t+1}) = v\hat{\tau}_t \; + \varpi \, log\,(\tau) \; f_t \tag{47}$$

$$NWn\hat{w}_t = \chi R^e NW \left(s_t + r^n_{t-1} - \pi_t + e\hat{f}p_{t-1} + n\hat{w}_{t-1} \right) + w^e \hat{w}^e_t \tag{48}$$

$$C^e c^e{}_t = R^e NW \left(r^n_{t-1} - \pi_t + e\hat{f}p_{t-1} + n\hat{w}_{t-1} \right)$$

\

$$-\chi R^e NW \left(s_t + r^n_{t-1} - \pi_t + e\hat{f}p_{t-1} + n\hat{w}_{t-1} \right) \tag{49}$$

$$r^e_t = \frac{1-\delta}{R^e} \hat{q}_t \; - \hat{q}_{t-1} + \frac{r^k}{R^e} \, \hat{r}^k_t \tag{50}$$

$$\hat{w}^e_t = \hat{mc}_t + \frac{(1-\gamma)\, tot^{a-1}}{\gamma + (1-\gamma)\, tot^{a-1}} \hat{tot}_t + \hat{y}_t \tag{51}$$

$$l \, \hat{l}_t = K \left(\hat{q}_t + \hat{k}_t \right) \; - NWn\hat{w}_t \tag{52}$$

$$\hat{x}_t = \frac{1-\gamma}{1-\gamma+\gamma \, tot^{1-a}} \, \hat{x}_{ft} + \frac{\gamma}{\gamma + (1-\gamma) \; tot^{a-1}} \, \hat{x}_{ht} \tag{53}$$

$$\hat{x}_t = \frac{C}{X} \, \hat{c}_t + \frac{C^e}{X} \hat{c}^e_t \; + \frac{I}{X} \hat{\imath}_t \tag{54}$$

$$\hat{x}_{ht} - \hat{x}_{ft} = (-a)\ tot_t \tag{55}$$

$$C\,\hat{c}_t + d\,\hat{d}_t + B_t^* - B^* = wN\ (\hat{w}_t + \hat{n}_t) + \frac{d}{\beta}\left(\beta r_{t-1}^n\ - \pi_t + \hat{d}_{t-1}\right) + R\ \left(B_{t-1}^* - B^*\right)$$

$$+R\,B^* r_{t-1} + \frac{Y}{(\gamma + (1-\gamma)\ tot^{a-1})^{\frac{1}{1-a}}}\left(tot_t\,\frac{(1-\gamma)\ tot^{a-1}}{\gamma + (1-\gamma)\ tot^{a-1}} + \hat{y}_t\right)$$

$$-\frac{Y}{(\gamma + (1-\gamma)\ tot^{a-1})^{\frac{1}{1-a}}}\,\frac{b-1}{b}\left(\hat{y}_t + \frac{(1-\gamma)\ tot^{a-1}}{\gamma + (1-\gamma)\ tot^{a-1}}\hat{tot}_t + m\hat{c}_t\right) \tag{56}$$

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