Banking Globalization and International Business Cycles

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Abstract

This paper constructs a two-country DSGE model to study the nature of the recent financial crisis and its effects that spread immediately throughout the world owing to the globalization of banking. In the model, financial intermediaries (FIs) enter into chained credit contracts at home and abroad, engaging in cross-border lending to entrepreneurs by undertaking cross-border borrowing from investors. The FIs as well as the entrepreneurs in two countries are credit constrained, so all of their net worths matter. Our model reveals that under FIs' globalization, adverse shocks that hit one country affect the other, yielding business cycle synchronization on both the real and financial sides. It also suggests that the FIs' globalization, net worth shock, and credit constraints are key to understanding the recent financial crisis.

Keywords: Financial accelerator; financial intermediaries; correlation (quantity) puzzle; business cycle synchronization; contagion; monetary policy

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1 Introduction

The recent financial crisis demonstrates the importance of a global linkage between the financial market, the financial system, and the real economy. The deterioration in the U.S. subprime mortgage market impaired financial intermediaries' (FIs') capital. Combined with banking sector globalization, this led to the global malfunctioning of the financial market and the financial system, which weakened world demand. Figure 1 demonstrates those recent global downturns. GDP and investment dropped around 2007 not only in the United States but also in Japan and the euro area; in particular, in Iceland and Ireland, we observe volatile changes in GDP and investment. That volatile changes are accompanied by increasing financial globalization before the crisis. As the right panels show, cross-border lending to those countries increased, with Iceland experiencing particularly sharp rises by more than five times from 2005 to 2008.[1] The crisis caused cross-border lending to decline. Stock prices dropped in the major stock exchange markets. That impaired FIs' capital. FIs' net worth deteriorated in the United States, Japan, the euro area,[2] and corporate bond spreads jumped in those areas.[3] That further decreased world GDP and investment, creating the adverse feedback loop. Standard macroeconomic models have not, however, captured those global linkage via FIs, because FIs and the financial markets are treated as a veil.

In this paper, we construct a dynamic stochastic general equilibrium (DSGE) model to shed light on the nature of the recent financial crisis associated with its international propagation under banking globalization. In particular, we investigate whether and under which conditions our model yields a global economic downturn, as was observed in the recent financial crisis. First, by constructing the model, we simulate responses of real and financial variables to different shocks, asking which shock is responsible for the recent

[1] Cross-border lending is defined as consolidated claims on borrowers in the country or region concerned. Its data are available from the Consolidated International Banking Statistics released by the Bank for International Settlements (BIS). Consolidated claims are those on an immediate borrower basis and those of foreign claims. Claims on an immediate borrower basis identify counterparties according to the country in which the immediate borrower is located. Foreign claims consist of cross-border claims, local claims of foreign affiliates in foreign currency, and local claims of foreign affiliates in local currency.

Because we are interested in banking sector globalization, we use those statistics that report banks' international financial claims. Banks are categorized into each country by their nationalities on a consolidated basis, including their head offices and all their branches, and netting of inter-office accounts. Those statistics are used to recognize the country-risk exposure of the major individual nationality banking groups.

Consolidated claims in Europe include cross-border claims among European countries.

[2] FIs' net worth is defined as "corporate equities + equity in the noncorporate business sector" held by the financial business sector. They are obtained from the Flow of Funds Accounts for the United States and Japan, and the Euro Area Integrated Economic and Financial Accounts for the Euro area.

[3] Corporate bond spreads are differences between corporate bond rates and government bond rates.

global economic downturn. Second, we ask whether globalization enhances business cycle synchronization, simulating economic responses under varying degrees of globalization. Third, we ask whether credit frictions, in particular, the presence of credit-constrained FIs, enhance business cycle synchronization, comparing our model with one that omits FIs' credit constraint. Finally, we draw implications for various policy measures, discussing the effects of monetary, capital injection, and macroprudential policies on the financial market and the real economy at home and abroad.

In the model, FIs enter into chained credit contracts at home and abroad. Following Hirakata, Sudo, and Ueda (2009, 2010, HSU), the credit contracts are vertically chained between investors and FIs and between FIs and entrepreneurs. The context of the credit contract is based on the financial accelerator model by Bernanke, Gertler, and Gilchrist (1999, BGG). Unlike BGG, FIs are credit-constrained, as are entrepreneurs. In this paper, the HSU model is extended to a two-country model. Under banking globalization, FIs undertake cross-border lending to entrepreneurs through cross-border borrowing from investors. FIs as well as entrepreneurs in two countries are credit constrained, so all of their net worths influence the cost-of-funds for the entrepreneurs and, in turn, the real economy in the two countries.

The global chained credit contracts and the presence of the credit-constrained FIs produce a new channel of business cycle synchronization. Consider, for example, an adverse shock, which leads to a decrease in FIs' net worth. Under banking globalization, the FIs supply funds to entrepreneurs in the two countries; the adverse shock thus decreases the loans in both countries, and investment and output decrease simultaneously. Such a new channel does not arise, unless we consider credit-constrained FIs. This common lender effect has been shown empirically by Kaminsky and Reinhart (2000) and Van Rijckeghem and Weder (2003). Figure 2 and Table 1 provide supporting evidence. Figure 2 plots the relation between cross-border lending to OECD countries (except for Luxemburg) before the crisis and GDP changes in those countries during the crisis. This figure and simple regression, reported in Table 1, suggest that countries with larger cross-border lending tended to be more severely affected by the recent crisis.[4]

This paper reveals, first, that under banking globalization, adverse shocks that hit one country affect the other, yielding business cycle synchronization on both the real and financial sides. An adverse productivity shock and a tighter monetary policy shock in one country reduce GDP, investment, and asset prices in the other country. For the productivity shock, however, cross-border lending increases and risk premiums decrease

[4]Considering country-specific differences, we look at not only the level of cross-border lending during 2006Q4 but also changes in cross-border lending from 2002Q4 to 2006Q4.

in the foreign country, which is not observed in the recent financial crisis. An adverse shock to FIs' net worth in one country not only simultaneously reduces GDP, investment, and asset prices in the other, but also reduces cross-border lending and raises risk premiums. In this respect, the adverse shock to FIs' net worth is key to understanding the recent financial crisis.[5]

Second, banking globalization enhances business cycle synchronization. For a shock to FIs' net worth, without banking globalization, no business cycle synchronization occurs; a bilateral correlation for GDP is slightly negative. Under banking globalization, business cycles are synchronized, and as globalization intensifies the degree of business cycle synchronization increases significantly. In this respect, FIs' globalization is also key to understanding the recent financial crisis.

Third, business cycle synchronization is enhanced, compared with a standard BGG model in which FIs are not credit constrained. The presence of credit-constrained FIs works to enhance the financial accelerator effect, as is pointed out by HSU (2009). Under banking globalization, the common lender effect also contributes to an increase in business cycle synchronization. In a standard two-country BGG model, because FIs are not credit constrained, a shock to FIs' net worth has no effect on the economy, and there is no common lender effect. In our model, on the other hand, because FIs are credit constrained, an adverse shock to FIs' net worth in one country raises the cost-of-funds in two countries, dampening GDP and investment. As a result, the effect of globalization on business cycle synchronization is much greater than that in the standard two-country BGG model. In this respect, FIs' credit constraint likewise is key to understanding the recent financial crisis.

Lastly, our study suggests that under globalization, policy in one country has a global impact. Accommodative monetary policy and capital injection policy to FIs in one country are effective in boosting GDP and investment in the other country.

The remainder of this paper is organized as follows. Section 2 gives an overview of related literature and stylized facts. Section 3 presents a two-country sticky price model in which both FIs and entrepreneurs are credit constrained. Section 4 shows the model's simulation results. Section 5 concludes.

[5] This account is consistent with HSU (2010) and Perri and Quadrini (2010). Perri and Quadrini (2010) point to the importance of the credit shock. Our paper further argues that among the credit shocks, the shock to the FI sector is important. An opposing view exists, however. For example, Chari, Christiano, and Kehoe (2008) cast a doubt on the detrimental effect of financial market disruptions on investment by pointing out that nonfinancial firms' retained earnings are greater than investment.

2 Related Literature and Stylized Facts

In this section, we provide an overview of related literature and stylized facts on three points: (1) business cycle synchronization; (2) macroeconomic effects of FIs; and (3) globalization. First, we check the presence of business cycle synchronization and review theoretical studies that have sought to explain business cycle synchronization. Second, we introduce empirical studies on the effect of FIs' credit conditions, and theoretical studies on their implications from a macroeconomic perspective. Third, we examine the evolution of globalization from the viewpoints of trade and financial openness.

2.1 Business Cycle Synchronization

In Figure 1, we showed the evidence of global downturns in the recent financial crisis. In the United States, Japan, and Europe, in particular, in Iceland and Ireland, economic activity such as GDP and investment weakened; cross-border lending contracted; asset prices dropped; FIs' net worth deteriorated; and corporate bond spreads jumped.

To examine business cycle synchronization for longer periods, we calculate bilateral correlations for GDP and investment in the G7 countries. GDP and investment data are detrended with the Hodrick–Prescott filter with λ=1,600. Tables 2 to 4 report the results. We find that correlations are positive in most cases.[6] Bilateral correlations for GDP (investment) between the United States and Japan are 0.23 (0.29) for the sample of 1970Q1 to 2008Q4. Table 4 reports changes in bilateral correlations for GDP between three major countries: the United States, Japan, and Germany. The full sample, 1970Q1 to 2008Q4, is divided into four subsamples: the 1970s, 1980s, 1990s, and 2000s. In the 1990s, GDP correlations are negative between the United States and Japan and between the United States and Germany.[7] In the 2000s, GDP correlations are the highest. The GDP correlation between the United States and Japan is 0.81 in the 2000s, jumping up from 0.23 for the full sample.

Theoretically, business cycle synchronization has been regarded as a correlation puzzle or a quantity puzzle since Backus, Kehoe, and Kydland (1992, BKK). BKK constructed a standard international real business cycle model, and pointed out that their model predicted a negative correlation for output and investment. The reason is that in response to a productivity shock it is efficient to increase investment and the labor supply in the more productive country and reduce them in the less productive one. The bilateral

[6]See Backus, Kehoe, and Kydland (1992, 1994), Frankel and Rose (1998), and Ambler, Cardia, and Zimmermann (2004).

[7]Heathcote and Perri (2004) point out decreases in bilteral correlations from 1972–1986 to 1986–2000.

correlations for output and investment thus become negative or close to zero.

Motivated by BKK, a number of papers have tackled the correlation puzzle and demonstrated that frictions in the financial markets resolve the puzzle.[8] For example, Faia (2007) extended the financial accelerator model by BGG to a two-country model, and showed that her model predicted positive output correlations.[9]

Existing DSGE models are, however, still unable to explain the synchronized movements in various variables such as the decrease in cross-border lending and the rise in corporate bond spreads. In most of those models, the deterioration in FIs' net worth plays no economic role. Furthermore, Faia (2007) argues that financial globalization weakens business cycle synchronization, although many empirical studies report that such business cycle synchronization is enhanced.[10]

2.2 Financial Intermediaries

The main contribution of this paper is to construct a two-country DSGE model that explicitly incorporates credit-constrained FIs. Without FIs' credit constraint, a deterioration in FIs' net worth does not have any economic impact. This eliminates an important spillover channel, which gives rise to what is often called the common lender effect, arising when borrowers in multiple countries have a common lender. In such a case, an adverse shock in one country worsens the credit conditions of FIs, which causes a withdrawal of funds from another country; it thus explains positive bilateral correlations. Several empirical studies support the existence of the common lender effect.[11]

The recent financial crisis and ample empirical studies suggest that declines in FIs' net worth generate a macroeconomic downturn.[12] For example, Peek and Rosengren

[8]See BKK (1994), Baxter and Crucini (1995), Heathcote and Perri (2002, 2004), Kehoe and Perri (2002), Iacovielloa and Minetti (2006), Faia (2007), Dedola and Lombardo (2009), Devereux and Yetman (2009), and Perri and Quadrini (2010). Dedola and Lombardo (2009) and Devereux and Yetman (2009) calculate the optimal portfolio of investors using the second-order approximation. Dedola and Lombardo (2009) yield negative output correlations. As the financial friction, they introduce the BGG model as in Faia (2007), but assume that capital goods in two countries are tradable, unlike in Faia (2007). Devereux and Yetman (2009) do not report output correlations, but report positive correlations for asset holdings. As the financial friction, they introduce the Kiyotaki and Moore (1997) model. Their model abstracts from nominal stickiness, and keep total assets and labor fixed. As another reason for the positive bilateral correlation, Kose and Yi (2006) and Burstein, Kurz, and Tesar (2008) point out complementarity between products.

[9]See also Gertler, Gilchrist, and Natalucci (2007) for the BGG model extended to an small open economy model.

[10]See Kose, Prasad, and Terrones (2003), Morgan, Strahan, and Rime (2004), and Imbs (2004, 2006). In contrast, Heathcote and Perri (2004) report opposing results from both empirical and theoretical sides.

[11]See Kaminsky and Reinhart (2000), and Van Rijckeghem and Weder (2003).

[12]See Peek and Rosengren (1997, 2000), Calomiris and Mason (2003), Anari, Kolari, and Mason

(1997, 2000) identify a loan supply shock that is specific to Japanese banks but external to the U.S. credit market using panel data, and report that the worsening of FIs' credit conditions generates a macroeconomic downturn.

Theoretically, our model is the extension of the financial accelerator model of HSU (2009, 2010) to a two-country model. The HSU model is built upon the BGG model. In contrast to BGG, however, there are two credit-constrained borrowers, FIs and entrepreneurs. Shocks to the FI sector as well as those to the entrepreneurial sector are amplified and propagated to the aggregate fluctuations, through endogenous developments in the net worth in the FI sector and the entrepreneurial sector.[13]

2.3 Globalization

It is often pointed out that increasing globalization was behind the recent crisis, which enhanced business cycle synchronization. Accordingly, we examine whether there was an increase in globalization before the onset of the financial crisis. The literature on the wave of globalization both in goods and financial markets is voluminous.[14]

Figure 3 illustrates globalization in the goods market. As a proxy for trade openness, the figure demonstrates the movements of (exports + imports)/2 as a share of GDP for the United States, Japan, Germany, and the euro area from 1970. In the United States, we observe a steady increase in trade openness. In Japan, Germany, and the euro area, we observe an accelerated increase in trade openness from the middle of the 1990s.[15]

Figures 4 to 6 illustrate globalization in the financial market. Using BIS's Consolidated International Banking Statistics, we report cross-border lending in the form of consolidated claims on borrowers in the United States, Japan, Europe, and developing countries from 1999 to 2009 in Figure 4. The top panel indicates the level of consolidated claims; the middle panel indicates the ratio of consolidated claims to nominal GDP at

(2005), Ashcraft (2005).

[13] The HSU model is constructed with reference to two lines of literature. The first strand focuses on the credit friction associated with the entrepreneurs (BGG; Kiyotaki and Moore [1997], Christiano, Motto, and Rostagno [2004]). The second strand considers the credit friction of the FIs (Bernanke and Blinder [1988], Goodfriend and McCallum [2007], Van den Heuvel [2008], Gerali, Neri, Sessa, and Signoretti [2008], Dib [2009], Curdia and Woodford [2009], Gertler and Karadi [2009], Gertler and Kiyotaki [2010]). In considering the two types of frictions above, our model is close to the model by Chen (2001), Aikman and Paustian (2006), and Meh and Moran (2004), who use quantitative extensions of the model of Holmstrom and Tirole (1997).

[14] See, for example, Crafts (2000), Eichengreen (2001), Bordo, Taylor, and Williamson (2003), Edison, Klein, Ricci, and Slok (2004), Obstfeld and Taylor (2004), Kose, Prasad, Rogoff, and Wei (2006), and Goldberg (2009).

[15] As for longer records of trade openness, see Findlay and O'Rourke (2003) and originally Maddison (1995, 2001).

the end of the calendar year; and the bottom panel indicates the ratio of consolidated claims to non-financial firms' total liabilities. We find that consolidated claims, both in their level and in their ratios, increased over the sample periods, outstandingly in Europe. It suggests increasing risk exposures in the countries examined. For the United States in 2009, the ratio of consolidated claims to nominal GDP (non-financial firms' total liabilities) reaches 40 (15) percent. Figure 5 decomposes consolidated claims on the non-bank private sector and banks.[16] Again, we observe increases in consolidated claims, both on the non-bank private sector and banks.[17] Figure 6 demonstrates the movements of the ratio of cross-border fund-raising to total fund-raising using the Flow of Funds Accounts compiled by the Bank of Japan. The statistics report a reference table, Channels of Fund-Raising by the Nonfinancial Sector. The cross-border fund-raising is the sum of fund-raising by the domestic nonfinancial sector via overseas markets and by the overseas sector. The ratio of cross-border fund-raising increases from 1979. In 2008, in particular, the ratio of cross-border fund-raising reached 23 percent largely reflecting the increase in fund-raising by the overseas sector.[18]

3 Model

We consider a two-country economy with credit and goods markets. Two countries are of equal size. The economy in each country consists of 10 types of agents: a household, investors, FIs, entrepreneurs, capital goods producers, final goods producers, retail goods producers, wholesale goods producers, the monetary authority, and the government.

3.1 Credit Market

Our setting for the credit market is taken from HSU (2009, 2010). As shown in Figure 7, investors, FIs, and entrepreneurs make chained credit contracts. FIs own their net worth, but not sufficiently to finance the loans to the entrepreneurs. Consequently, FIs make credit contracts with investors to borrow the rest of the funds (hereafter IF contracts). Entrepreneurs are the ultimate borrowers of the funds. They also own their net worth,

[16] The figures report not foreign claims but international claims. International claims equal foreign claims minus local claims of foreign affiliates in local currency.

[17] Those upward trends are confirmed in longer-term data using the BIS Locational International Banking Statistics. They report international financial claims of banks resident in a given country.

[18] While the Flow of Funds Accounts show a clear increase in banking globalization in Japan, the previous BIS statistics do not. Such a difference can be explained, because the overseas non-financial sector in the Flow of Funds Accounts corresponds to the non-financial sector outside Japan. If that sector is resident in the United States, the BIS statistics classify the cross-border lending not as the one to Japan but as the one to the United States.

but not sufficiently to finance their projects. Hence, the entrepreneurs engage in the credit contract with the FIs, to finance the rest of the funds (hereafter FE contracts). There are two sources of informational asymmetry in the IF contract and in the FE contract. This makes both FIs and entrepreneurs credit constrained. The model of credit frictions is based on the costly state verification model developed by BGG.

In the two-country model, the chained credit contracts are depicted as Figure 8. Under banking globalization, FIs undertake cross-border lending to entrepreneurs through cross-border borrowing from investors.[19] The four parameters τ_H^F, τ_F^F, τ_H^E, and τ_F^E represent exogeneous degrees of banking globalization or financial openness, which determines the allocation of finance between the home country and the foreign country. When entrepreneurs in the home country borrow funds, $1-\tau_H^E$ of their net worth $N^E(s^t)$ is used to borrow from the home FI and τ_H^E of their net worth to borrow from the foreign FI. FIs in the home country borrow a portion of $1-\tau_H^F$ from the home investors and τ_H^F from the foreign investors.[20] Put differently, $0 < \tau_H^E$, τ_H^F, τ_F^E, and $\tau_F^F < 1$ represent the degree of banking globalization from FIs' borrowing and lending sides: τ_H^F and τ_F^F capture the degree of banking globalization from FIs' borrowing side, or the financial openness of the interbank market, and τ_H^E and τ_F^E capture the degree of banking globalization from FIs' lending side or the financial openness of foreign direct investment.

FE contract

We begin with the FE contract between FIs in the home country and entrepreneurs in the home country. At the beginning of each period, each FI – say, a type-i FI – in the home country makes loan contracts with specific group of entrepreneurs – say, group-j_i entrepreneurs – in the home country. Group-j_i entrepreneurs are attached to the FI.[21]

[19] Because many notations are used, this figure summarizes variables and parameters in the credit markets. The left (right) panel represents the home (foreign) country. Superscripts F and E denote FIs and entrepreneurs, respectively. Subscripts H and F denote the country of the FIs with credit connections. The asterisk (*) indicates a variable in the foreign country.

[20] In equilibrium, investors' and FIs' returns from investing in the home country equal those from investing in the foreign country. Up to the first order, therefore, the portfolio choice becomes indeterminate, and we set the portfolio exogenously. To endogenize the optimal portfolio choice of each country's investors, a second-order approximation might be needed as in Dedola and Lombardo (2009), Devereux and Sutherland (2009), and Devereux and Yetman (2009). However, our model is more complex, because investors, FIs, and entrepreneurs are risk neutral, and goods are traded by debt contracts with defaults. Also note that although the allocation of net worth used for borrowing from home and foreign lenders is exogenous, the allocation of borrowings between the two lenders is endogenously determined.

[21] We assume that the bankruptcy cost associated with a credit contract between FI other than type-i FI and group-j_i entrepreneurs is high enough. Therefore, group-j_i entrepreneurs can borrow funds only from a certain monopolistic FI. There is no direct finance from investors to entrepreneurs. Moreover, FIs do not lend funds to other FIs, because FIs can receive only the risk-free rate of return while their cost of funds exceeds the risk-free rate.

In this two-country model, we further assume that each entrepreneur faces two monopolistic FIs at

Each group-j_i entrepreneur owns net worth $N^E\left(s^t\right)$.[22] It uses $1-\tau_H^E$ of the net worth to purchase capital of $(1-\tau_H^E)Q\left(s^t\right)K_H\left(s^t\right)$, where s^t is state of the economy in period t and $Q\left(s^t\right)$ is the price paid to capital in units of the household consumption index. $(1-\tau_H^E)K_H\left(s^t\right)$ is the quantity of capital purchased by a group-j_i entrepreneur. Following BGG, we assume that entrepreneurs are subject to an idiosyncratic productivity shock $\omega_H^E\left(s^{t+1}\right)$[23] so that the net return to capital is $\omega_H^E\left(s^{t+1}\right)R_H^E\left(s^{t+1}\right)$, where $R_H^E\left(s^t\right)$ is the aggregate return to capital. The FE contract specifies (1) the amount of debt that a group-j_i entrepreneur borrows from type-i FI, $(1-\tau_H^E)(Q\left(s^t\right)K_H\left(s^t\right)-N^E\left(s^t\right))$; (2) the cut-off value for the idiosyncratic shock $\omega_H^E\left(s^{t+1}\right)$, which we denote by $\overline{\omega}_H^E\left(s^{t+1}|s^t\right)$, such that entrepreneurs repay their debt for $\omega_H^E\left(s^{t+1}\right)\geq\overline{\omega}_H^E\left(s^{t+1}|s^t\right)$ and declare the default for $\omega_H^E\left(s^{t+1}\right)<\overline{\omega}_H^E\left(s^{t+1}|s^t\right)$; and (3) a loan rate that group-j_i entrepreneurs repay when they do not default, $Z_H^E\left(s^{t+1}|s^t\right)$, which we will specify below. *Ex post*, the non-default entrepreneur j_i receives $(1-\tau_H^E)\left(\omega_H^E\left(s^{t+1}\right)-\overline{\omega}_H^E\left(s^{t+1}|s^t\right)\right)R_H^E\left(s^{t+1}\right)Q\left(s^t\right)K_H\left(s^t\right)$ and the default entrepreneur receives nothing from the contract.

There is a participation constraint for entrepreneurs in the FE contract. Instead of participating in the FE contract, group-j_i entrepreneurs can purchase capital goods using their own net worth $N^E\left(s^t\right)$, without participating in loan contracts with FIs. In this alternative case, the *ex post* return to their investments equals $(1-\tau_H^E)\omega_H^E\left(s^{t+1}\right)R_H^E\left(s^{t+1}\right)N^E\left(s^t\right)$. Therefore, an FE contract between an FI and entrepreneurs is agreed only when the following inequality is expected to hold:

$$\begin{aligned}&\overbrace{\left[1-\Gamma_t^E\left(\overline{\omega}_H^E\left(s^{t+1}|s^t\right)\right)\right]}^{\text{share of entrepreneurial earnings paid to entrepreneur}}\quad R_H^E\left(s^{t+1}|s^t\right)Q\left(s^t\right)K_H\left(s^t\right)\\ &\geq\ R_H^E\left(s^{t+1}|s^t\right)N^E\left(s^t\right)\\ &\qquad\text{for }\forall j_i,s^{t+1}|s^t,\end{aligned}\tag{1}$$

where

home and abroad. It implies that when a Japanese manufacturer constructs a factory in the United States, it borrows a portion of funds from a Japanese bank and remaining funds from a U.S. bank.

[22]Net worth depends on group j_i, but in what follows we do not indicate the subscript of j_i for simplicity. The same applies to capital K and idiosyncratic productivity shock ω.

[23]The ω^E is unit mean, lognormal random variables distributed independently over time and across entrepreneurs and FIs. We express its density function of these variables as $f_t^E\left(\omega^E\right)$, and its cumulative distribution functions as $F_t^E\left(\omega^E\right)$.

$$\Gamma_t\left(\overline{\omega}\left(s^{t+1}|s^t\right)\right) \equiv \overbrace{G_t\left(\overline{\omega}\left(s^{t+1}|s^t\right)\right)}^{\text{expected productivity of defaulted borrowers}}$$
$$+\overline{\omega}\left(s^{t+1}|s^t\right) \overbrace{\int_{\overline{\omega}(s^{t+1}|s^t)}^{\infty} dF_t\left(\omega\right)}^{\text{portion of non-defaulted borrowers}} ,$$

$$G_t\left(\overline{\omega}\left(s^{t+1}|s^t\right)\right) \equiv \int_0^{\overline{\omega}\left(s^{t+1}|s^t\right)} \omega dF_t\left(\omega\right).$$

Note that $1-\Gamma_t^E$ is the expected share of profits that goes to the borrowers in the FE contract. The left-hand side of the inequality (1) shows the expected return from the FE contract for group-j_i entrepreneurs, and the right-hand side of the inequality (1) shows the expected return from investing the entrepreneurial net worth $N^E\left(s^t\right)$. Credit contracts are signed only when the inequality holds.

Similarly, we model the FE contract between FIs in the home country and entrepreneurs in the foreign country. The entrepreneurs are subject to an idiosyncratic productivity shock $\omega_H^{E*}\left(s^{t+1}\right)$, and the FE contract specifies the cut-off value $\overline{\omega}_H^{E*}\left(s^{t+1}|s^t\right)$.[24] An entrepreneurial participation constraint is described as

$$\left[1-\Gamma_t^{E*}\left(\overline{\omega}_H^{E*}\left(s^{t+1}|s^t\right)\right)\right] R_H^{E*}\left(s^{t+1}|s^t\right) Q^*\left(s^t\right) K_H^*\left(s^t\right)$$

$$\geq R_H^{E*}\left(s^{t+1}|s^t\right) N^{E*}\left(s^t\right) \quad \text{for } \forall j_i, s^{t+1}|s^t. \tag{2}$$

Variables with the superscript $*$ correspond to those in the foreign country. $\tau_H^E K_H^*\left(s^t\right)$ represents the quantity of capital purchased by entrepreneurs in the foreign country using loans from the FI in the home country. $Q^*\left(s^t\right)$ is the price paid to capital in units of the household consumption index in the foreign country.

The inequality (1) and (2) gives the expression for the expected earnings of a type-i

[24] In addition, we introduce idiosyncratic shocks ω_F^E and ω_F^{E*} associated with the FE contracts between FIs in the foreign country and entrepreneurs in the two countries. Each of them is the same as ω_H^E and ω_H^{E*}, respectively. However, the cut-off values for the idiosyncratic shocks $\overline{\omega}_H^E$ and $\overline{\omega}_H^{E*}$ are different from $\overline{\omega}_F^E$ and $\overline{\omega}_F^{E*}$. In other words, an entrepreneur in the home country faces one idiosyncratic shock ω^E and two cut-off values $\overline{\omega}_H^E$ and $\overline{\omega}_F^E$ when entering into two FE contracts. It leads to a possibility that an entrepreneur declares the default for one FE contract but not for the other FE contract. If the default is declared, its lender monitors the entrepreneur and receives a portion of entrepreneurial profits that are obtained due to the lender's loans.

FI from each of the FE contract

$$\overbrace{\Phi_t^E\left(\overline{\omega}_H^E\left(s^{t+1}|s^t\right)\right)}^{\text{share of entrepreneurial earnings paid to FI}} \qquad (1-\tau_H^E)R_H^E\left(s^{t+1}|s^t\right)Q\left(s^t\right)K_H\left(s^t\right)$$

$$+ \qquad \overbrace{\Phi_t^{E*}\left(\overline{\omega}_H^{E*}\left(s^{t+1}|s^t\right)\right)}^{\text{share of entrepreneurial earnings paid to FI}} \qquad \tau_F^E e(s^{t+1}|s^t)R_H^{E*}\left(s^{t+1}|s^t\right)Q^*\left(s^t\right)K_H^*\left(s^t\right),$$

where $e(s^t)$ represents a real exchange rate. The first term indicates earnings from the FE contract with entrepreneurs in the home country. The second term indicates earnings from the FE contract with entrepreneurs in the foreign country. The earnings are converted from units of the household consumption index in the foreign country to units of the household consumption index in the home country with their relative price of $e(s^{t+1}|s^t)$. Φ_t represents a net lender's share, defined as

$$\Phi_t\left(\overline{\omega}\left(s^{t+1}|s^t\right)\right) \equiv \Gamma_t\left(\overline{\omega}\left(s^{t+1}|s^t\right)\right) - \mu G_t\left(\overline{\omega}_{i,t+1}\right).$$

A parameter μ $(0<\mu<1)$ represents the parameter of monitoring costs. In particular, we define four parameters: μ_H^E, μ_F^E, μ_H^F, and μ_F^F. The parameter μ_H^E (μ_F^E) represents the cost to monitor entrepreneurs by FIs in the home (foreign) country. The parameter μ_H^F (μ_F^F) represents the cost to monitor FIs by investors in the home (foreign) country.

Because each type-i FI lends a continuum number of entrepreneurs in group j_i, the loan risk of the FI is perfectly diversified. For convenience, we define the expected return on the loans to entrepreneurs, $R^F\left(s^{t+1}|s^t\right)$ by

$$\begin{aligned}
&\int_{j_i}\Phi_t^E\left(\overline{\omega}_H^E\left(s^{t+1}|s^t\right)\right)(1-\tau_H^E)R_H^E\left(s^{t+1}|s^t\right)Q\left(s^t\right)K_H\left(s^t\right)dj_i \\
&+\int_{j_i}\Phi_t^{E*}\left(\overline{\omega}_H^{E*}\left(s^{t+1}|s^t\right)\right)\tau_F^E\frac{e(s^{t+1}|s^t)}{e(s^t)}R_H^{E*}\left(s^{t+1}|s^t\right)e(s^t)Q^*\left(s^t\right)K_H^*\left(s^t\right)dj_i \\
&\equiv R^F\left(s^{t+1}|s^t\right)\left\{\begin{array}{c}(1-\tau_H^E)(Q\left(s^t\right)K_H\left(s^t\right)-N^E\left(s^t\right)) \\ +\tau_F^E e(s^t)(Q^*\left(s^t\right)K_H^*\left(s^t\right)-N^{E*}\left(s^t\right))\end{array}\right\}, \\
&\text{for } \forall s^{t+1}|s^t.
\end{aligned} \tag{3}$$

The left-hand side of equation (3) is the gross profit that a specific type-i FI receives from a continuum number of FE contracts with group-j_i entrepreneurs in the two countries. On the right-hand side of the equation, $\tau_F^E e(s^t)(Q^*\left(s^t\right)K_H^*\left(s^t\right)-N^{E*}\left(s^t\right))$ represents loans to entrepreneurs in the foreign country in units of the household consumption index in the home country.

The relationship between the cut-off value $\overline{\omega}_H^E\left(s^{t+1}|s^t\right)$ and non-default entrepreneurs' loan rate $Z_H^E\left(s^{t+1}|s^t\right)$ is given by

$$\overline{\omega}_H^E\left(s^{t+1}|s^t\right)R_H^E\left(s^{t+1}|s^t\right)Q\left(s^t\right)K_H\left(s^t\right)=Z_H^E\left(s^{t+1}|s^t\right)\left(Q\left(s^t\right)K_H\left(s^t\right)-N^E\left(s^t\right)\right). \tag{4}$$

Similarly, for the FE contract between FIs in the home country and entrepreneurs in the foreign country, we obtain $Z_H^{E*}\left(s^{t+1}|s^t\right)$ as

$$\overline{\omega}_H^{E*}\left(s^{t+1}|s^t\right)R_H^{E*}\left(s^{t+1}|s^t\right)Q^*\left(s^t\right)K_H^*\left(s^t\right)=Z_H^{E*}\left(s^{t+1}|s^t\right)\left(Q^*\left(s^t\right)K_H^*\left(s^t\right)-N^{E*}\left(s^t\right)\right). \tag{5}$$

IF contract

We next turn to the IF contract. A type-i FI splits these gross profits from the FE contract with investors according to another credit contract, the IF contract. The IF contract has the same costly state verification structure as does the FE contract, whereas FIs now need to act as the borrowers rather than lenders. In the IF contract, investors lend the loans to a continuum number of FIs. Each type-i FI in the home country owns the net worth $N^F\left(s^t\right)$, and invests in the loans to group-j_i entrepreneurs in the home country an amount $(1-\tau_H^E)(Q\left(s^t\right)K_H\left(s^t\right)-N^E\left(s^t\right))$ and group-j_i entrepreneurs in the foreign country an amount $\tau_F^E(Q^*\left(s^t\right)K_H^*\left(s^t\right)-N^{E*}\left(s^t\right))$. The type-$i$ FI then borrows the rest from investors in the home country by a portion of $1-\tau_H^F$ and investors in the foreign country by a portion of τ_H^F. It repays the loan using its profit from the FE contracts. On top of $\omega_H^E\left(s^{t+1}\right)$ and $\omega_H^{E*}\left(s^{t+1}\right)$, which are the idiosyncratic productivity shocks associated with entrepreneurs, we assume that the type-i FI is subject to an idiosyncratic productivity shock $\omega_H^F\left(s^{t+1}\right)$[25] and its *ex post* gross return on the loans to entrepreneurs is given by $\omega_H^F\left(s^{t+1}\right)R^F\left(s^{t+1}\right)$. Here, the IF contract specifies (1) the amount of debt that the type-i FI borrows from investors; (2) the cut-off value for the idiosyncratic shock $\omega_H^F\left(s^{t+1}\right)$ and $\omega_H^{F*}\left(s^{t+1}\right)$, which we denote by $\overline{\omega}_H^F\left(s^{t+1}|s^t\right)$ and $\overline{\omega}_H^{F*}\left(s^{t+1}|s^t\right)$, such that FIs repay their debt for $\omega_H^F\left(s^{t+1}\right)\geq\overline{\omega}_H^F\left(s^{t+1}|s^t\right)$ and declare the default for $\omega_H^F\left(s^{t+1}\right)<\overline{\omega}_H^F\left(s^{t+1}|s^t\right)$; and (3) the return rate of the loan when type-i FI does not default, $Z_H^F\left(s^{t+1}|s^t\right)$ and $Z_H^{F*}\left(s^{t+1}|s^t\right)$.

Similar to the FE contract, there is a participation constraint for the investors in

[25] We assume that two variables ω^E and ω^F are unit mean, lognormal random variables distributed independently over time and across entrepreneurs and FIs. We express the density function of these variables as $f_t^E\left(\omega^E\right)$ and $f_t^F\left(\omega^F\right)$, and their cumulative distribution functions as $F_t^E\left(\omega^E\right)$ and $F_t^F\left(\omega^F\right)$. FI's idiosyncratic productivity shock ω^F is associated with the shock in bankruptcy costs, technology of financing short-term assets and liabilities, or the quality of borrowers in the FE contract that differs across FIs.

the IF contract. Given the risk-free rate of return in the economy $R\left(s^{t}\right)$ and $R^{*}\left(s^{t}\right)$, investors' profit from the investment in the loans to the FIs must equal the opportunity cost of lending. That is,

$$\begin{aligned}
&\Phi_{t}^{F}\left(\overline{\omega}_{H}^{F}\left(s^{t+1}|s^{t}\right)\right)(1-\tau_{H}^{F}) \\
&\cdot R^{F}\left(s^{t+1}|s^{t}\right)\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right)) \\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))\end{array}\right\}
\end{aligned}$$

$$\begin{aligned}
\geq\ & R\left(s^{t}\right)(1-\tau_{H}^{F}) \\
&\cdot\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right)) \\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))-N^{F}\left(s^{t}\right)\end{array}\right\},
\end{aligned} \tag{6}$$

$$\begin{aligned}
&\Phi_{t}^{F*}\left(\overline{\omega}_{H}^{F*}\left(s^{t+1}|s^{t}\right)\right)\tau_{H}^{F} \\
&\cdot\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right)) \\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))\end{array}\right\}
\end{aligned}$$

$$\begin{aligned}
\geq\ & \frac{e(s^{t+1}|s^{t})}{e(s^{t})}R^{*}\left(s^{t}\right)\tau_{H}^{F} \\
&\cdot R^{F}\left(s^{t+1}|s^{t}\right)\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right)) \\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))-N^{F}\left(s^{t}\right)\end{array}\right\}.
\end{aligned} \tag{7}$$

Equation (6) represents the participation constraint for the home investors in the IF contract. The left-hand side is the expected profits from the investment in the loans to the FIs, where $R^{F}\left(s^{t+1}|s^{t}\right)$ is given by equation (3). The right-hand side is the expected profits from the investment in risk-free assets.

Expected net profits for the type-i FI in the home country are expressed by

$$\begin{aligned}
&\sum_{s^{t+1}}\Pi\left(s^{t+1}|s^{t}\right)\left[1-\Gamma_{t}^{F}\left(\overline{\omega}_{H}^{F}\left(s^{t+1}|s^{t}\right)\right)\right](1-\tau_{H}^{F}) \\
&\cdot R^{F}\left(s^{t+1}|s^{t}\right)\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right)) \\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))\end{array}\right\}
\end{aligned}$$

$$+\sum_{s^{t+1}}\Pi\left(s^{t+1}|s^{t}\right)\left[1-\Gamma_{t}^{F*}\left(\overline{\omega}_{H}^{F*}\left(s^{t+1}|s^{t}\right)\right)\right]\tau_{H}^{F}$$
$$\cdot R^{F}\left(s^{t+1}|s^{t}\right)\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right))\\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))\end{array}\right\}, \tag{8}$$

where $\Pi\left(s^{t+1}|s^{t}\right)$ is a probability weight for state s^{t+1}, depending on the information set available at period t. Note that $1-\Gamma_{t}^{F}\left(\overline{\omega}_{H}^{F}\left(s^{t+1}|s^{t}\right)\right)$ represents the borrower's share in the IF contract.

The relationship between the cut-off values $\overline{\omega}_{H}^{F}\left(s^{t+1}|s^{t}\right)$ and $\overline{\omega}_{H}^{F*}\left(s^{t+1}|s^{t}\right)$ and non-default FIs' loan rates $Z_{H}^{F}\left(s^{t+1}|s^{t}\right)$ and $Z_{H}^{F*}\left(s^{t+1}|s^{t}\right)$ is given by

$$\begin{aligned}&\overline{\omega}_{H}^{F}\left(s^{t+1}|s^{t}\right)\\ &\cdot R^{F}\left(s^{t+1}|s^{t}\right)\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right))\\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))\end{array}\right\}\\ =\;&Z_{H}^{F}\left(s^{t+1}|s^{t}\right)\\ &\cdot\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right))\\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))-N^{F}\left(s^{t}\right)\end{array}\right\},\end{aligned} \tag{9}$$

$$\begin{aligned}&\overline{\omega}_{H}^{F*}\left(s^{t+1}|s^{t}\right)\\ &\cdot R^{F}\left(s^{t+1}|s^{t}\right)\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right))\\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))\end{array}\right\}\\ =\;&Z_{H}^{F*}\left(s^{t+1}|s^{t}\right)\\ &\cdot\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t}\right)K_{H}\left(s^{t}\right)-N^{E}\left(s^{t}\right))\\ +\tau_{F}^{E}e(s^{t})(Q^{*}\left(s^{t}\right)K_{H}^{*}\left(s^{t}\right)-N^{E*}\left(s^{t}\right))-N^{F}\left(s^{t}\right)\end{array}\right\},\end{aligned} \tag{10}$$

Optimal credit contract

Expected returns to capital $R_{H}^{E}\left(s^{t+1}|s^{t}\right)$ and $R_{H}^{E*}\left(s^{t+1}|s^{t}\right)$ are derived by solving the optimal credit contract. $R_{H}^{E}\left(s^{t+1}|s^{t}\right)$ and $R_{H}^{E*}\left(s^{t+1}|s^{t}\right)$ are hereafter called cost-of-funds. They represent the cost for entrepreneurs in the home country to borrow funds from FIs in the home country and FIs in the foreign country, respectively. A difference of $R_{H}^{E}\left(s^{t+1}|s^{t}\right)$ and $R_{H}^{E*}\left(s^{t+1}|s^{t}\right)$ from the risk-free rate is called the external finance premium.

A type-i FI in the home country maximizes its expected profit (8) by optimally choosing the variables $\overline{\omega}_{H}^{F}$, $\overline{\omega}_{H}^{F*}$, $\overline{\omega}_{H}^{E}$, $\overline{\omega}_{H}^{E*}$, K_{H}, K_{H}^{*}, subject to the investors' participation constraints (6) and (7) and entrepreneurial participation constraints (1) and (2). We obtain

$$
\begin{aligned}
0 = \sum_{s^{t+1}|s^t} \Pi\left(s^{t+1}|s^t\right) \Big[& R_H^E\left(s^{t+1}|s^t\right)\left\{\left(1-\Gamma_t^E\right)\Phi_t^{E\prime}+\Gamma_t^{E\prime}\Phi_t^E\right\} \\
& \cdot\left\{\left(1-\tau_H^F\right)\left(1-\Gamma_t^F\right)+\tau_H^F\left(1-\Gamma_t^{F*}\right)\right\} \\
& +\frac{(1-\tau_H^F)\Gamma_t^{F\prime}}{\Phi_t^{F\prime}}\left\{\left(1-\Gamma_t^E\right)\Phi_t^F\Phi_t^{E\prime}R_H^E\left(s^{t+1}|s^t\right)+\Gamma_t^{E\prime}\Phi_t^F\Phi_t^E R_H^E\left(s^{t+1}|s^t\right)\right. \\
& \left. -\Gamma_t^{E\prime}R(s^t)\right\} \\
& +\frac{\tau_H^F\Gamma_t^{F*\prime}}{\Phi_t^{F*\prime}}\left\{\left(1-\Gamma_t^E\right)\Phi_t^{F*}\Phi_t^{E\prime}R_H^E\left(s^{t+1}|s^t\right)+\Gamma_t^{E\prime}\Phi_t^{F*}\Phi_t^E R_H^E\left(s^{t+1}|s^t\right)\right. \\
& \left. -\Gamma_t^{E\prime}\frac{e(s^{t+1})}{e(s^t)}R^*(s^t)\right\}
\end{aligned}
$$

for $\forall j_i$, (11)

$$
\begin{aligned}
0 = \sum_{s^{t+1}|s^t} \Pi\left(s^{t+1}|s^t\right) \Big[& R_H^{E*}\left(s^{t+1}|s^t\right)\left\{\left(1-\Gamma_t^{E*}\right)\Phi_t^{E*\prime}+\Gamma_t^{E*\prime}\Phi_t^{E*}\right\} \\
& \cdot\left\{\left(1-\tau_H^F\right)\left(1-\Gamma_t^F\right)+\tau_H^F\left(1-\Gamma_t^{F*}\right)\right\} \\
& +\frac{(1-\tau_H^F)\Gamma_t^{F\prime}}{\Phi_t^{F\prime}}\left\{\left(1-\Gamma_t^{E*}\right)\Phi_t^F\Phi_t^{E*\prime}R_H^{E*}\left(s^{t+1}|s^t\right)+\Gamma_t^{E*\prime}\Phi_t^F\Phi_t^{E*} R_H^{E*}\left(s^{t+1}|s^t\right)\right. \\
& \left. -\Gamma_t^{E*\prime}R(s^t)\right\} \\
& +\frac{\tau_H^F\Gamma_t^{F*\prime}}{\Phi_t^{F*\prime}}\left\{\left(1-\Gamma_t^{E*}\right)\Phi_t^{F*}\Phi_t^{E*\prime}R_H^{E*}\left(s^{t+1}|s^t\right)+\Gamma_t^{E*\prime}\Phi_t^{F*}\Phi_t^{E*} R_H^{E*}\left(s^{t+1}|s^t\right)\right. \\
& \left. -\Gamma_t^{E*\prime}\frac{e(s^{t+1})}{e(s^t)}R^*(s^t)\right\}
\end{aligned}
$$

for $\forall j_i$. (12)

In the contract between FIs and entrepreneurs both in the home country, the ratio of capital K_H to net worth N^F and N^E is same across FIs and entrepreneurs. Similarly, in the contract between FIs in the home country and entrepreneurs in the foreign country, the ratio of capital K_H^* to net worth N^F and N^{E*} is the same across FIs and entrepreneurs. That facilitates aggregation.

Simplified form of the external finance premium

From equations (3), (6), and (7), the external finance premium $\mathrm{E}_t\{R_H^E\left(s^{t+1}\right)\}/R\left(s^t\right)$

is simplified as[26]

$$\frac{\mathrm{E}_t\left\{R_H^E\left(s^{t+1}\right)\right\}}{R\left(s^t\right)}=F\left(\frac{N^F\left(s^t\right)}{Q\left(s^t\right)K_H\left(s^t\right)},\frac{N^E\left(s^t\right)}{Q\left(s^t\right)K_H\left(s^t\right)},\frac{N^{F*}\left(s^t\right)}{Q^*\left(s^t\right)K_H^*\left(s^t\right)},\frac{N^{E*}\left(s^t\right)}{Q^*\left(s^t\right)K_H^*\left(s^t\right)}\right). \tag{13}$$

$\mathrm{E}_t\{R_H^E\left(s^{t+1}\right)\}$ is called cost-of-funds. The cost-of-funds plays an important role in investment. Higher cost-of-funds lowers the price of capital Q, and discourages investment. In BGG, the external finance premium is decreasing in the entrepreneurial net worth ratio. In HSU, FIs as well as entrepreneurs are credit constrained, and the external finance premium is decreasing in both FIs' and entrepreneurial net worth ratios. In our model, the external finance premium depends on four net worth ratios: FIs' and entrepreneurial net worth ratios in the two countries. We investigate numerically how each net worth affects the external finance premium in the next section. Under banking globalization ($\tau > 0$), the external finance premium is decreasing in the four net worth ratios.

Dynamic behavior of net worth

The net worths of FIs and entrepreneurs, $N^F\left(s^t\right)$ and $N^E\left(s^t\right)$, depend on their earnings from the credit contracts and their labor income. In addition to the profits from entrepreneurial projects, both FIs and entrepreneurs inelastically supply a unit of labor to wholesale goods producers and receive labor income $W^F\left(s^t\right)$ and $W^E\left(s^t\right)$. We assume that each FI and entrepreneur survives to the next period with a constant probability γ^F and γ^E; then the aggregate net worths of FIs and entrepreneurs are given by

$$N^F\left(s^t\right)=\gamma^F V^F\left(s^t\right)+W^F\left(s^t\right)+\varepsilon^{nF}\left(s^t\right), \tag{14}$$

$$N^E\left(s^t\right)=\gamma^E V^E\left(s^t\right)+W^E\left(s^t\right)+\varepsilon^{nE}\left(s^t\right), \tag{15}$$

with

[26] To be more precise, the external finance premium depends on other variables such as the real exchange rate and the risk-free rate in the foreign country.

$$
\begin{aligned}
V^F\left(s^t\right) \equiv & \left[1-\Gamma_{t-1}^F\left(\overline{\omega}_H^F\left(s^t\right)\right)\right](1-\tau_H^F)R^F\left(s^t\right) \\
& \cdot\left\{\begin{array}{c} (1-\tau_H^E)(Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right)-N^E\left(s^{t-1}\right)) \\ +\tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right)K_H^*\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right)) \end{array}\right\} \\
& +\left[1-\Gamma_{t-1}^{F*}\left(\overline{\omega}_H^{F*}\left(s^t\right)\right)\right]\tau_H^F R^F\left(s^t\right) \\
& \cdot\left\{\begin{array}{c} (1-\tau_H^E)(Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right)-N^E\left(s^{t-1}\right)) \\ +\tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right)K_H^*\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right)) \end{array}\right\}, \qquad (16)
\end{aligned}
$$

$$
\begin{aligned}
V^E\left(s^t\right) \equiv & \left(1-\Gamma_{t-1}^E\left(\overline{\omega}_H^E\left(s^t\right)\right)\right)(1-\tau_H^E)R_H^E\left(s^t\right)Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right) \\
& +\left(1-\Gamma_{t-1}^E\left(\overline{\omega}_F^E\left(s^t\right)\right)\right)\tau_H^E R_F^E\left(s^t\right)Q\left(s^{t-1}\right)K_F\left(s^{t-1}\right). \qquad (17)
\end{aligned}
$$

FIs and entrepreneurs that fail to survive at period t consume $\left(1-\gamma^F\right)V^F\left(s^t\right)$ and $\left(1-\gamma^E\right)V^E\left(s^t\right)$, respectively. Following Gilchrist and Leahy (2002), we consider $\varepsilon^{nF}\left(s^t\right)$ and $\varepsilon^{nE}\left(s^t\right)$, once-and-for-all changes in the FI's and entrepreneurial net worth.

3.2 Goods Market

For the setup of the goods market, we follow the two-country model of BKK (1992, 1994), and its sticky price extension by Clarida, Gali, and Gertler (2002) and Faia (2007). Final goods produced in two countries are different and tradable; labor and physical capital are immobile; bond markets, implicit in the model, are complete. Consumption goods in each country are produced by the final goods producers using the Dixit-Stiglitz aggregator of differentiated retail goods. These retail goods are produced by the monopolistic producers who set Calvo-type sticky prices, using the wholesale goods. The wholesale goods are produced by the competitive firms converting capital and labor inputs. Capital goods are supplied by entrepreneurs, and labor inputs are supplied by household, FIs, and entrepreneurs.

Household

A representative household in the home country is infinitely lived, and maximizes the following utility function:

$$
\max_{C(s^t),H(s^t),D(s^t),B^*(s^t)} \sum_{l=0} \beta^{t+l}\mathrm{E}_t\left\{\frac{C\left(s^{t+l}\right)^{1-\sigma}}{1-\sigma}-\chi_2\frac{H\left(s^{t+l}\right)^{1+\frac{1}{\chi_1}}}{1+\frac{1}{\chi_1}}\right\}, \qquad (18)
$$

subject to the budget constraint

$$
\begin{aligned}
& C\left(s^t\right)+D\left(s^t\right)+e(s^t)B^*\left(s^t\right) \\
\leq\ & W\left(s^t\right)H\left(s^t\right)+R\left(s^{t-1}\right)D\left(s^{t-1}\right)+R^*\left(s^{t-1}\right)e(s^t)B^*\left(s^{t-1}\right)+\Pi\left(s^t\right)-T\left(s^t\right).
\end{aligned}
$$

$C\left(s^t\right)$ is final goods consumption given by

$$
C\left(s^t\right)=\left((1-\gamma_H)^{1/\eta}C_H\left(s^t\right)^{(\eta-1)/\eta}+\gamma_H^{1/\eta}C_F\left(s^t\right)^{(\eta-1)/\eta}\right)^{\eta/(\eta-1)}, \tag{19}
$$

where $C_H\left(s^t\right)$ and $C_F\left(s^t\right)$ denote the consumption of home-produced goods spent in the home country and the consumption of foreign-produced goods spent in the home country, respectively. $H\left(s^t\right)$ is hours worked. $P\left(s^t\right)$ is the aggregate price of the final goods given by

$$
P\left(s^t\right)=\left((1-\gamma_H)P_H\left(s^t\right)^{1-\eta}+\gamma_H P_F\left(s^t\right)^{1-\eta}\right)^{1/(1-\eta)}. \tag{20}
$$

$W\left(s^t\right)$ is the real wage in units of the household consumption index, and $T\left(s^t\right)$ is the lump-sum transfer. $R\left(s^t\right)$ and $R^*\left(s^t\right)$ are the real risk-free return from the deposit $D\left(s^t\right)$ and $B^*\left(s^t\right)$ between time t and $t+1$. Parameters $\beta\in(0,1)$, χ_1, and χ_2 are the subjective discount factor, the elasticity of leisure, and the utility weight on leisure. A parameter η represents the elasticity of substitution between home-produced goods and foreign-produced goods. Bond markets are complete; bonds are contingent on the set of aggregate states. The ratio of the marginal utility of consumption in the home country to the marginal utility of consumption in the foreign country becomes proportional to the real exchange rate. $D\left(s^t\right)$ is real domestic deposits held by investors, and $B^*\left(s^t\right)$ is real foreign deposits held by investors.

Trade openness is captured by γ_H. The parameter γ_H represents the weight on foreign-produced goods. Similarly, we define the weight on home-produced goods in the foreign country as γ_F. Those parameters indicate the inverse degree of a home bias.

Final goods producer

The final goods $Y_H\left(s^t\right)$ are composites along a continuum of retail goods $Y_H\left(h,s^t\right)$. The final goods producer purchases retails goods in the competitive market and sells the output to a household and capital producers with price $P_H\left(s^t\right)$. The production technology of the final goods is given by

$$Y_H\left(s^t\right) = \left[\int_0^1 Y_H\left(h, s^t\right)^{\frac{\epsilon-1}{\epsilon}} dh\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{21}$$

where $\epsilon > 1$. The corresponding price index is given by

$$P_H\left(s^t\right) = \left[\int_0^1 P_H\left(h, s^t\right)^{1-\epsilon} dh\right]^{\frac{1}{1-\epsilon}}. \tag{22}$$

Retail goods producer

The retail goods producers $h \in [0,1]$ are populated over a unit interval, each producing differentiated retail goods $Y_H(h, s^t)$, with production technology

$$Y_H\left(h, s^t\right) = y_H\left(h, s^t\right), \tag{23}$$

where $y_H(h, s^t)$ for $h \in [0,1]$ are the wholesale goods that is used for producing the retail goods $Y_H(h, s^t)$ by the retail goods producer $h \in [0,1]$. The retail goods producers are price takers in the input market and choose their inputs taking the input price $P(s^t)/X_H(s^t)$ as given. They are monopolistic suppliers in their output market, and set their prices to maximize profits. Consequently, the retail goods producer h faces a downward-sloping demand curve:

$$Y_H\left(h, s^t\right) = \left(\frac{P_H\left(h, s^t\right)}{P_H\left(s^t\right)}\right)^{-\epsilon} Y_H\left(s^t\right).$$

The retail goods producers are subject to nominal rigidity. They can change prices in a given period only with probability $(1-\xi)$, according to Calvo-type price stickiness. Denoting the price set by the active retail goods producers by $P_H^O(h, s^t)$, retailer h 's optimization problem with respect to its products' price $P_H^O(h, s^t)$ is written as follows:

$$\sum_{l=0}^{\infty} \xi^l \beta^l E_t \frac{C\left(s^{t+l}\right)^{-\sigma}}{C\left(s^t\right)^{-\sigma}} \left(\frac{P_H^O\left(h, s^t\right) Y_H\left(h, s^{t+l}\right)}{P\left(s^{t+l}\right)} - \frac{\left(\frac{P\left(s^{t+l}\right)}{X_H\left(s^{t+l}\right)}\right) Y_H\left(h, s^{t+l}\right)}{P\left(s^{t+l}\right)}\right) = 0.$$

Using equations (21), (22), and (23), final goods $Y_H(s^t)$ produced in period t are expressed with wholesale goods produced in period t as the following equation:

$$\begin{aligned} y_H\left(s^t\right) &= \int_0^1 y_H\left(h, s^t\right) dh = \int_0^1 \left(\frac{P_H\left(h, s^t\right)}{P_H\left(s^t\right)}\right)^{-\epsilon} Y_H\left(s^t\right) dh \\ &= \left[\int_0^1 \left(\frac{P_H\left(h, s^t\right)}{P_H\left(s^t\right)}\right)^{-\epsilon} dh\right] Y_H\left(s^t\right). \end{aligned} \tag{24}$$

Because of the stickiness of the retail goods price, the aggregate price index for the final goods $P_H\left(s^t\right)$ evolves according to the law of motion below:

$$P_H\left(s^t\right)^{1-\epsilon} = (1-\xi) P_H^O\left(h, s^t\right)^{1-\epsilon} + \xi P_H\left(s^{t-1}\right)^{1-\epsilon}.$$

Wholesale goods producer

The wholesale goods producers produce wholesale goods $y_H\left(s^t\right)$ and sell them to the retail goods producers with the relative price $1/X_H\left(s^t\right)$. They hire three types of labor inputs $H\left(s^t\right)$, $H^F\left(s^t\right)$, and $H^E\left(s^t\right)$, and capital $K\left(s^{t-1}\right)$. Those labor inputs are supplied by household, FIs, and entrepreneurs for wages $W\left(s^t\right)$, $W^F\left(s^t\right)$, and $W^E\left(s^t\right)$, respectively. Capital is supplied by home (foreign) entrepreneurs with the rental price $R_H^E\left(s^t\right)$ ($R_F^E\left(s^t\right)$). At the end of each period, the capital is sold back to the entrepreneurs at price $Q\left(s^t\right)$. The price of a unit of capital $Q\left(s^t\right)$ is the same for $K_H\left(s^{t-1}\right)$ and $K_F\left(s^{t-1}\right)$.[27] The maximization problem for the wholesale goods producer is given by

$$\begin{aligned} \max_{y_H(s^t), K(s^{t-1}), H(s^t), H^F(s^t), H^E(s^t)} & \frac{1}{X_H\left(s^t\right)} y_H\left(s^t\right) \\ & + Q\left(s^t\right)\{(1-\tau_H^E) K_H\left(s^{t-1}\right) + \tau_H^E K_F\left(s^{t-1}\right)\}(1-\delta) \\ & - Q\left(s^{t-1}\right)\left\{(1-\tau_H^E) R_H^E\left(s^t\right) K_H\left(s^{t-1}\right) + \tau_H^E R_F^E\left(s^t\right) K_F\left(s^{t-1}\right)\right\} \\ & - W\left(s^t\right) H\left(s^t\right) - W^F\left(s^t\right) H^F\left(s^t\right) - W^E\left(s^t\right) H^E\left(s^t\right), \end{aligned} \tag{25}$$

[27] For capital supplier's point of view, entrepreneurs in the home country provide the wholesale goods producers with $K_H\left(s^{t-1}\right)$ and $K_F\left(s^{t-1}\right)$ by borrowing funds from FIs in the home country and FIs in the foreign country, respectively.

subject to

$$K\left(s^{t}\right) = (1-\tau_{H}^{E})K_{H}\left(s^{t}\right)+\tau_{H}^{E}K_{F}\left(s^{t}\right), \tag{26}$$

$$\begin{aligned} y_{H}\left(s^{t}\right) &= A\exp\left(e^{A}\left(s^{t}\right)\right)K\left(s^{t-1}\right)^{\alpha}H\left(s^{t}\right)^{(1-\Omega_{F}-\Omega_{E})(1-\alpha)} \\ &\quad H^{F}\left(s^{t}\right)^{\Omega_{F}(1-\alpha)}H^{E}\left(s^{t}\right)^{\Omega_{E}(1-\alpha)}, \end{aligned} \tag{27}$$

where $A\exp\left(e^{A}\left(s^{t}\right)\right)$ denotes the level of technology of wholesale production. $\delta\in(0,1]$, α, Ω_F, and Ω_E are the depreciation rate of capital goods, the capital share, the share of FIs' labor inputs, and the share of entrepreneurial labor inputs.

Capital goods producer

The capital goods producers own the technology that converts final goods to capital goods. In each period, capital goods producers in the home country purchase $I\left(s^{t}\right)$ amounts of final goods from the final goods producers in the home country. In addition, they purchase $K\left(s^{t-1}\right)(1-\delta)$ of used capital goods from the entrepreneurs in the home country at price $Q\left(s^{t}\right)$. They then produce new capital goods $K\left(s^{t}\right)$, using the technology F_I, and sell them in the competitive market at price $Q\left(s^{t}\right)$. Consequently, the capital goods producer's problem is to maximize the following profit function:

$$\max_{I(s^{t})}\sum_{l=0}^{\infty}\mathrm{E}_{t}\Lambda\left(s^{t+l}\right)\left[Q\left(s^{t+l}\right)\left(1-F_{I}\left(I\left(s^{t+l}\right),I\left(s^{t+l-1}\right)\right)\right)I\left(s^{t+l}\right)-I\left(s^{t+l}\right)\right], \tag{28}$$

where F_I is defined as follows:

$$F_{I}\left(I\left(s^{t+l}\right),I\left(s^{t+l-1}\right)\right)\equiv\frac{\kappa}{2}\left(\frac{I\left(s^{t+l}\right)}{I\left(s^{t+l-1}\right)}-1\right)^{2}.$$

Note that κ is a parameter associated with investment technology with an adjustment cost.[28] Here, the evolvement of the total capital available at period t is described as

$$K\left(s^{t}\right)=\left(1-F_{I}\left(I\left(s^{t}\right),I\left(s^{t-1}\right)\right)\right)I\left(s^{t}\right)+(1-\delta)K\left(s^{t-1}\right). \tag{29}$$

Resource constraint

[28] Equation (28) does not include a term for the purchase of the used capital $K\left(s^{t-1}\right)$ from the entrepreneurs at the end of the period. This is because we assume, following BGG, that the price of old capital that the entrepreneurs sell to the capital goods producers, say $\overline{Q}\left(s^{t}\right)$, is close to the price of the newly produced capital $Q\left(s^{t}\right)$ around the steady state.

The resource constraint for final goods is written as

$$Y\left(s^{t}\right)=C_{H}\left(s^{t}\right)+C_{H}^{*}\left(s^{t}\right)+I\left(s^{t}\right)+G\left(s^{t}\right)+C_{H}^{E}\left(s^{t}\right)+C_{H}^{E*}\left(s^{t}\right), \tag{30}$$

where $C_H^E(s^t)$ and $C_H^{E*}(s^t)$ represent the consumption of home-produced goods spent in the home country and the foreign country, respectively. In order to isolate the asymmetry arising from differences in monitoring costs and consumption by entrepreneurs and FIs, we assume that monitoring costs and consumption by entrepreneurs and FIs are spent equally between two countries:

$$C_{H}^{E}\left(s^{t}\right)=0.5\left(\frac{P_{H}\left(s^{t}\right)}{P\left(s^{t}\right)}\right)^{-\eta}Y^{E}\left(s^{t}\right), \tag{31}$$

where monitoring costs and consumption by entrepreneurs and FIs in the home country are

$$\begin{aligned}
Y^{E}\left(s^{t}\right) \;=\;& \mu^{E}G_{t}^{E}\left(\overline{\omega}_{H}^{E}\left(s^{t}\right)\right)R_{H}^{E}\left(s^{t}\right)(1-\tau_{H}^{E})Q\left(s^{t-1}\right)K_{H}\left(s^{t-1}\right)\\
&+\mu^{E}G_{t}^{E}\left(\overline{\omega}_{H}^{E*}\left(s^{t}\right)\right)e(s^{t-1})R_{H}^{E*}\left(s^{t}\right)\tau_{F}^{E}Q^{*}\left(s^{t-1}\right)K_{H}^{*}\left(s^{t-1}\right)\\
&+\mu^{F}G_{t}^{F}\left(\overline{\omega}_{H}^{F}\left(s^{t}\right)\right)(1-\tau_{H}^{F})R^{F}\left(s^{t}\right)\\
&\left\{\begin{array}{c}(1-\tau_{H}^{E})(Q\left(s^{t-1}\right)K_{H}\left(s^{t-1}\right)-N^{E}\left(s^{t-1}\right))\\ +\tau_{F}^{E}e(s^{t-1})(Q^{*}\left(s^{t-1}\right)K_{H}^{*}\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right))\end{array}\right\}\\
&+\mu^{F}G_{t}^{F}\left(\overline{\omega}_{F}^{F}\left(s^{t}\right)\right)\tau_{F}^{F}e(s^{t-1})R^{F*}\left(s^{t}\right)\\
&\left\{\begin{array}{c}1/e(s^{t-1})\tau_{H}^{E}(Q\left(s^{t-1}\right)K_{F}\left(s^{t-1}\right)-N^{E}\left(s^{t-1}\right))\\ +(1-\tau_{F}^{E})(Q^{*}\left(s^{t-1}\right)K_{F}^{*}\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right))\end{array}\right\}\\
&+(1-\gamma^{E})V^{E}\left(s^{t}\right)+(1-\gamma^{F})V^{F}\left(s^{t}\right).
\end{aligned} \tag{32}$$

The first two terms on the right-hand side of the equation correspond to the bankruptcy costs spent by FIs. The third and the fourth terms correspond to the bankruptcy costs incurred by investors. The last two equations are the FIs' and entrepreneurial consumption. Similarly, $C_H^{E*}(s^t)$ and $Y^{E*}(s^t)$ are defined.

3.3 Rest of the Economy

Government

The government collects lump-sum tax from the household $T(s^t)$, and spends $G(s^t)$. A budget balance is maintained for each period t. Thus, we have

$$G\left(s^t\right) = T\left(s^t\right). \tag{33}$$

Monetary authority

The monetary authority sets the nominal interest rate $R^n\left(s^t\right)$, according to a standard Taylor rule with inertia

$$R^n\left(s^t\right) = \rho R^n\left(s^{t-1}\right) + (1-\theta)\left(\phi_\pi \pi_H\left(s^t\right) + \phi_y \log\left(\frac{Y\left(s^t\right)}{Y}\right)\right) + \varepsilon^R\left(s^t\right), \tag{34}$$

where ρ is the autoregressive parameter of the policy rate, ϕ_π and ϕ_y are the policy weight on inflation rate of final home-produced goods, and output gap $\log\left(Y\left(s^t\right)/Y\right)$, respectively. $\pi_H\left(s^t\right)$ denotes the inflation rate of home-produced goods at period t, that is, $\pi_H\left(s^t\right) = P_H\left(s^t\right)/P_H\left(s^{t-1}\right)$.

Because the monetary authority determines the nominal interest rate, the real interest rate in the economy is given by the following Fisher equation:

$$R\left(s^t\right) \equiv \mathrm{E}_t\left\{\frac{R^n\left(s^t\right)}{\pi\left(s^{t+1}\right)}\right\}. \tag{35}$$

$\pi\left(s^t\right)$ denotes the aggregate inflation rate at period t, that is, $\pi\left(s^t\right) = P\left(s^t\right)/P\left(s^{t-1}\right)$.

Exogenous variables

The exogenous shocks to the model are the productivity shock, the monetary policy shock, FIs' net worth shock, and entrepreneurial net worth shock. The productivity shock follows the process as

$$e^A\left(s^t\right) = \rho_A e^A\left(s^{t-1}\right) + \varepsilon^A\left(s^t\right), \tag{36}$$

where $\rho_A \in (0,1)$ is the autoregressive root. $\varepsilon^A\left(s^t\right)$, $\varepsilon^R\left(s^t\right)$, $\varepsilon^{nF}\left(s^t\right)$, and $\varepsilon^{nE}\left(s^t\right)$ are innovations that are mutually independent, serially uncorrelated, and normally distributed with mean zero, respectively.

Appendix A provides a summary of the model.

4 Simulation

4.1 Calibration

We follow HSU and originally BGG for parameter values. The parameter values are symmetric in two countries. See Appendix B for details.

Regarding the parameters of the two-country model, six parameters capture economic openness. First, we set $\gamma = \gamma_H = \gamma_F = 0.15$ in the benchmark. γ_H and γ_F represent trade openness in the home and foreign countries. As defined in equation (19), the parameter γ_H represents the weight on foreign produced goods. If it is zero, there is no demand for the foreign goods; this implies no trade of goods. If it is 0.5, there is no home bias. A household in the home country demands equally for the home-produced goods and foreign-produced goods, provided that their prices are the same. Following Faia (2007), we set them at 0.15 in the benchmark. That value is consistent with the data for the United States and Japan. As Figure 3 shows, trade in those countries accounts for 15 percent of total GDP. A trade share for Europe is higher, reaching more than 30 percent. That partly reflects active cross-border trade among European countries.

Second, we set $\tau^F = \tau^F_H = \tau^F_F = 0$ and $\tau^E = \tau^E_H = \tau^E_F = 0$ in the benchmark for the parameters of banking globalization or financial openness. It is difficult to measure the actual degree of banking globalization that matches our model, but Figures 4 to 6 provide some clues. The bottom panel of Figure 4 indicates the ratio of foreign claims to non-financial firms' total liabilities; the latter corresponds to entrepreneurial total assets, QK, in our model. If foreign claims are all debts and two countries are symmetrical, foreign claims correspond to $\tau^E(QK-N^E)+\tau^F(QK-N^E-N^F)$ in our model. Therefore, the ratio of foreign claims to non-financial firms' total liabilities equal

$$\begin{aligned} & \tau^E(1 - N^E/QK) + \tau^F(1 - N^E/QK - N^F/QK) \\ = \; & 0.5\tau^E + 0.4\tau^F. \end{aligned}$$

According to Figure 4, the latest ratios are about 15 percent for the United States, 10 percent for Japan, and 35 percent for the euro area. Because actual foreign claims are not all debts, those ratios give the upper limit of τ^E and τ^F. Distribution between τ^E and τ^F is illustrated by Figure 5, which decomposes foreign claims to those on the non-bank private sector and on banks. For the United States, foreign claims on the non-bank private sector are twice as large as those on banks. It suggests $\tau^E > \tau^F$. On the contrary, for Japan and Europe, foreign claims on the non-bank private sector is lower than those on banks. It suggests $\tau^E < \tau^F$. Finally, Japan's τ^E is demonstrated in Figure 4 as fund-raising by the domestic non-financial sector via overseas markets; it is 3.5 percent in 2008.

4.2 Net Worth and Cost-of-Funds

To examine the property of the credit market, we analyze cost-of-funds $\mathrm{E}_t\left\{R_H^E\left(s^{t+1}\right)\right\}$ for entrepreneurs in the home and the foreign country. To begin with, we focus on the partial equilibrium only of the credit market.[29]

For varying FIs' and entrepreneurial net worth ratios in the foreign country, we calculate how cost-of-funds moves. In Figure 9, the top (bottom) two panels indicate changes in the premiums to FIs' (entrepreneurial) net worth ratios in the foreign country. Net worth ratios, N^{F*}/Q^*K^* or N^{E*}/Q^*K^*, deviate from the steady state by -0.05 to 0.05. The two left (right) panels indicate changes in the cost-of-funds in the home (foreign) country.

Without banking globalization, the effect of net worth on cost-of-funds is limited to the country concerned. In Figure 9, black lines with a plus symbol indicate the case without banking globalization ($\tau = \tau^F = \tau^E = 0$). Both FIs and entrepreneurs borrow funds from agents in their resident country. Lines in the two left panels are flat, suggesting that without banking globalization the cost-of-funds in the home country is independent of net worth in the foreign country. The two right panels suggest that as net worth in the foreign country decreases, the cost-of-funds in the foreign country increases. The increase in the cost-of-funds is steeper in response to a change in FIs' net worth than to a change in entrepreneurial net worth. This is consistent with HSU. This arises from the fact that FIs' net worth is smaller than entrepreneurial net worth in the United States.

Those results do not change when the interbank (FIs' borrowing) markets are open. Blue lines with circles indicate the case in which FIs borrow half of their funds from the other country ($\tau^F = 0.5$). The lines are identical to the black lines with a plus symbol. In the partial equilibrium, because the risk-free rates in the two countries are the same and the real exchange rate does not change, FIs are indifferent between borrowing funds

[29] In the general equilibrium, equation (25) makes entrepreneurial returns to capital in the home country obtained by financing funds from FIs in the home country $R_H^E\left(s^t\right)$ equal those obtained by financing funds from FIs in the foreign country $R_F^E\left(s^t\right)$. In the partial equilibrium, because equation (25) does not bind, the two returns differ. We define the average entrepreneurial cost-of-funds in the home country by

$$R^E\left(s^{t+1}|s^t\right) \equiv (1-\tau_H^E)R_H^E\left(s^{t+1}|s^t\right) + \tau_H^E R_F^E\left(s^{t+1}|s^t\right),$$

and analyze changes in $R^E\left(s^{t+1}|s^t\right)$. Similarly, we analyze $R^{E*}\left(s^{t+1}|s^t\right)$, average entrepreneurial cost-of-funds in the foreign country.

from the home country and borrowing funds from the foreign country.

When FIs' lending markets are open, a change in net worth in the home country affects cost-of-funds in the foreign country, and mitigates a change in cost-of-funds in the home country. Red lines with dots indicate the case in which entrepreneurs borrow half of their funds from the other country ($\tau^E = 0.5$). As FIs' net worth in the foreign country decreases, cost-of-funds in the home country increases, as the top-left panel demonstrates. Entrepreneurs in the foreign country borrow a portion of funds from the FIs in the home country, and their financial conditions are constant. That mitigates an increase in cost-of-funds in the foreign country, as the top-right panel demonstrates. Entrepreneurial net worth also influences cost-of-funds in the other country. This is illustrated by the bottom-left panel. From investors' viewpoint in the home country, the worsening of the entrepreneurial net worth in the foreign country enhances the agency cost problem. This increases the cost-of-funds in the home country. On the other hand, from investors' viewpoint in the foreign country, the entrepreneurial net worth in the home country stays constant. This mitigates a change in the cost-of-funds in the foreign country.

4.3 Impulse Responses

The previous cost-of-funds curves are drawn using a partial equilibrium framework. Some key variables are kept fixed. Model dynamics are neglected, such as developments in net worth and the price of capital.

In the following exercises, we compute the equilibrium response of the economy to shocks in a general equilibrium framework. We study four types of adverse shocks: (i) a productivity shock; (ii) a monetary policy shock; (iii) a net worth shock in the FI sector; and (iv) a net worth shock in the entrepreneurial sector. The last two shocks, (iii) and (iv), are the sectoral shocks that hit each of the participants in the credit market. For those shocks, we introduce an innovation either in equation (14) or (15) , following Gilchrist and Leahy (2002).

Our particular focus is on bilateral correlations for macroeconomic variables, namely, GDP and investment. In the following figures, we show responses of GDP and investment to shocks, and examine whether a shock in one country yields a similar response of GDP and investment in the other country. To analyze the financial accelerator channel, we also present responses of net worth ratios in two countries. The net worth ratios are the ratio of the sum of FIs' and entrepreneurial net worth ($N = N^F + N^E$) to total assets (QK). The left (right) panels demonstrate the economic variables in the home (foreign) country. Finally, the real exchange rate is demonstrated in the bottom-left panel.

For comparison with our chained credit contract model (hereafter, CCC model), we also simulate a "BGG model." In the BGG model, entrepreneurs are credit-constrained, but FIs are not. The FI sector is dropped from the CCC model, and the investors and entrepreneurs make direct credit contracts. Because there is no agency problem associated with the FIs, the FIs' net worth plays no role. Thus, the external finance premium reflects only the entrepreneurial net worth. Consequently, the financial accelerator effect of the BGG model comes only from the entrepreneurial sector.[30]

4.3.1 Benchmark (No Banking Globalization)

As our benchmark, we simulate economic responses of GDP, investment, net worth ratios, and the real exchange rate in the economy of $\gamma = 0.15$ and $\tau = \tau^F = \tau^E = 0$. FIs do not engage in either cross-border lending or borrowing.

Productivity shock Figure 10 illustrates economic responses to a negative productivity shock in the home country. We consider the productivity shock that decreases the productivity of wholesale goods-producing sector by one percent at the impact, and returns to the steady-state level with the autoregressive parameter of 0.85.

We find business cycle synchronization with respect to GDP and investment. As the left panels shows, in the home country GDP and investment decrease. Because productivity decreases, real marginal costs increase, and inflation rates rise. That raises nominal interest rates and lowers the real exchange rate, indicating home currency appreciation. In the foreign country, we observe a fall in GDP and investment. GDP and investment exhibit positive bilateral correlations in the two countries. This finding is consistent with Faia (2007). As she explains, the credit market friction as well as nominal stickiness plays a key role. The adverse productivity shock raises the real marginal costs and increases inflation rates in the home country. Demand shifts from home-produced goods to foreign-produced goods raises inflation rates in the foreign country. In response, foreign monetary policy is tightened, deteriorating net worth. That raises cost-of-funds, which in turn decreases GDP and investment in the foreign country.

Compared with the BGG model, our CCC model reports greater responses of GDP

[30] We set parameter values related to the entrepreneurial sector in our BGG model to the same values used in our baseline model. Thus, we set the values of σ^E, μ^E, and n^E the same across the two models. Furthermore, we choose the same steady-state return to capital R^E for the two models. We choose to do so because we aim to compare the models' dynamics in a similar economic environment with respect to aggregate investment. Our choice yields the recalibrated values of γ^E and R for the BGG model, which differ from the baseline model.

and investment in the foreign country. The total impacts of two countries are greater in the CCC model than those in the BGG model, also. That result is consistent with HSU (2009), which points out that the CCC model enhances the financial accelerator effect. In the home country, the responses of GDP and investment are almost equal. This is because the economy's response to nominal interest rates is larger in the CCC model than in the BGG model, but the economy's response to the productivity shock is almost the same in the two models. Since GDP and investment in the foreign country drop more, bilateral correlations of those variables become larger in the CCC model than those in the BGG model.

Monetary policy shock Figure 11 illustrates economic responses to the tightening monetary policy shock in the home country. We consider a case where the nominal interest rate rises unexpectedly by 0.25 percent (one percent annually) at the impact.

We again find business cycle synchronization with respect to GDP and investment. A rise in the nominal interest rate in the home country increases the real interest rate, causing investors' opportunity cost to rise. Net worth worsens, and investment falls. Due to a rise in the nominal interest rate, the real exchange rate drops, implying home currency appreciation. In the foreign country, GDP and investment decrease due to two channels. First, a decrease in demand caused by the increase in the real interest rate lowers demand for foreign-produced goods as well as home-produced goods. In the foreign country, this lowers returns to capital, deteriorating net worth and dampening GDP and investment. Second, because the home currency appreciates, there occurs a shift of demand from home-produced goods to foreign-produced goods. In the foreign country, it increases inflation rates, inducing monetary tightening. Net worth worsens, and GDP and investment decrease.

Compared with the BGG model, our CCC model reports greater responses of GDP and investment in the two countries. The CCC model enhances the financial accelerator effect due to the presence of credit-constrained FIs.

FIs' net worth shock Figure 12 illustrates economic responses to a negative shock of FIs' net worth in the home country. We consider a case in which FIs' net worth declines by one percent of the steady-state GDP. Although the shock to the net worth is a one-time shock and therefore has no inertia, its impacts on the economy are persistent. That is, as the demand for capital goods is weakened, the capital price falls, leading to a further decrease in the investment owing to the endogenous declines in the entrepreneurial net worth as well as the FIs' net worth.

GDP and investment are not synchronized. Responding to the decline in FIs' net worth in the home country, cost-of-funds increases, and GDP and investment decrease. Deflation occurs, which lowers nominal interest rates. The real exchange rate increases, indicating home currency depreciation. In the foreign country, GDP and investment increase, because the home country experiences deflation; it shifts demand for goods from foreign-produced goods to home-produced goods. In the foreign country, inflation rates drop, and monetary policy is accommodated. Net worth is improved, and cost-of-capital declines, increasing GDP and investment in the foreign country. As we will show soon, however, GDP and investment come to have positive bilateral correlations under banking globalization.

In the BGG model, the FIs' net worth shock has no effect on the economy. Because FIs are not credit constrained, their net worth plays no role.

Entrepreneurial net worth shock Figure 13 illustrates economic responses to a negative shock of entrepreneurial net worth in the home country. We consider a case in which entrepreneurial net worth declines by one percent of the steady-state GDP.

We find first that GDP and investment are not synchronized. The shock to entrepreneurial net worth yields opposing responses of GDP and investment in the two countries. Second, compared with Figure 12, for the decline in net worth of the same size, the entrepreneurial net worth shock has smaller impacts on GDP and investment than FIs' net worth shock. This result is in line with HSU and Figure 9. Third, compared with the BGG model, our CCC model reports greater responses of GDP and investment in the two countries.

4.3.2 Effects of Banking Globalization

Next, we consider an economy under banking globalization. FIs engage in both cross-border lending and borrowing. The degree of banking globalization is characterized by $\tau = \tau^F = \tau^E = 0.1$. We simulate impulse responses of economic variables in response to the four types of adverse shocks.

Productivity shock Figure 14 plots GDP, investment, the sum of FIs' and entrepreneurial net worth ratios in the two countries, and the real exchange rate. In addition, Figure 15 plots the FIs' net worth ratios, the entrepreneurial net worth ratios, the external finance premiums, the price of capital (asset prices), and cross-border lending in the two countries.[31] Figures 14 and 15 illustrate that banking globalization, captured

[31] Cross-border lending is in the unit of final consumption goods in the FIs' country.

by positive τ, yields a larger spillover of the productivity shock in one country to the other country. The two countries experience declines in GDP, investment, FIs' net worth ratios, and asset prices.

Two channels arise from banking globalization. The first is through the exchange rate. In the home country, the real interest rate increases. The real exchange rate decreases, meaning home appreciation and foreign depreciation. For FIs in the foreign country, it binds the participation constraint of investors in the home country more severely. The net worth ratio worsens and the cost-of-funds increases in the foreign country. GDP and investment are thus dampened. Second, through a decrease in returns to capital, the adverse shock in the home country damages the credit conditions of FIs in the home country. Because those FIs lend funds to entrepreneurs in the foreign country, the cost-of-funds increases for the entrepreneurs in the foreign country. It dampens GDP and investment in the foreign country.

The second channel above is compared to the so-called common lender effect. This effect arises when borrowers in multiple countries have a common lender. Suppose, for example, that an adverse shock hits in one country. Then, the FI, the lender to borrowers in the country, withdraws funds from another country; loans thus shrink in multiple countries. Our model successfully captures this common lender effect. When τ^E is non-zero, entrepreneurs in the two countries have a common lender. The adverse shock in one country aggravates FIs' net worth, raising cost-of-funds for foreign borrowers. The common lender effect is absent in the BGG model because FIs are not credit constrained. The BGG model, therefore, yields a smaller spillover of the shock to the foreign country.

The result that banking globalization enhances business cycle synchronization is consistent with empirical studies (Kose, Prasad, and Terrones [2003], Morgan, Strahan, and Rime [2004], and Imbs [2004, 2006]).

The model's prediction of simultaneous drops in financial and real variables is consistent with the recent financial crisis shown in Figure 1. However, a decrease in an external finance premium in the foreign country and increases in cross-border lending except for loans from foreign FIs to home entrepreneurs appear to be inconsistent with those figures.

Monetary policy shock As Figures 16 and 17 illustrate, for the monetary policy shock, we obtain similar results to those for the productivity shock. First, the spillover effect increases due to the banking globalization. GDP and investment in the foreign country decline more. Second, our CCC model reports a larger spillover effect than the BGG model.

FIs' net worth shock Figures 18 and 19 illustrate that due to banking globalization, the FIs' net worth shock yields completely opposite movements of economic variables in the foreign economy, compared with those without banking globalization. Without banking globalization, the worsening of credit conditions of FIs in the home country increases GDP and investment in the foreign country. Under banking globalization, the common lender effect arises; the worsening of credit conditions of FIs in the home country increases the cost-of-funds for entrepreneurs in the foreign country. It dampens GDP and investment in the foreign country as well as in the home country. In response to adverse FIs' net worth shock, the two countries experience simultaneous economic downturns.

Compared with the responses to the productivity shock, the responses to the FIs' net worth shock are more consistent with our observations on the recent financial crisis that are shown in Figure 1. The adverse FIs' net worth shock dampens GDP, investment, FIs' net worth ratios, and asset prices in the two countries. It also dampens cross-border lending except for loans from foreign FIs to home entrepreneurs, and increases the external finance premium in the two countries.

Entrepreneurial net worth shock Also for the entrepreneurial net worth shock, we find very different movements of economic variables in the foreign economy between the cases with and without banking globalization. Figures 20 and 21 suggest that on impact the worsening of entrepreneurial net worth in the home country decreases investment in both of the countries. Due to the worsening of entrepreneurial net worth in the home country, entrepreneurs' defaults increase. FIs both in the home and the foreign country thus pay higher monitoring costs, reducing their profits, and the FIs' net worths decrease in the two countries. It raises cost-of-funds for entrepreneurs in the foreign country. Investment thus falls in the foreign country.

However, because the worsening in FIs' net worth is not so large, declines in GDP and investment in the foreign country are not as great as those in response to the same size of shock to FIs' net worth. While investment falls on impact in the foreign country, its fall is not persistent and GDP increases on impact in the foreign country. As a result, bilateral correlations for GDP and investment become negative.

4.4 Bilateral Correlations

Tables 5 and 6 report bilateral correlations for macroeconomic variables (GDP and investment, respectively) between the two countries. As before, we consider the four kinds of adverse shocks: (1) a productivity shock; (2) a monetary policy shock; (3) a net worth shock in the FI sector; and (4) a net worth shock in the entrepreneurial sector. In each case, adverse shocks occur in both of the countries. A bilateral correlation for the shocks is zero, but as we will see below, our model predicts positive bilateral correlations for GDP and investment.[32] For comparison, the tables report bilateral correlations predicted by the BGG model in parentheses.

In the benchmark, predicted bilateral correlations are positive for aggregate shocks. In response to the productivity shock, a bilateral correlation for GDP is 0.28 and a bilateral correlation for investment is 0.53. In response to the monetary policy shock, a bilateral correlation for GDP is 0.14 and a bilateral correlation for investment is 0.27. Those bilateral correlations are greater than those in the BGG model, except for the investment correlation in response to the monetary policy shock. For the other shocks, bilateral correlations are almost zero. For example, for FIs' net worth shock, a negative bilateral correlation for GDP is -0.11.

Under banking globalization, predicted bilateral correlations become greater than those without banking globalization in many cases. For the productivity shock, GDP bilateral correlations increase from 0.28 to 0.41. For the monetary policy shock, GDP bilateral correlations increase from 0.14 to 0.44. For FIs' net worth shock, GDP bilateral correlations increase from -0.11 to 0.30. Those increases are sharper in the CCC model than in the BGG model. Although investment bilateral correlations are lower in the CCC model (0.27) than in the BGG model (0.38) without banking globalization, they become higher in the CCC model (0.71) than in the BGG model (0.46) under banking globalization.

To examine the effect of globalization in more detail, Figures 22 illustrates GDP bilateral correlations for a wide range of openness parameter values. The horizontal axis represents varying trade openness parameter values (γ), FIs' borrowing openness parameter values in the IF contract (τ^F), and FIs' lending openness parameter values in the FE contract (τ^E) with the other parameter values fixed. Each row represents different shocks. For the productivity shock and the monetary policy shock, bilateral correlations increase, as either trade or financial openness increases. That increase is steeper in the CCC model than in the BGG model. For the net worth shocks, changes in trade and financial openness have small impacts on bilateral correlations, except for one case: when FIs' lending openness (τ^E) changes. The slope of bilateral correlations is the steepest of all the shocks and openness parameters. When $\tau^E = 0.5$, the bilateral correlation reaches one; GDPs in the two countries are perfectly correlated. Because FIs

[32]Previous literature often assumed positive bilateral correlations for structural shocks. It is 0.3 for the technology shock and 0.6 for the monetary policy shock in Faia (2007).

in one country lend the same amount of funds to entrepreneurs in the two countries, FIs' net worth shock has equall impacts on the two countries.

Finally, we examine the effect of price stickiness. Its effect has already been discussed briefly in Section 4.3 and by Faia (2007). Faia (2007) extends a sticky-price BGG model to a two-country model and suggests that price stickiness as well as the BGG-type financial friction contributes to business cycle synchronization. Regarding the CCC as an extension to BGG, our earlier paper HSU (2009) constructs the closed-economy model with a flexible price and analyzes the basic property of the CCC.

Figures 23 illustrates GDP bilateral correlations for a wide range of openness parameter values, comparing those with and without sticky prices. We find three things. First, without FIs' globalization ($\tau^F = \tau^E = 0$), a technology shock does not yield a positive bilateral correlation for GDP. In this respect, price stickiness is essential to account for business cycle synchronization. This finding is consistent with the discussions made in Section 4.3 and by Faia (2007). Second, in the presence of FIs' globalization (either τ^F or τ^E), the technology shock yields business cycle synchronization. Third, for a positive τ^E, the FIs' net worth shock also yields business cycle synchronization. The latter two points arise from the common lender effect and confirm our previous result that FIs' globalization and credit constraints are important factors in business cycle synchronization.

5 Concluding Remarks

This paper has developed a two-country model to explain business cycle synchronization in the economy where the financial markets, the financial system, and the real economy are linked globally. The model incorporates chained credit contracts between investors and credit-constrained FIs as well as credit-constrained FIs and credit-constrained entrepreneurs. Under banking globalization, the FIs engage in cross-border lending and borrowing, enhancing business cycle synchronization on both the real and financial sides.

We draw several implications. The first concerns the nature of the recent financial crisis. Our simulation suggests that the net worth shock in the FI sector is an important factor. This is because not the productivity shock but the net worth shock in the FI sector accounts for a simultaneous decline in cross-border lending and rise in external finance premiums, which are consistent with actual responses shown in Figure 1. Furthermore, our simulation suggests that globalization is another important factor. In the model, business cycle synchronization is enhanced as globalization intensifies. This is consistent with our experiences in the 2000s. Compared with the bursting of the dotcom bubble in 2000, the recent financial crisis had a broader impact. As Figures 3 to 6 illustrate, the underlying factor is rapid globalization, particularly in Europe. As a result, many European countries such as Iceland and Ireland suffered heavily from the subprime mortgage problem that originated in the United States.[33]

The second implication concerns policy responses to a global financial crisis. As globalization intensifies, policy has a greater global impact. In the recent financial crisis, the Fed slashed its policy rates consecutively. Capital injection policy was implemented to support the financial markets and the financial system. Our model suggests that under banking globalization, those policy helps mitigate the downturn in foreign countries. Our model may also provide a framework to analyze the effects of the pegged exchange rate policy, the currency swap program that were implemented by central banks in collaboration with the Fed, and the cross-border collateral arrangements that were introduced by some central banks and proved to be resilient to adverse shocks in the recent episode.

Finally, our model enables us to investigate developments in foreign assets and global imbalances, and their effects on the financial market and the real economy.[34] It would be interesting for future research to investigate how welfare changes if two countries with different financial technology are interconnected with different degrees of banking globalization.

[33] Japanese banks were relatively less damaged than U.S. and European banks, but the Japanese economy experienced deep recessions. It is true that Japanese banks had less financial exposure than European banks. However, as we discussed in calibration, Japan's financial openness may reach 10 percent. Trade openness is not low, which shot up in the 2000s from 10 to 20 percent. Such economic openness predicts strong bilateral correlations. For example, economic openness of $\gamma = 0.2$, $\tau^E = 0.065$, $\tau^E = 0.035$ yields a bilateral correlation for GDP as high as 0.43 in response to productivity shocks. It accounts for about half of the observed correlation in the 2000s between Japan and the United States, that is, 0.81. Considering that simulated productivity shocks are completely uncorrelated and equally large in two countries, either correlated productivity shocks or the occurrence of extremely large shocks in the U.S. economy yield a bilateral correlation that is even closer to the observed one.

[34] See Caballero, Farhi, and Gourinchas (2008) and Mendoza, Quadrini, and Rios-Rull (2009).

A Summary of the Model

This Appendix summarizes the model. For the optimization problems, we report their first-order conditions. All the necessary equations are provided to find equilibrium solutions in the home country . The equations in the foreign country are depicted in the same way.

A.1 Welfare

$$U(s^t) = \frac{C\left(s^t\right)^{1-\sigma}}{1-\sigma} - \chi_2 \frac{H\left(s^t\right)^{1+\frac{1}{\chi_1}}}{1+\frac{1}{\chi_1}}, \tag{37}$$

$$W(s^t) = U(s^t) + \beta W(s^{t+1}). \tag{38}$$

A.2 Credit Market

Participation Constraints of Investors

$$\begin{aligned}
&\Phi_H^F R^F\left(s^t\right) \\
&\cdot \left\{(1-\tau_H^E)(Q\left(s^{t-1}\right) K_H\left(s^{t-1}\right) - N^E\left(s^{t-1}\right)) + \tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right) K_H^*\left(s^{t-1}\right) - N^{E*}\left(s^{t-1}\right))\right\} \\
&\geq R\left(s^{t-1}\right) \\
&\cdot \left\{\begin{array}{c} (1-\tau_H^E)(Q\left(s^{t-1}\right) K_H\left(s^{t-1}\right) - N^E\left(s^{t-1}\right)) \\ +\tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right) K_H^*\left(s^{t-1}\right) - N^{E*}\left(s^{t-1}\right)) - N^F\left(s^{t-1}\right) \end{array}\right\},
\end{aligned} \tag{39}$$

$$\begin{aligned}
&\Phi_H^{F*} R^F\left(s^t\right) \\
&\cdot \left\{(1-\tau_H^E)(Q\left(s^{t-1}\right) K_H\left(s^{t-1}\right) - N^E\left(s^{t-1}\right)) + \tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right) K_H^*\left(s^{t-1}\right) - N^{E*}\left(s^{t-1}\right))\right\} \\
&\geq \frac{e(s^t)}{e(s^{t-1})} R^*\left(s^{t-1}\right) \\
&\cdot \left\{\begin{array}{c} (1-\tau_H^E)(Q\left(s^{t-1}\right) K_H\left(s^{t-1}\right) - N^E\left(s^{t-1}\right)) \\ +\tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right) K_H^*\left(s^{t-1}\right) - N^{E*}\left(s^{t-1}\right)) - N^F\left(s^{t-1}\right) \end{array}\right\},
\end{aligned} \tag{40}$$

$$\begin{aligned}
&\Phi_H^E(1-\tau_H^E) R_H^E\left(s^t\right) Q\left(s^{t-1}\right) K_H\left(s^{t-1}\right) \\
&+\Phi_H^{E*} \tau_F^E \frac{e(s^t)}{e(s^{t-1})} R_H^{E*}\left(s^t\right) e(s^{t-1}) Q^*\left(s^{t-1}\right) K_H^*\left(s^{t-1}\right)
\end{aligned}$$

$$\equiv R^F\left(s^t\right)\left\{\begin{array}{c}(1-\tau_H^E)(Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right)-N^E\left(s^{t-1}\right))\\+\tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right)K_H^*\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right))\end{array}\right\}. \tag{41}$$

Participation Constraints of Entrepreneurs

$$\left[1-\Gamma_H^E\right]Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right)\geq N^E\left(s^{t-1}\right), \tag{42}$$

$$\left[1-\Gamma_H^{E*}\right]Q^*\left(s^{t-1}\right)K_H^*\left(s^{t-1}\right)\geq N^{E*}\left(s^{t-1}\right). \tag{43}$$

Optimal Credit Contracts

$$\begin{aligned}0=&\,R_H^E\left(s^{t+1}\right)\left\{\left(1-\Gamma_H^E\right)\Phi_H^{E\prime}+\Gamma_H^{E\prime}\Phi_H^E\right\}\\&\cdot\left\{\left(1-\tau_H^F\right)\left(1-\Gamma_H^F\right)+\tau_H^F\left(1-\Gamma_H^{F*}\right)\right\}\\&+\frac{(1-\tau_H^F)\Gamma_H^{F\prime}}{\Phi_H^{F\prime}}\left\{\left(1-\Gamma_H^E\right)\Phi_H^F\Phi_H^{E\prime}R_H^E\left(s^{t+1}\right)+\Gamma_H^{E\prime}\Phi_H^F\Phi_H^E R_H^E\left(s^{t+1}\right)\right.\\&\left.-\Gamma_H^{E\prime}R(s_t)\right\}\\&+\frac{\tau_H^F\Gamma_H^{F*\prime}}{\Phi_H^{F*\prime}}\left\{\left(1-\Gamma_H^E\right)\Phi_H^{F*}\Phi_H^{E\prime}R_H^E\left(s^{t+1}\right)+\Gamma_H^{E\prime}\Phi_H^{F*}\Phi_H^E R_H^E\left(s^{t+1}\right)\right.\\&\left.-\Gamma_H^{E\prime}\frac{e(s^{t+1})}{e(s^t)}R^*(s_t)\right\},\end{aligned} \tag{44}$$

$$\begin{aligned}0=&\,R_H^{E*}\left(s^{t+1}\right)\left\{\left(1-\Gamma_H^{E*}\right)\Phi_H^{E*\prime}+\Gamma_H^{E*\prime}\Phi_H^{E*}\right\}\\&\cdot\left\{\left(1-\tau_H^F\right)\left(1-\Gamma_H^F\right)+\tau_H^F\left(1-\Gamma_H^{F*}\right)\right\}\\&+\frac{(1-\tau_H^F)\Gamma_H^{F\prime}}{\Phi_H^{F\prime}}\left\{\left(1-\Gamma_H^{E*}\right)\Phi_H^F\Phi_H^{E*\prime}R_H^{E*}\left(s^{t+1}\right)+\Gamma_H^{E*\prime}\Phi_H^F\Phi_H^{E*}R_H^{E*}\left(s^{t+1}\right)\right.\\&\left.-\Gamma_H^{E*\prime}R(s_t)\right\}\\&+\frac{\tau_H^F\Gamma_H^{F*\prime}}{\Phi_H^{F*\prime}}\left\{\left(1-\Gamma_H^{E*}\right)\Phi_H^{F*}\Phi_H^{E*\prime}R_H^{E*}\left(s^{t+1}\right)+\Gamma_H^{E*\prime}\Phi_H^{F*}\Phi_H^{E*}R_H^{E*}\left(s^{t+1}\right)\right.\\&\left.-\Gamma_H^{E*\prime}\frac{e(s^{t+1})}{e(s^t)}R^*(s_t)\right\}.\end{aligned} \tag{45}$$

Dynamic Behavior of Net Worth

$$N^F\left(s^t\right)=\gamma^F V^F\left(s^t\right)+\frac{\Omega_F}{1-\Omega_F-\Omega_E}H\left(s^t\right)W\left(s^t\right), \tag{46}$$

$$N^E\left(s^t\right)=\gamma^E V^E\left(s^t\right)+\frac{\Omega_E}{1-\Omega_F-\Omega_E}H\left(s^t\right)W\left(s^t\right), \tag{47}$$

$$\begin{aligned} V^{F}\left(s^{t}\right) \equiv & \left[1-\Gamma_{H}^{F}\right](1-\tau_{H}^{F})R^{F}\left(s^{t}\right) \\ & \cdot\left\{\begin{array}{c} (1-\tau_{H}^{E})(Q\left(s^{t-1}\right)K_{H}\left(s^{t-1}\right)-N^{E}\left(s^{t-1}\right)) \\ +\tau_{F}^{E}e(s^{t-1})(Q^{*}\left(s^{t-1}\right)K_{H}^{*}\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right)) \end{array}\right\} \\ & +\left[1-\Gamma_{H}^{F*}\right]\tau_{H}^{F}R^{F}\left(s^{t}\right) \\ & \cdot\left\{\begin{array}{c} (1-\tau_{H}^{E})(Q\left(s^{t-1}\right)K_{H}\left(s^{t-1}\right)-N^{E}\left(s^{t-1}\right)) \\ +\tau_{F}^{E}e(s^{t-1})(Q^{*}\left(s^{t-1}\right)K_{H}^{*}\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right)) \end{array}\right\}, \end{aligned} \tag{48}$$

$$\begin{aligned} V^{E}\left(s^{t}\right) \equiv & \left(1-\Gamma_{H}^{E}\right)(1-\tau_{H}^{E})R_{H}^{E}\left(s^{t}\right)Q\left(s^{t-1}\right)K_{H}\left(s^{t-1}\right) \\ & +\left(1-\Gamma_{F}^{E}\right)\tau_{H}^{E}R_{F}^{E}\left(s^{t}\right)Q\left(s^{t-1}\right)K_{F}\left(s^{t-1}\right). \end{aligned} \tag{49}$$

A.3 Goods Market

Consumption

$$C\left(s^{t}\right)^{-\sigma}e\left(s^{t}\right)=C^{*}\left(s^{t}\right)^{-\sigma}, \tag{50}$$

$$C\left(s^{t}\right)^{-\sigma}=C\left(s^{t+1}\right)^{-\sigma}\beta r(s^{t}), \tag{51}$$

$$C\left(s^{t}\right)^{-\sigma}W\left(s^{t}\right)=\chi_{2}H\left(s^{t}\right)^{1/\chi}, \tag{52}$$

$$C_{H}\left(s^{t}\right)=(1-\gamma_{H})p_{H}\left(s^{t}\right)^{-\eta}C\left(s^{t}\right), \tag{53}$$

$$C_{F}\left(s^{t}\right)=\gamma_{H}p_{F}\left(s^{t}\right)^{-\eta}C\left(s^{t}\right), \tag{54}$$

$$C_{H}^{E}\left(s^{t}\right)=0.5\left(\frac{P_{H}\left(s^{t}\right)}{P\left(s^{t}\right)}\right)^{-\eta}Y^{E}\left(s^{t}\right), \tag{55}$$

$$C_{F}^{E}\left(s^{t}\right)=0.5\left(\frac{P_{F}\left(s^{t}\right)}{P\left(s^{t}\right)}\right)^{-\eta}Y^{E}\left(s^{t}\right), \tag{56}$$

$$
\begin{aligned}
Y^E\left(s^t\right) &= \mu^E G_H^E R_H^E\left(s^t\right)(1-\tau_H^E)Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right) \\
&+\mu^E G_H^E e(s^{t-1})R_H^{E*}\left(s^t\right)\tau_F^E Q^*\left(s^{t-1}\right)K_H^*\left(s^{t-1}\right) \\
&+\mu^F G_H^F(1-\tau_H^F)R^F\left(s^t\right) \\
&\left\{\begin{array}{c} (1-\tau_H^E)(Q\left(s^{t-1}\right)K_H\left(s^{t-1}\right)-N^E\left(s^{t-1}\right)) \\ +\tau_F^E e(s^{t-1})(Q^*\left(s^{t-1}\right)K_H^*\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right)) \end{array}\right\} \\
&+\mu^F G_F^F \tau_F^F e(s^{t-1})R^{F*}\left(s^t\right) \\
&\left\{\begin{array}{c} 1/e(s^{t-1})\tau_H^E(Q\left(s^{t-1}\right)K_F\left(s^{t-1}\right)-N^E\left(s^{t-1}\right)) \\ +(1-\tau_F^E)(Q^*\left(s^{t-1}\right)K_F^*\left(s^{t-1}\right)-N^{E*}\left(s^{t-1}\right)) \end{array}\right\} \\
&+(1-\gamma^E)V^E\left(s^t\right)+(1-\gamma^F)V^F\left(s^t\right). \qquad (57)
\end{aligned}
$$

Capital and Investment

$$
R_H^E\left(s^t\right)=\frac{R^k\left(s^t\right)+(1-\delta)Q\left(s^t\right)}{Q\left(s^{t-1}\right)}, \qquad (58)
$$

$$
R_F^E\left(s^t\right)=\frac{R^k\left(s^t\right)+(1-\delta)Q\left(s^t\right)}{Q\left(s^{t-1}\right)}, \qquad (59)
$$

$$
R^k\left(s^t\right)=\frac{\alpha}{1-\alpha}\frac{1}{1-\Omega_F-\Omega_E}\frac{H\left(s^t\right)W\left(s^t\right)}{K\left(s^{t-1}\right)} \qquad (60)
$$

$$
\begin{aligned}
&Q\left(s^t\right)\left\{1-\frac{\kappa}{2}\left(\frac{I\left(s^t\right)}{I\left(s^{t-1}\right)}-1\right)^2-\frac{I\left(s^t\right)}{I\left(s^{t-1}\right)}\right\}\kappa\left(\frac{I\left(s^t\right)}{I\left(s^{t-1}\right)}-1\right) \\
= \;& 1+\beta\left(\frac{C\left(s^t\right)}{C\left(s^{t+1}\right)}\right)^\sigma Q\left(s^{t+1}\right)\left(\frac{I\left(s^{t+1}\right)}{I\left(s^t\right)}\right)^2\kappa\left(\frac{I\left(s^{t+1}\right)}{I\left(s^t\right)}-1\right), \qquad (61)
\end{aligned}
$$

$$
K\left(s^t\right)=\left\{1-\frac{\kappa}{2}\left(\frac{I\left(s^t\right)}{I\left(s^{t-1}\right)}-1\right)^2\right\}I\left(s^t\right)+(1-\delta)K\left(s^{t-1}\right), \qquad (62)
$$

$$
K\left(s^t\right)=(1-\tau_H^E)K_H\left(s^t\right)+\tau_H^E K_F\left(s^t\right). \qquad (63)
$$

Production

$$
y_H\left(s^t\right)=A\exp\left(e^A\left(s^t\right)\right)K\left(s^{t-1}\right)^\alpha H\left(s^t\right)^{(1-\Omega_F-\Omega_E)(1-\alpha)}, \qquad (64)
$$

$$
\begin{aligned}
&y_H\left(s^t\right)=\Delta_H\left(s^t\right)(Y_H\left(s^t\right)-C_H\left(s^t\right)-C_H^E\left(s^t\right)) \\
&+\Delta_H^*\left(s^t\right)(Y_H^*\left(s^t\right)-C_H^*\left(s^t\right)-C_H^{E*}\left(s^t\right)). \qquad (65)
\end{aligned}
$$

Price Setting

$$X_H\left(s^t\right)=\left(1-\Omega_F-\Omega_E\right)\left(1-\alpha\right)\frac{A\exp\left(e^A\left(s^t\right)\right)K\left(s^{t-1}\right)^{\alpha}H\left(s^t\right)^{\left(1-\Omega_F-\Omega_E\right)\left(1-\alpha\right)}}{H\left(s^t\right)W\left(s^t\right)}, \tag{66}$$

$$\Delta_H(s^t)=(1-\xi)\left[\frac{1-\xi\left(\frac{1}{1+\pi_H(s^t)}\right)^{1-\varepsilon}}{1-\xi}\right]^{\frac{\varepsilon}{\varepsilon-1}}+\xi\left(\frac{1}{1+\pi_H(s^t)}\right)^{-\varepsilon}\Delta_H(s^{t-1}), \tag{67}$$

$$\Delta_H^*(s^t)=(1-\xi)\left[\frac{1-\xi\left(\frac{1}{1+\pi_H^*(s^t)}\right)^{1-\varepsilon}}{1-\xi}\right]^{\frac{\varepsilon}{\varepsilon-1}}+\xi\left(\frac{1}{1+\pi_H^*(s^t)}\right)^{-\varepsilon}\Delta_H^*(s^{t-1}), \tag{68}$$

$$K_H^p(s^t)=F_H^p(s^t)\left[\frac{1-\xi\left(\frac{1}{1+\pi_{H,t}}\right)^{1-\varepsilon}}{1-\xi}\right]^{\frac{1}{1-\varepsilon}}, \tag{69}$$

$$F_H^p(s^t)=1+\xi\beta\frac{C\left(s^{t+1}\right)^{-\sigma}}{C\left(s^t\right)^{-\sigma}}\frac{\left(1+\pi_H\left(s^{t+1}\right)\right)^{\varepsilon}}{1+\pi\left(s^{t+1}\right)}\frac{Y_H(s^{t+1})}{Y_H(s^t)}F_H^p(s^{t+1}), \tag{70}$$

$$K_H^p(s^t)=\frac{\varepsilon}{\varepsilon-1}\frac{1}{p_H\left(s^t\right)X_H\left(s^t\right)}+\xi\beta\frac{C\left(s^{t+1}\right)^{-\sigma}}{C\left(s^t\right)^{-\sigma}}\frac{\left(1+\pi_H\left(s^{t+1}\right)\right)^{\varepsilon+1}}{1+\pi\left(s^{t+1}\right)}\frac{Y_H(s^{t+1})}{Y_H(s^t)}K_H^p(s^{t+1}), \tag{71}$$

$$e(s^t)p_H^*(s^t)=p_H(s^t), \tag{72}$$

$$1+\pi_H(s^t)=\left(1+\pi(s^t)\right)\frac{p_H(s^t)}{p_H(s^{t-1})}, \tag{73}$$

$$1+\pi_H^*(s^t)=\left(1+\pi^*(s^t)\right)\frac{p_H^*(s^t)}{p_H^*(s^{t-1})}, \tag{74}$$

$$1=(1-\gamma_H)p_H\left(s^t\right)^{1-\eta}+\gamma_H p_F\left(s^t\right)^{1-\eta}. \tag{75}$$

Goods Market Clearing

$$\begin{aligned}Y_H\left(s^t\right) &= C_H\left(s^t\right)+C_H^*\left(s^t\right)+I\left(s^t\right)\\ &\quad +G\left(s^t\right)+C_H^E\left(s^t\right)+C_H^{E*}\left(s^t\right),\end{aligned} \tag{76}$$

$$GDP_H\left(s^t\right)\equiv C_H\left(s^t\right)+C_H^*\left(s^t\right)+I\left(s^t\right)+G\left(s^t\right). \tag{77}$$

Monetary Policy

$$R^n\left(s^t\right) = \rho R^n\left(s^{t-1}\right) + (1-\theta)\left(\phi_\pi \pi_H\left(s^t\right) + \phi_y \log\left(\frac{Y\left(s^t\right)}{Y}\right)\right) + e^R\left(s^t\right), \tag{78}$$

$$R\left(s^t\right) = \frac{R^n\left(s^t\right)}{\pi\left(s^{t+1}\right)}. \tag{79}$$

Exogenous Variable

$$e^A\left(s^t\right) = \rho_A e^A\left(s^{t-1}\right) + \varepsilon^A\left(s^t\right). \tag{80}$$

B Parameterization

B.1 Parameterization I

This Appendix provides parameterization of the variables associated with household, wholesalers, capital goods producers, retailers, final goods producers, government and monetary authority. Following precedent studies including BGG and Christiano, Motto, and Rostagno (2004), we choose conventional values for these parameters.

Parameters[35]

Parameter	Value	Description
β	0.99	Discount factor
δ	0.025	Depreciation rate
α	0.35	Capital share
R	0.99^{-1}	Risk-free rate
ϵ	6	Degree of substitutability
ξ	0.75	Probability that price cannot be adjusted
χ_1	3	Elasticity of labor
κ	2.5	Adjustment cost of investment
η	1	Elasticity of substitution between home produced goods and foreign produced goods
Ω_F, Ω_E	0.01	Share of FIs' and entrepreneurial labor inputs
ρ	0.8	Autoregressive parameter for the policy rate
ρ_a	0.85	Autoregressive parameter for TFP
ϕ_π	1.5	Policy weight on inflation
ϕ_y	0	Policy weight on output gap

[35]Figures are quarterly unless otherwise noted.

B.2 Parameterization II (Globalization)

Globalization parameters in the benchmark

γ_H	0.15	Trade openness in the home country
τ_H^E	0	Banking globalization in FIs' lending to entrepreneurs in the home country
τ_H^F	0	Banking globalization in FIs' borrowing in the home country
γ_F	0.15	Trade openness in the foreign country
τ_F^E	0	Banking globalization in FIs' lending to entrepreneurs in the foreign country
τ_F^F	0	Banking globalization in FIs' borrowing in the foreign country

B.3 Parameterization III (Credit Market)

Regarding the parameters in the credit market, we set values for six parameters that are linked to the IF contract and FE contract so that these values are consistent with the following seven conditions. These are as follows: (1) the risk spread, $R^E - R$, equal to 200 basis points annually; (2) the ratio of net worth held by FIs to capital, N^F/QK, is 0.1, which is close to the actual value according to the data;[36] (3) the ratio of net worth held by entrepreneurs to capital, N^E/QK, is 0.5, the approximate value in the data; (4) the annualized failure rate of FIs is two percent;[37] and (5) the annualized failure rate of entrepreneurs is two percent. Conditions (1), (3), and (5) are the same as those used in BGG. Two more conditions are set to be approximately consistent with the U.S. data: (6) the spread between the FIs' loan rate and the FIs' borrowing rate $Z^E - Z^F$ equals 230 basis points annually, which equals the historical average spread between the prime lending rate and the six-month certificate of deposit rate from 1980 to 2006; and (7) the spread between the FIs' borrowing rate and risk-free rate $Z^F - R$ equals 60 basis points annually, which turns out to be approximately the historical average spread between the six-month certificates of deposit rate and the six-month Treasury bill rate from 1980 to 2006.

The estimated parameters from those steady-state conditions include the lenders' bankruptcy cost in the IF contract μ_H^F and μ_F^F, the lenders' bankruptcy cost in the FE contract μ_H^E and μ_F^E, the standard error of the idiosyncratic productivity shock in the FI sector σ_H^F and σ_F^F, the standard error of the idiosyncratic productivity shock in the entrepreneurial sector σ_H^E and σ_F^E, the survival rate of FIs γ_H^F and γ_F^F, and the survival rate of entrepreneurs γ_H^E and γ_F^E.

[36] We calculate the steady-state value of N^E/QK based on the Flow of Funds data, released by the Federal Reserve Board. We calculate the historical series of the sum of corporate equities and equity in noncorporate business held by financial sectors divided by total liability and equity of the nonfinancial business sector, and set at the steady-state value of 0.1 for N^E/QK, which is the historical average from 1990 to 2005.

[37] Although the FI's failure rate may seem to be lower than the entrepreneur's failure rate, we set them to this value based on the observation of the CDS premium data during the recent crisis periods.

Calibrated parameters

Parameter	Value	Description
σ_F	0.107	S.E. of FIs' idiosyncratic productivity at steady state
σ_E	0.313	S.E. of entrepreneurial idiosyncratic productivity at steady state
μ_H^F, μ_F^F	0.033	Bankruptcy (monitoring) cost associated with FIs
μ_H^E, μ_F^E	0.013	Bankruptcy (monitoring) cost associated with entrepreneurs
γ_F	0.963	Survival rate of FIs
γ_E	0.984	Survival rate of entrepreneurs

Steady state conditions

Condition	Description
$R = 0.99^{-1}$	Risk-free rate
$Z^E = Z^F + 0.023^{.25}$	FIs' loan rate
$Z^F = R + 0.006^{.25}$	FIs' borrowing rate
$F\left(\overline{\omega}^F\right) = 0.02$	Default probability in the IF contract
$F\left(\overline{\omega}^E\right) = 0.02$	Default probability in the FE contract
$n^F = 0.1$	FIs' net worth/capital ratio
$n^E = 0.5$	Entrepreneurial net worth/capital ratio

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Table 1: Regressions of GDP Changes on Cross-Border Lending in the Recent Financial Crisis (OECD countries)

Dependent variable	GDP changes from 2007 to 2009	
Independent variables	Regression 1	Regression 2
Constant	-0.86	-1.49
	(-0.79)	(-1.96)
Cross-border lending	-0.019	
(ratio to nominal GDP, as of 2006Q4)	(-1.90)	
Changes in cross-border lending (ratio to nominal GDP, changes from 2002Q4 to 2006Q4)		-0.035
		(-2.27)
Samples	31	31
Adjusted R^2	0.08	0.12

Note: Figures in parentheses indicate t-statistics. Luxemburg is excluded.

Table 2: Observed Bilateral Correlations for GDP
1970Q1 to 2008Q4

	U.S.	Japan	Germany	France	Italy	U.K.	Canada
Japan	0.23	-	-	-	-	-	-
Germany	0.18	0.29	-	-	-	-	-
France	0.50	0.29	0.49	-	-	-	-
Italy	0.34	0.56	0.37	0.66	-	-	-
U.K.	0.65	0.23	0.05	0.49	0.51	-	-
Canada	0.75	0.14	0.01	0.46	0.51	0.62	-
Euro area	0.36	0.57	0.82	0.73	0.89	0.64	0.53

Note: Detrended with Hodrick-Prescott filter
Source: IMF, "InternationalFinancialStatistics."

Table 3: Observed Bilateral Correlations for Investment
1970Q1 to 2008Q4

	U.S.	Japan	Germany	France	Italy	U.K.	Canada
Japan	0.29	-	-	-	-	-	-
Germany	0.26	0.41	-	-	-	-	-
France	0.31	0.59	0.57	-	-	-	-
Italy	0.18	0.55	0.48	0.64	-	-	-
U.K.	0.43	0.37	0.04	0.42	0.44	-	-
Canada	0.41	0.25	-0.05	0.34	0.25	0.48	-
Euro area	0.54	0.73	0.75	0.81	0.80	0.68	0.52

Note: Detrended with Hodrick-Prescott filter.
Source: IMF, "International Financial Statistics."

Table 4: Observed Bilateral Correlations for GDP
for Different Samples

	U.S. – Japan	U.S. – Germany	Japan – Germany
1970Q1 to 2008Q4	0.23	0.18	0.29
1970Q1 to 1979Q4	0.18	0.75	0.30
1980Q1 to 1989Q4	0.19	0.08	0.12
1990Q1 to 1999Q4	-0.33	-0.49	0.26
2000Q1 to 2008Q4	0.81	0.56	0.65

Note: Detrended with Hodrick-Prescott filter.
Source: IMF, "International Financial Statistics."

Table 5: Predicted Bilateral Correlations for GDP

	Productivity shock only	Monetary policy shock only	FIs' net worth shock only	Entrepreneurial net worth shock only
Benchmark ($\tau = 0$)	0.28 (0.21)	0.14 (0.12)	-0.11 (–)	0.07 (-0.00)
Banking globalization ($\tau = 0.1$)	0.41 (0.21)	0.44 (0.16)	0.30 (–)	-0.05 (-0.00)

Note: Figures in parentheses indicate bilateral correlations predicted by the BGG model.

Table 6: Predicted Bilateral Correlations for Investment

	Productivity shock only	Monetary policy shock only	FIs' net worth shock only	Entrepreneurial net worth shock only
Benchmark ($\tau = 0$)	0.53 (0.37)	0.27 (0.38)	-0.05 (–)	0.07 (0.21)
Banking globalization ($\tau = 0.1$)	0.81 (0.38)	0.71 (0.46)	0.42 (–)	0.09 (0.20)

Note: Figures in parentheses indicate bilateral correlations predicted by the BGG model.

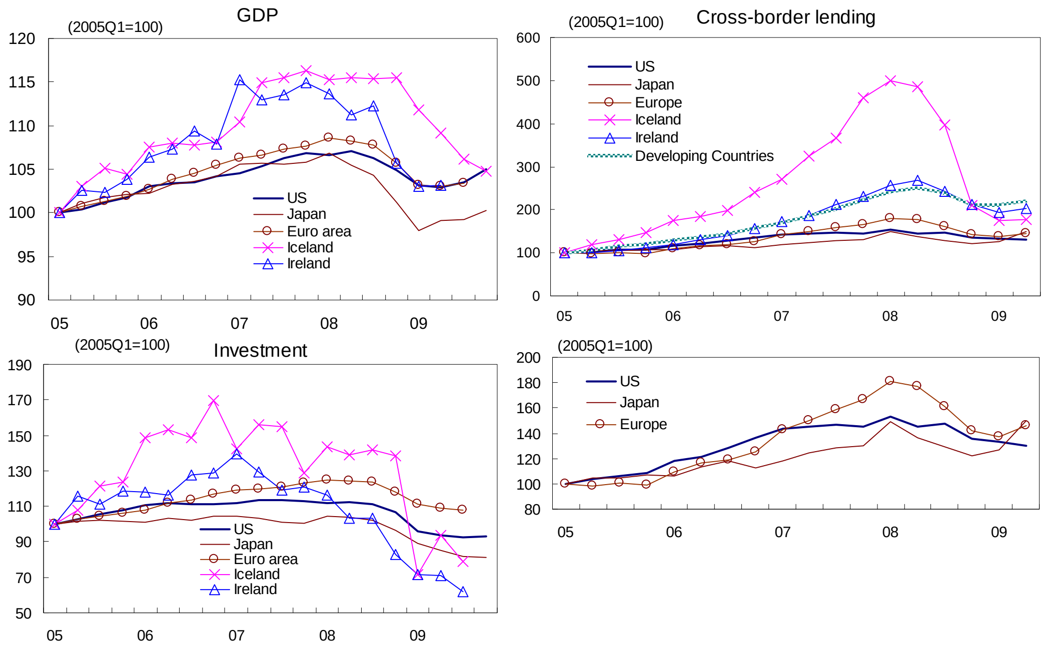


Figure 1-1: Global Downturns in the Recent Financial Crisis (1)

Note: Cross-border lending is defined as consolidated foreign claims on an immediate borrowers basis.

Sources: IMF, "International Financial Statistics"; BIS, "Consolidated International Banking Statistics."

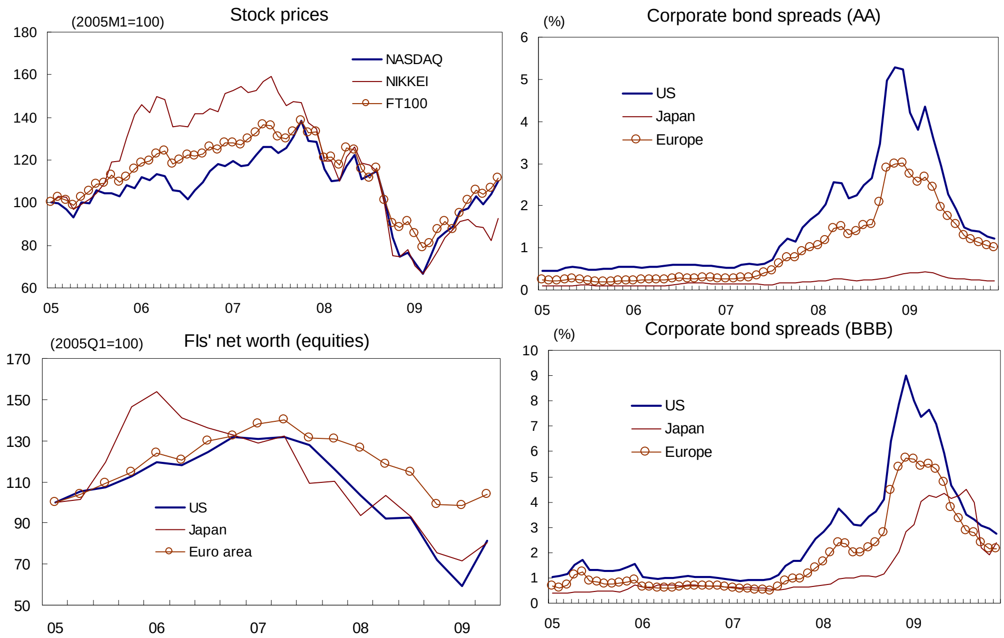


Figure 1-2: Global Downturns in the Recent Financial Crisis (2)

Note: FIs' net worth is defined as "corporate equities + equity in the noncorporate business sector" held by the financial business sector. Corporate bond spreads are differences between corporate bond rates and government bond rates.

Sources: Bloomberg; Federal Reserve, "Flow of Funds Accounts"; Bank of Japan, "Flow of Funds Accounts"; European Central Bank, "Euro Area Integrated Economic and Financial Accounts."

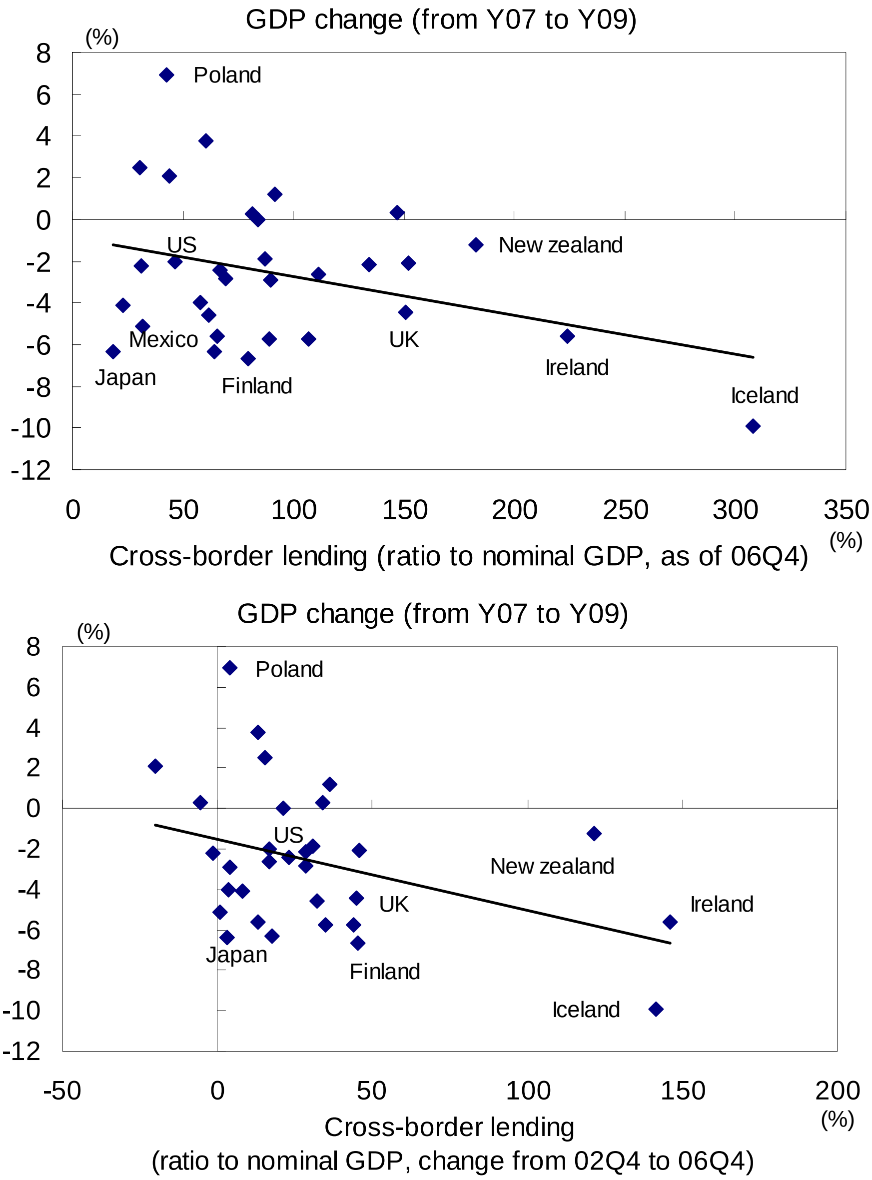


Figure 2: Cross-Border Lending versus GDP Changes in the Recent Financial Crisis (OECD countries)

Note: Cross-border lending is defined as consolidated foreign claims on an immediate borrowers basis. Luxemburg is excluded.

Sources: IMF, "International Financial Statistics"; IMF, "World Economic Outlook"; BIS, "Consolidated International Banking Statistics."

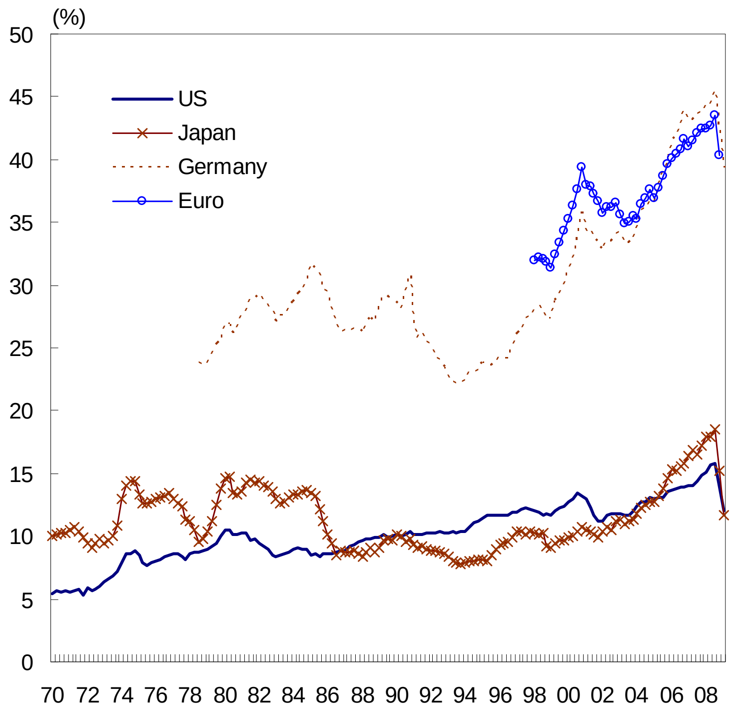


Figure 3: Trade Openness

Note: Trade openness is defined as (exports + imports)/2 as a share of GDP (percent).

Source: IMF, "International Financial Statistics."

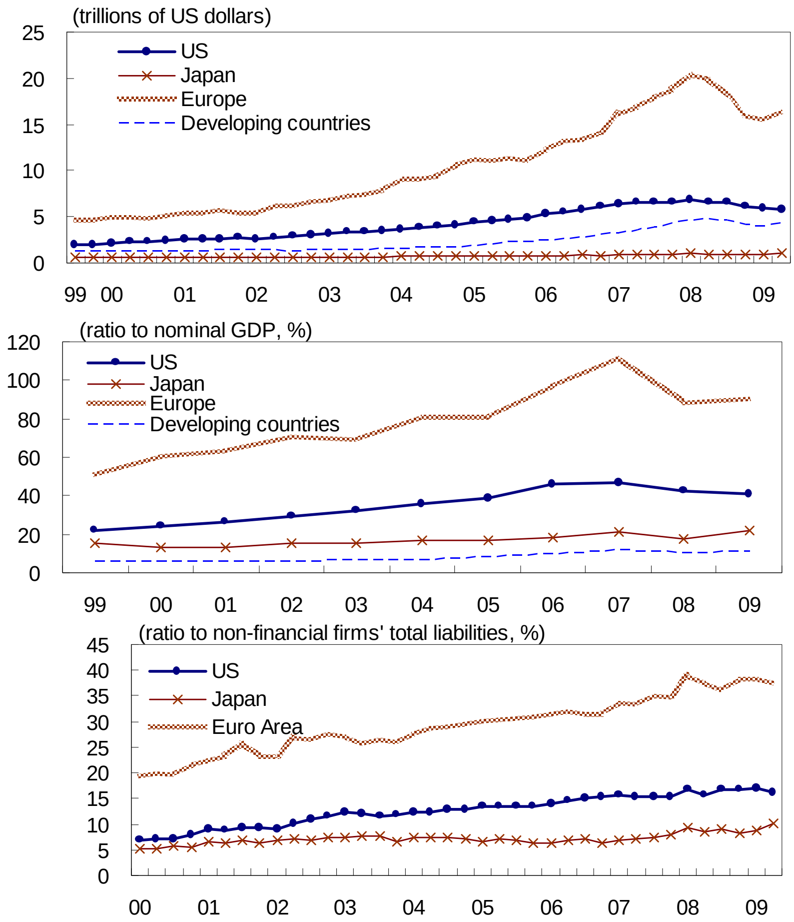
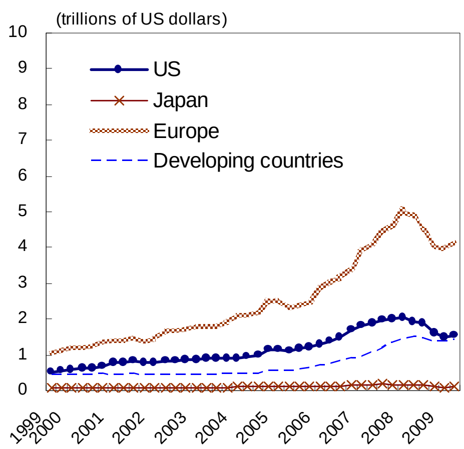


Figure 4: Cross-Border Lending

Note: Cross-border lending is defined as consolidated foreign claims on an immediate borrower basis. The middle panel indicates the ratio of consolidated claims to nominal GDP at the end of the calendar year. The figure for 2009 is that of June 2009. The bottom panel indicates the ratio of consolidated claims to non-financial firms' total liabilities.

Sources: BIS, "Consolidated International Banking Statistics"; IMF, "World Economic Outlook"; Federal Reserve, "Flow of Funds Accounts"; Bank of Japan, "Flow of Funds Accounts"; European Central Bank, "Euro Area Integrated Economic and Financial Accounts."



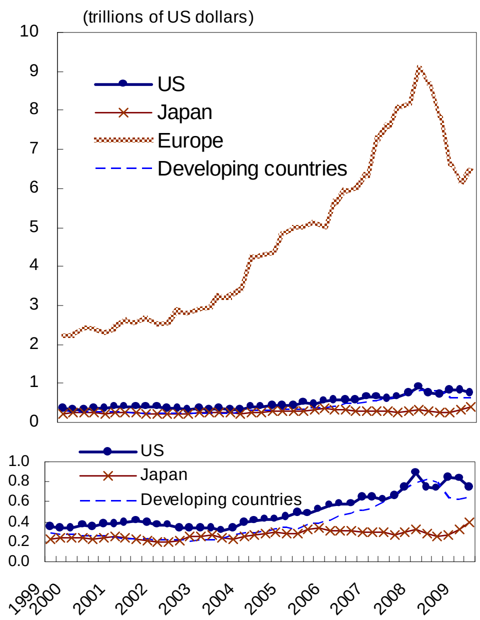


Figure 5: Cross-Border Lending to the Non-Bank Private Sector (left panel) and Banks (right panel).

Note: Cross-border lending is defined as consolidated international claims on an immediate borrower basis.

Source: BIS, "Consolidated International Banking Statistics."

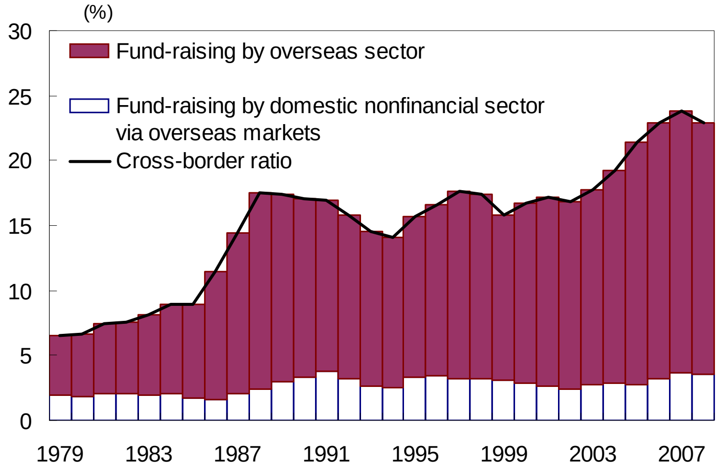


Figure 6: Channels of Fund-Raising by the Nonfinancial Sector

Source: Bank of Japan, "Flow of Funds Accounts."

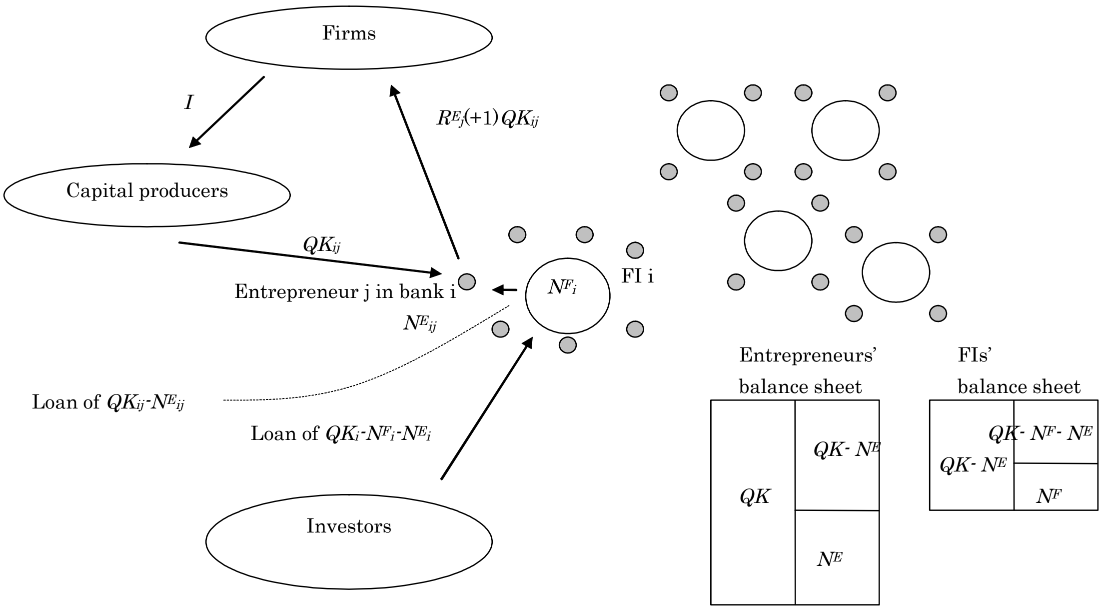


Figure 7: Chained Credit Contracts

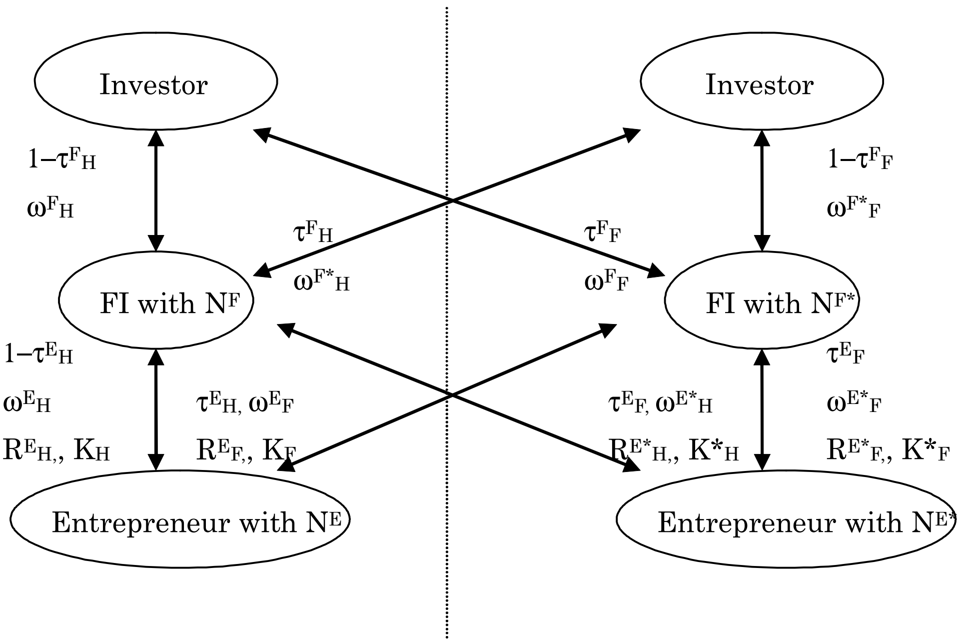


Figure 8: Chained Credit Contracts in Two Countries

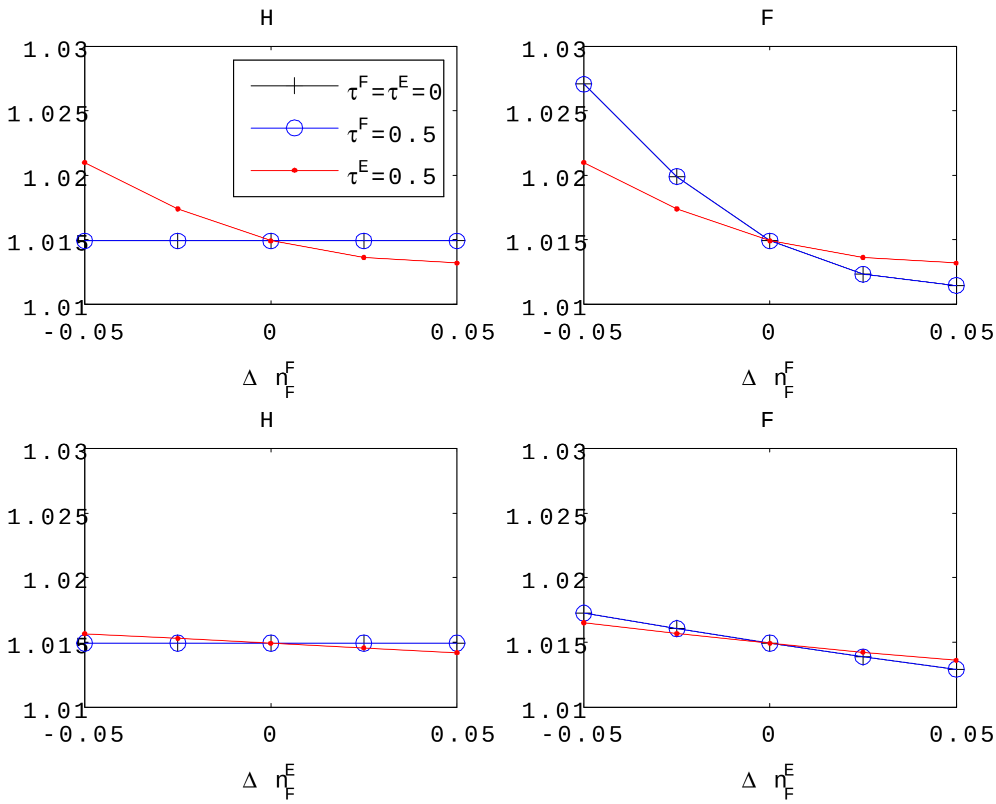


Figure 9: Cost-of-Funds versus Net Worth

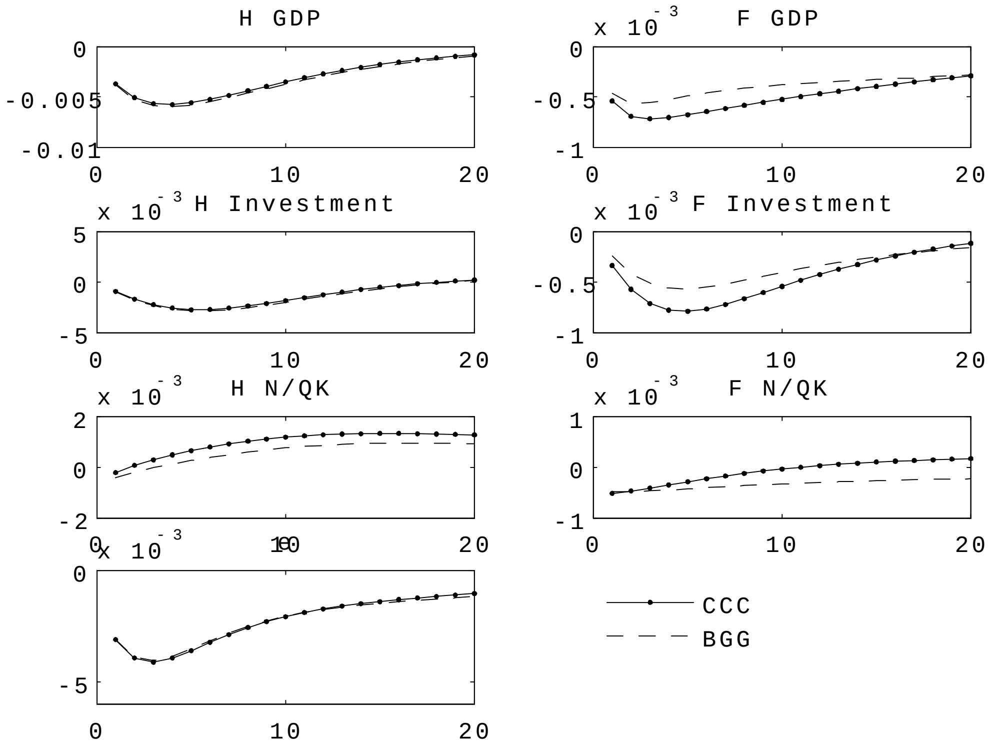


Figure 10: Productivity Shock in H without Banking Globalization

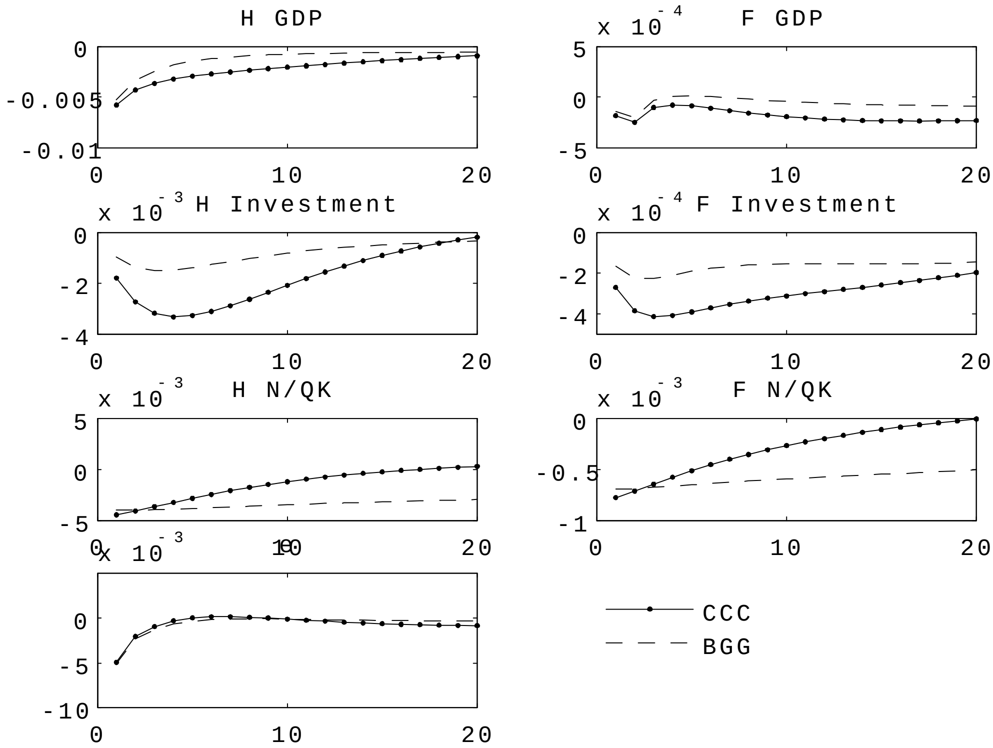


Figure 11: Monetary Policy Shock in H without Banking Globalization

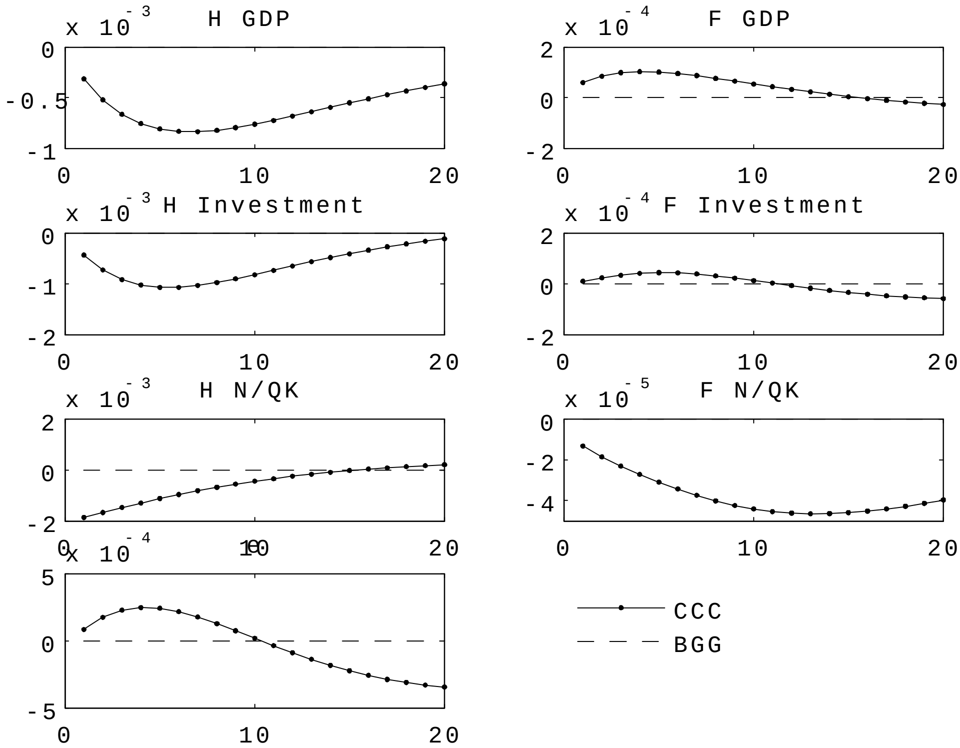


Figure 12: FIs' Net Worth Shock in H without Banking Globalization

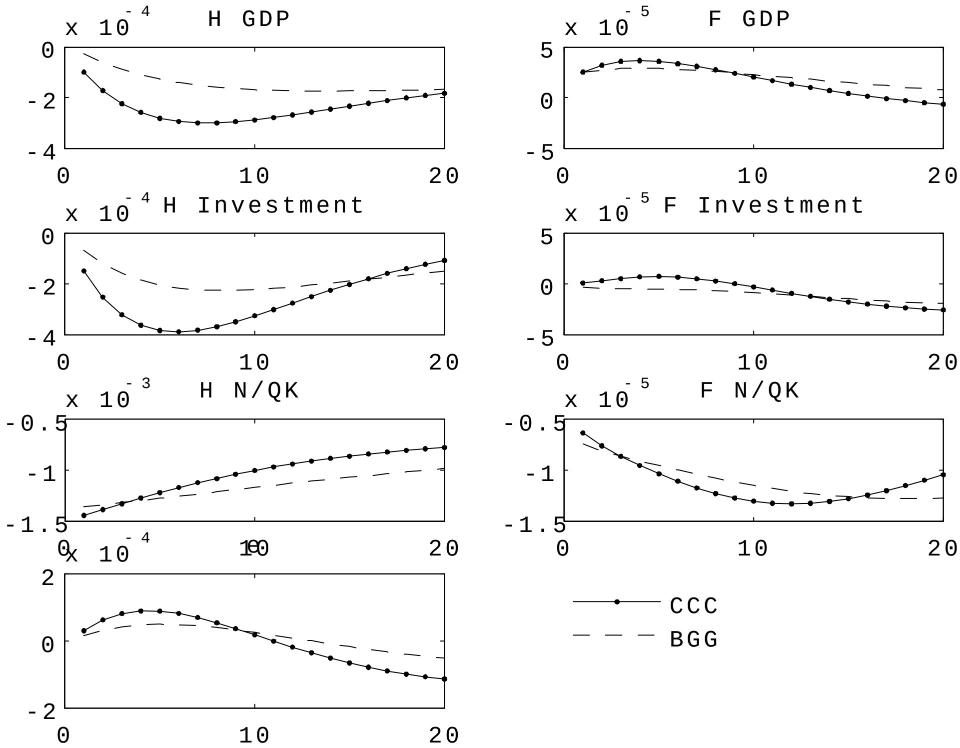


Figure 13: Entrepreneurial Net Worth Shock in H without Banking Globalization

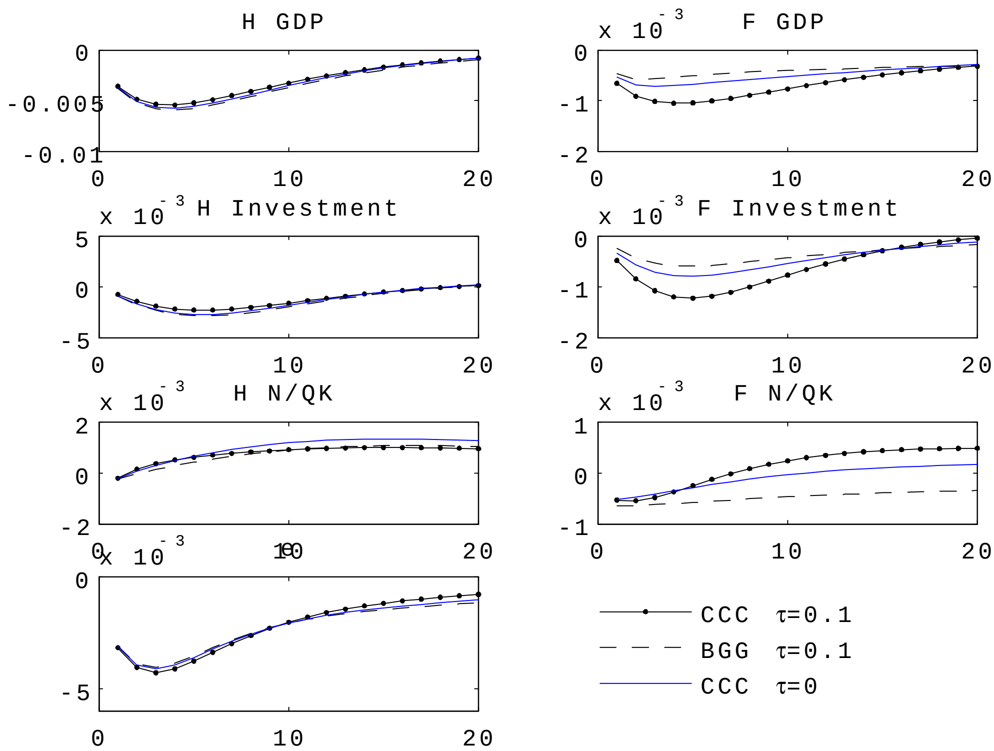


Figure 14: Productivity Shock in H under Banking Globalization (1)

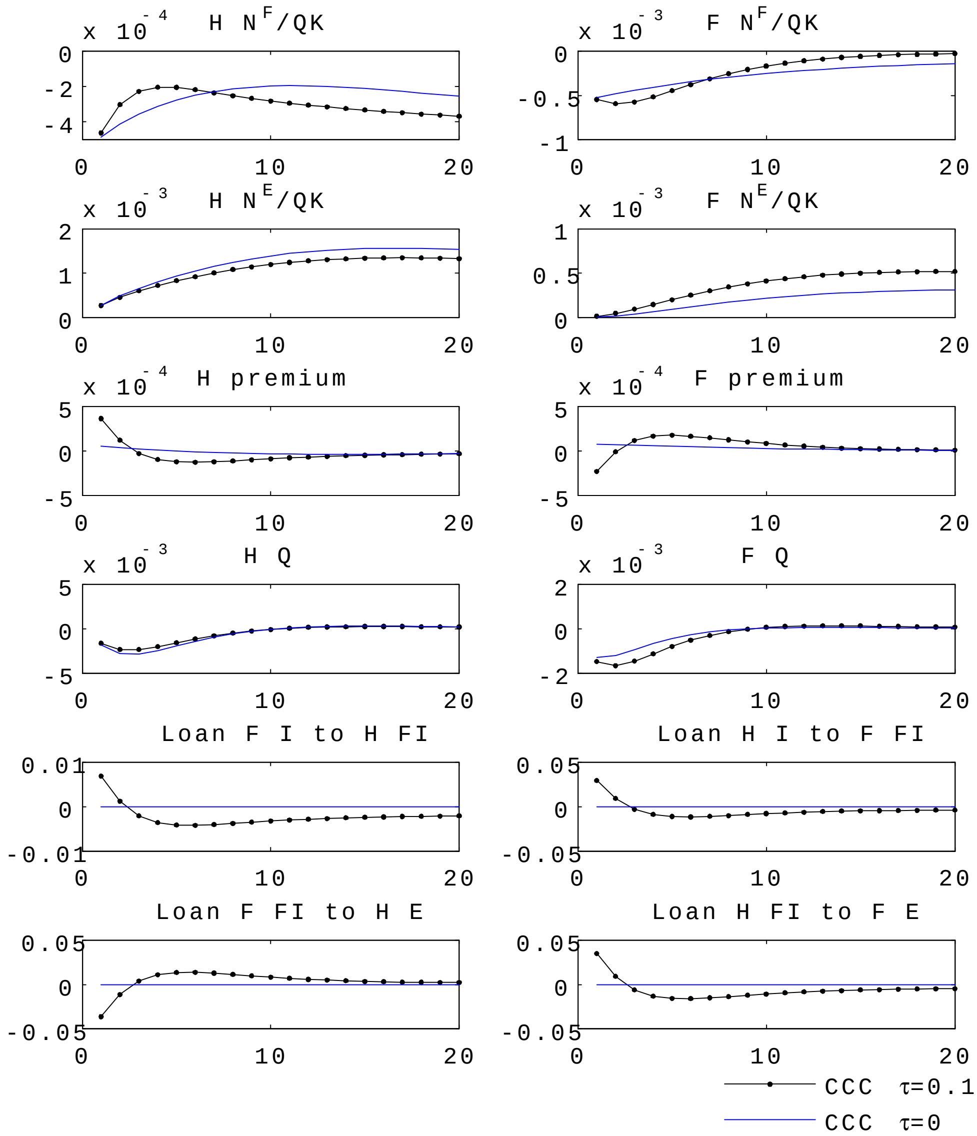


Figure 15: Productivity Shock in H under Banking Globalization (2)

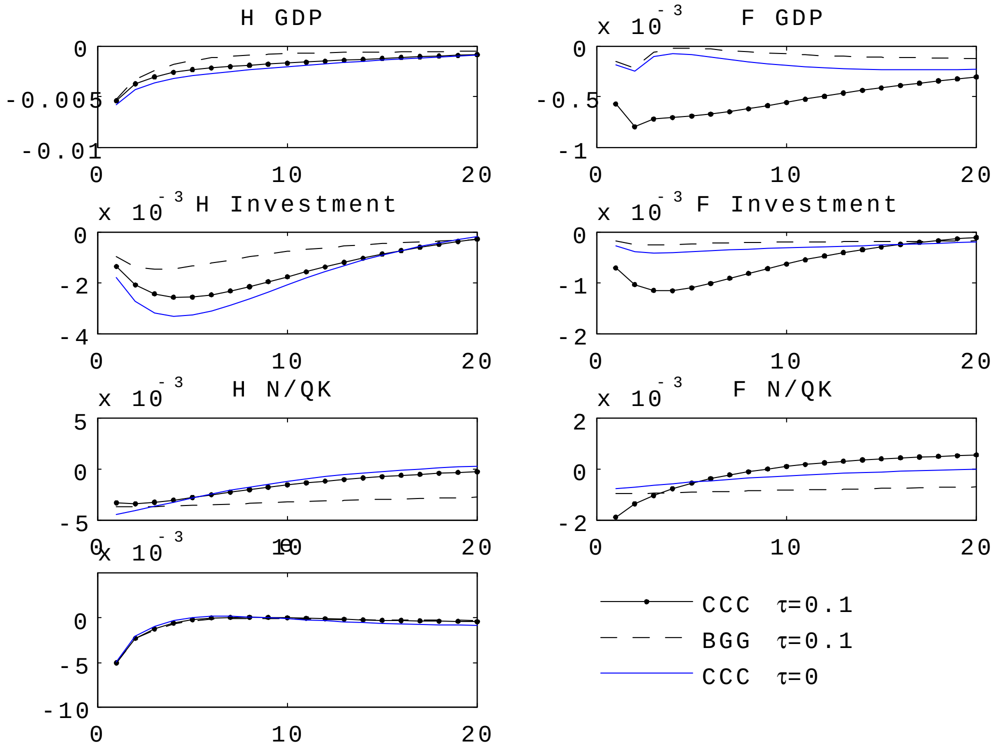


Figure 16: Monetary Policy Shock in H under Banking Globalization (1)

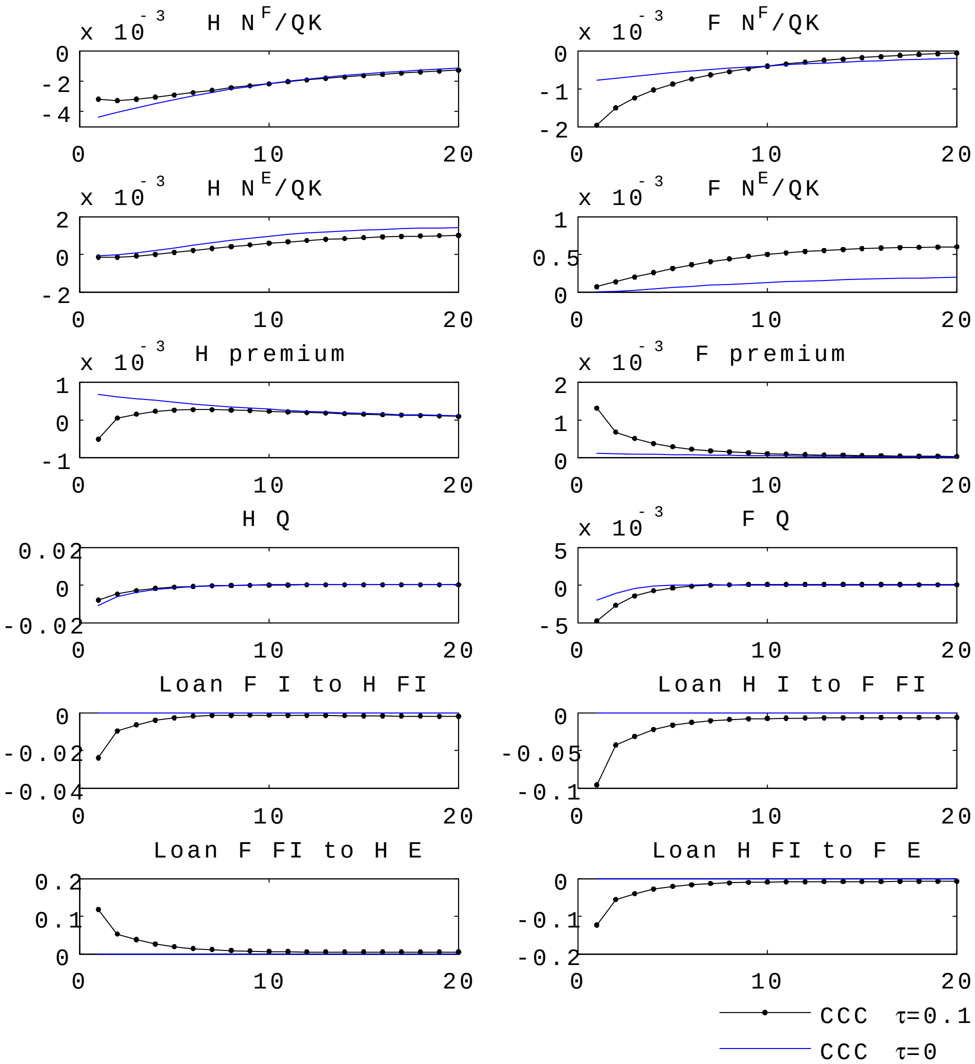


Figure 17: Monetary Policy Shock in H under Banking Globalization (2)

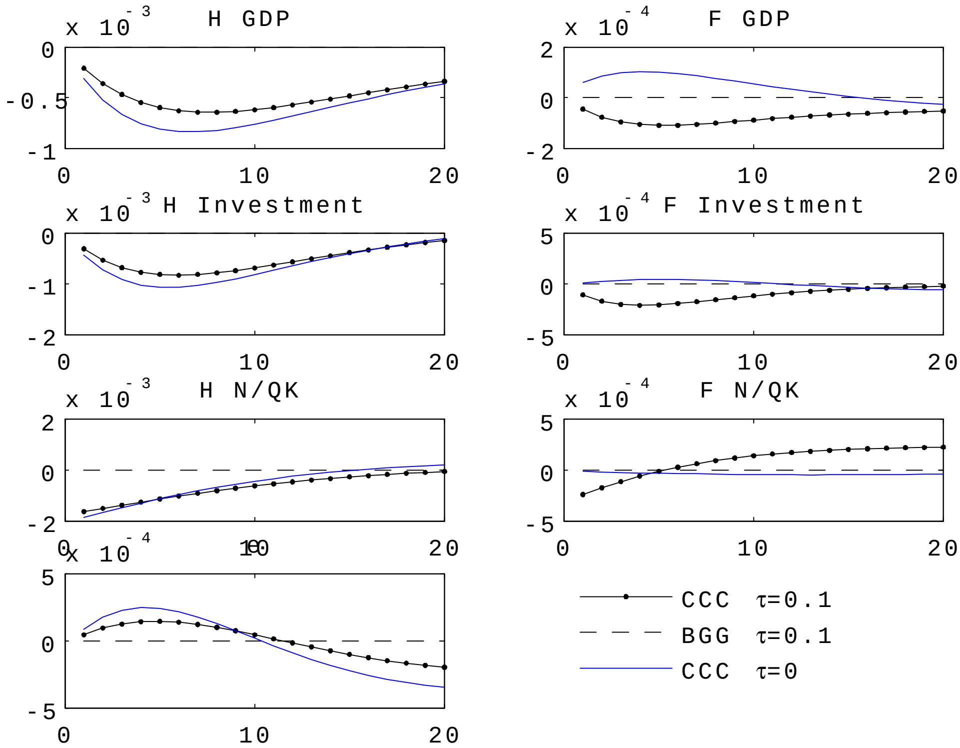


Figure 18: FIs' Net Worth Shock in H under Banking Globalization (1)

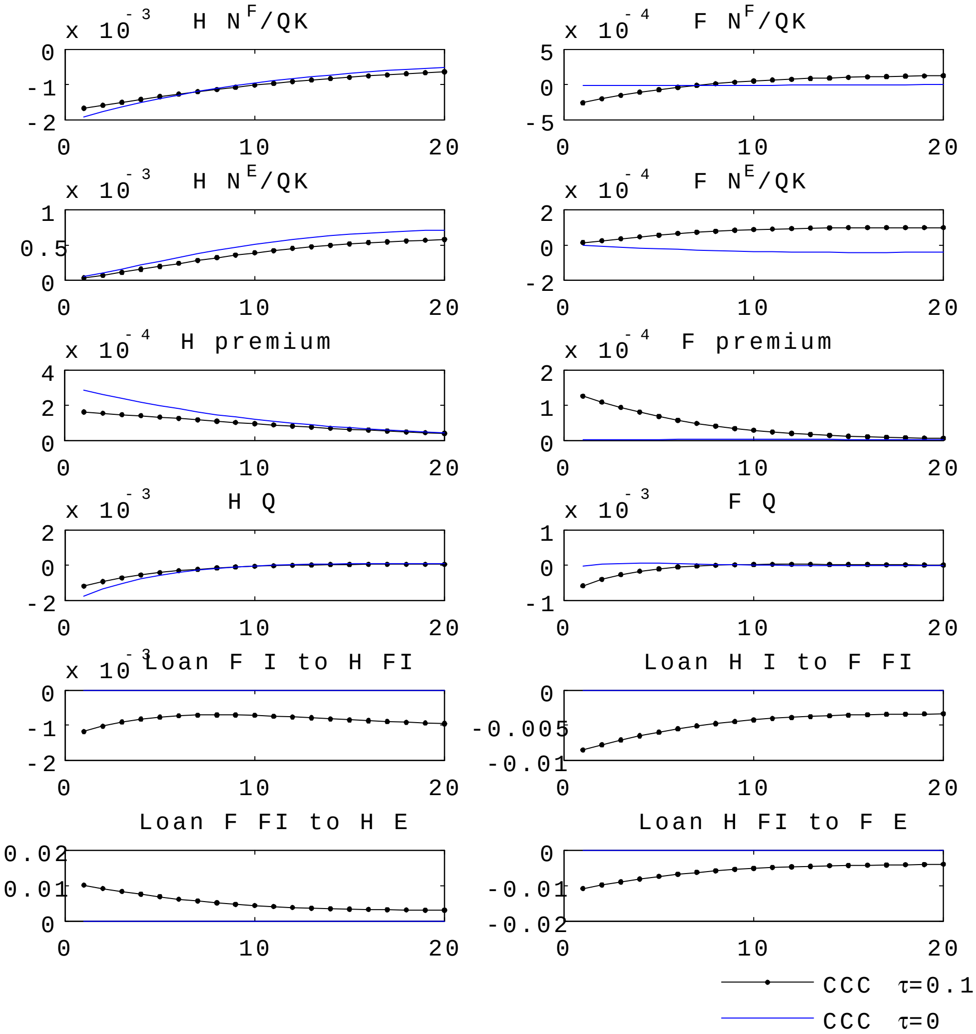


Figure 19: FIs' Net Worth Shock in H under Banking Globalization (2)

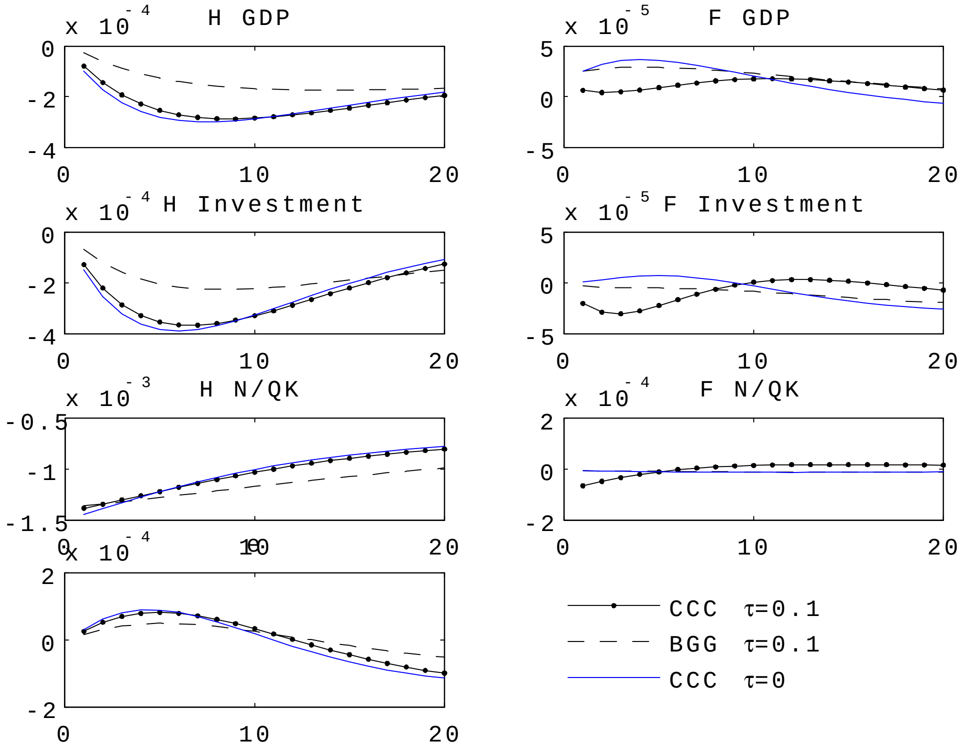


Figure 20: Entrepreneurial Net Worth Shock in H under Banking Globalization (1)

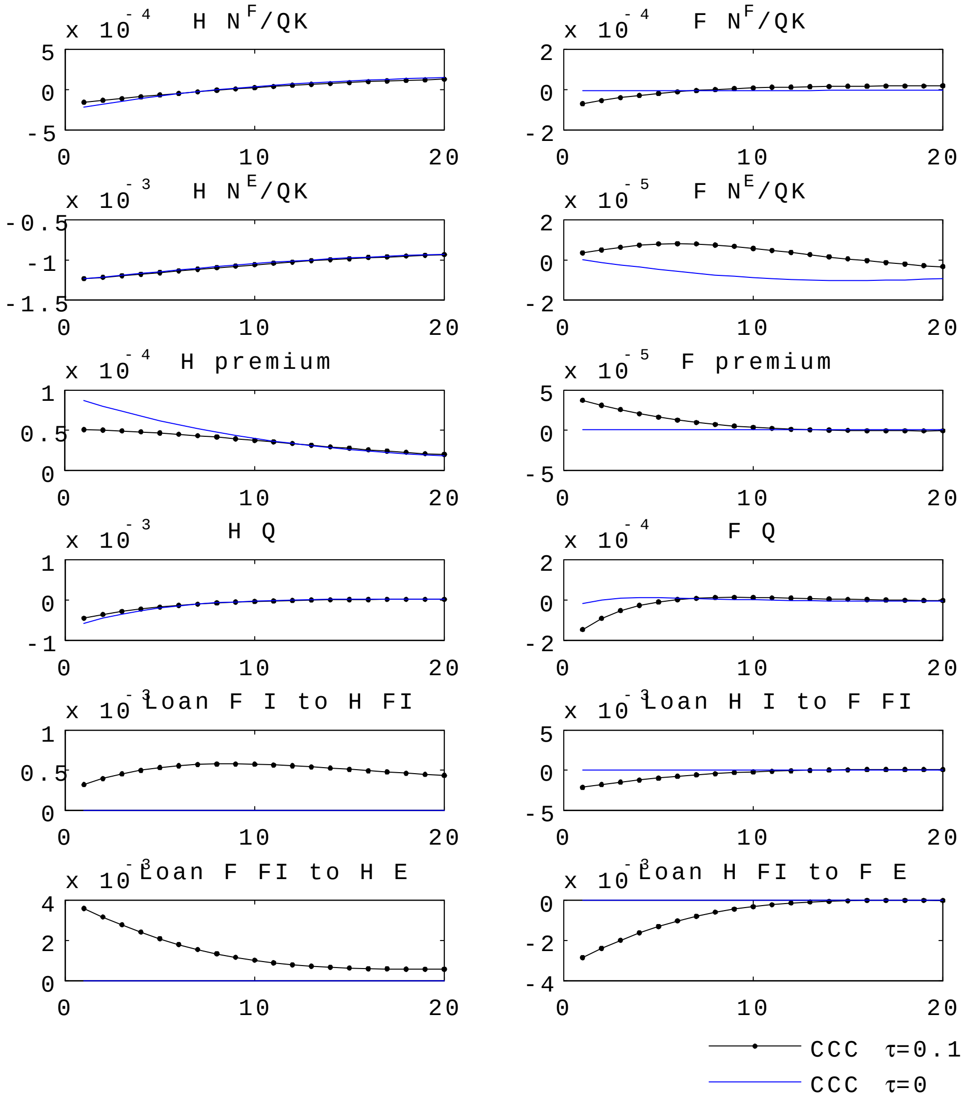


Figure 21: Entrepreneurial Net Worth Shock in H under Banking Globalization (2)

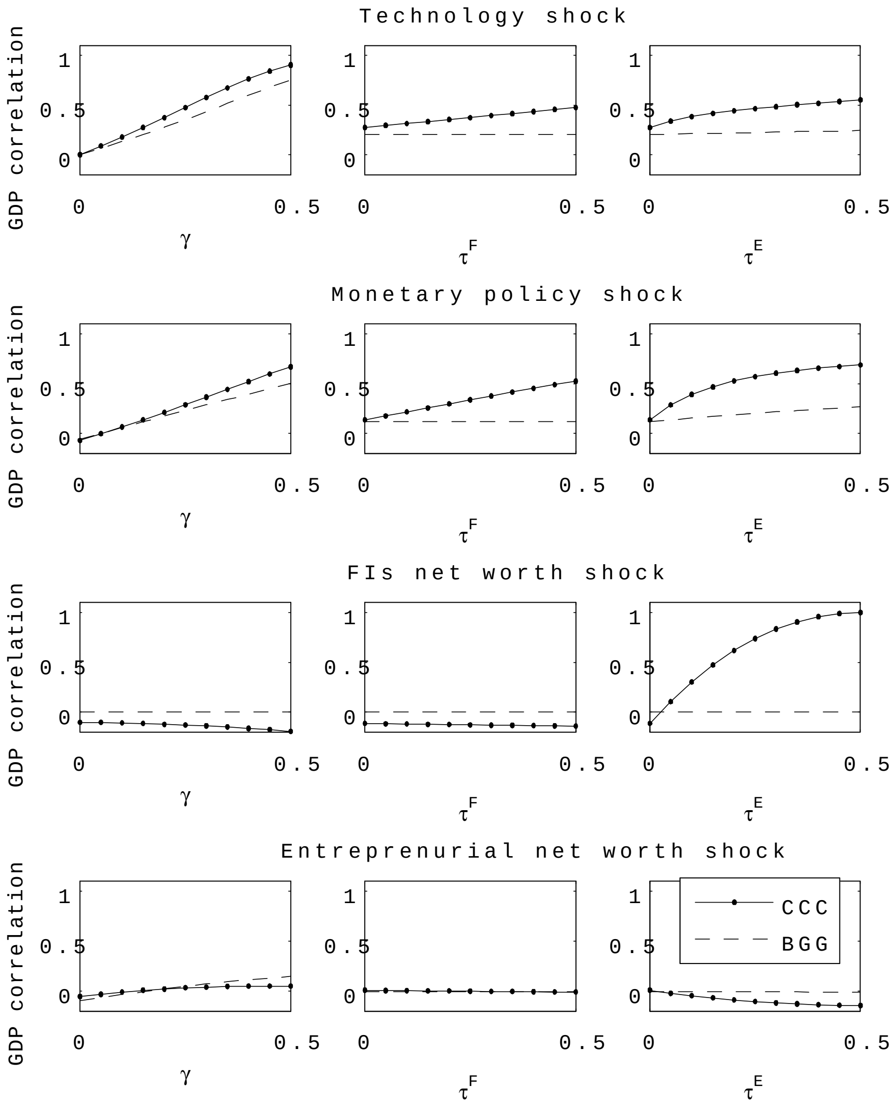


Figure 22: GDP Bilateral Correlations with Varying Openness Parameters

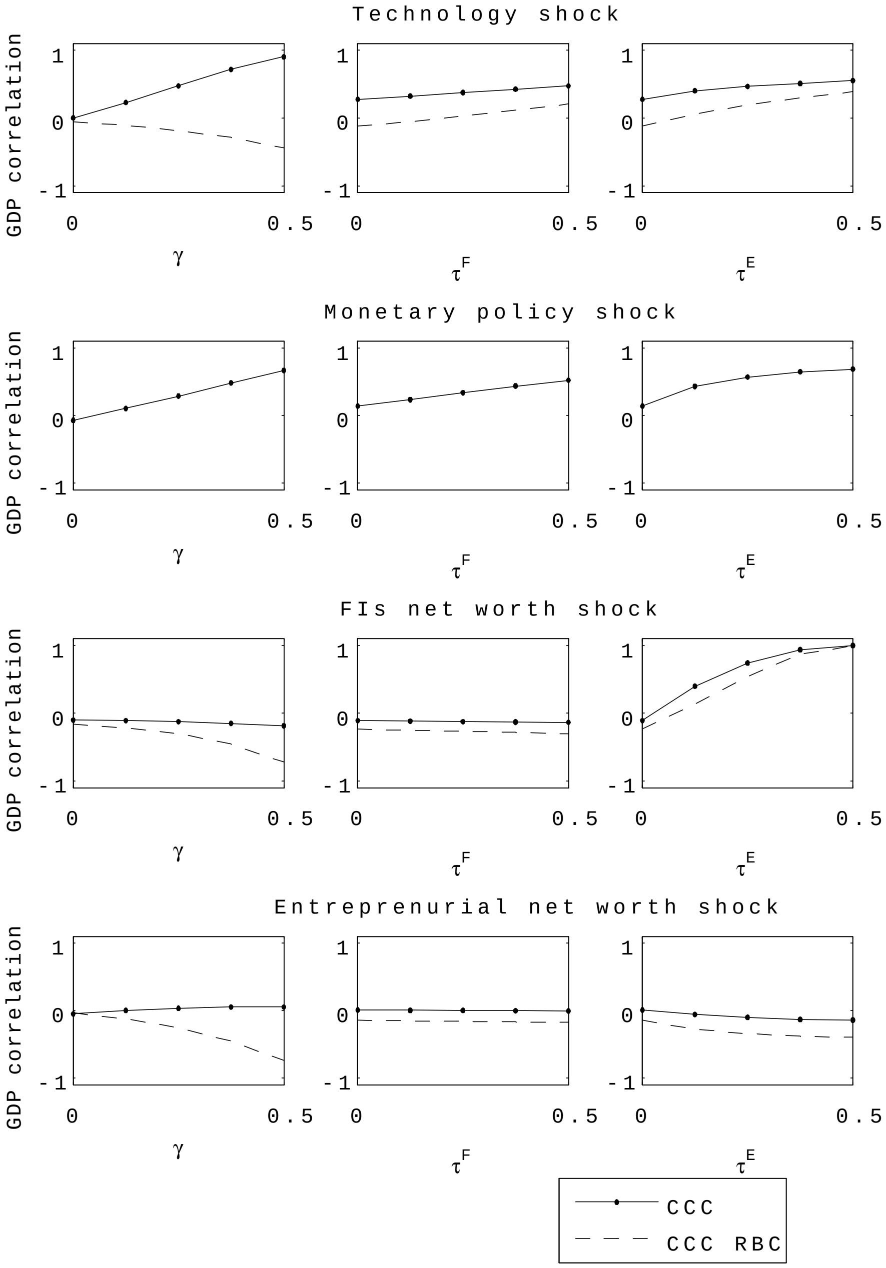


Figure 23: GDP Bilateral Correlations under Sticky and Flexible Price Models