Journal of International Economics 86 (2012) 1–16

Contents lists available at SciVerse ScienceDirect

Journal of International Economics

journal homepage: www.elsevier.com/locate/jie

Banking globalization and international business cycles: Cross-border chained credit contracts and financial accelerators

Kozo Ueda *

Bank of Japan, 2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo, Japan

A R T I C L E   I N F O

Article history:
Received 25 August 2010
Received in revised form 19 August 2011
Accepted 19 August 2011
Available online 26 August 2011

JEL classification:
E22
E32
E44
E52
F41

Keywords:
Financial accelerator
Financial intermediaries
Correlation (quantity) puzzle
Business cycle synchronization
Contagion
Monetary policy

A B S T R A C T

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.

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. Fig. 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. 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, and corporate bond spreads jumped in those areas. 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 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 et al. (2009, forthcoming, HSU) the credit

* Tel.: +81(0)3279-1111.
E-mail address: kouzou.ueda@boj.or.jp.

0022-1996/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.jinteco.2011.08.012

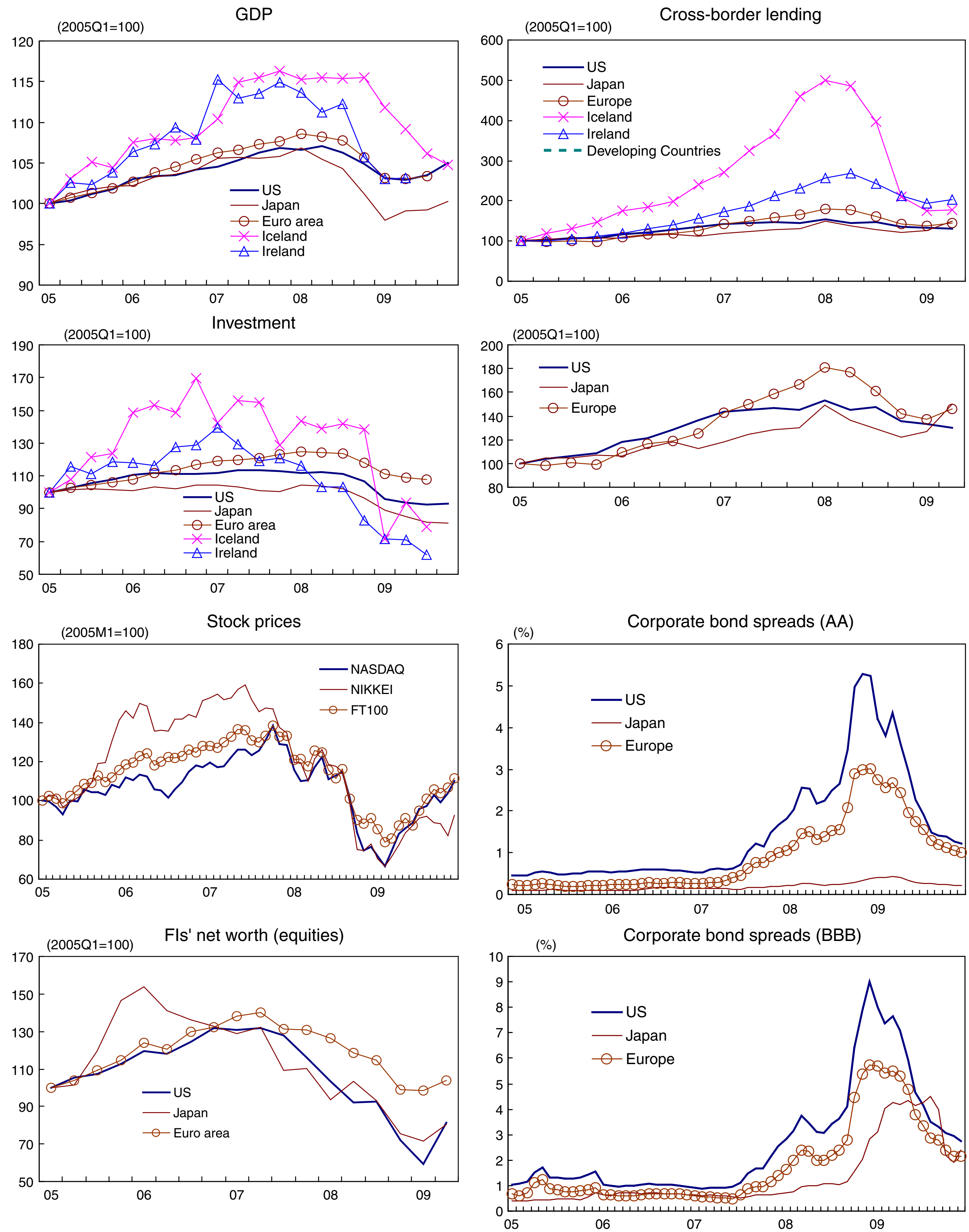

Fig. 1. Global downturns in the recent financial crisis.

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 et al. (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), although they are not studies on the recent financial crisis.

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 in one country reduces GDP, investment, and asset prices in the other country. However, cross-border lending increases and risk premiums decrease 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.

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.

2. Related literature

In this section, we review related theoretical literature on business cycle synchronization and the common lender effect. Theoretically, business cycle synchronization has been regarded as a correlation puzzle or a quantity puzzle since Backus et al. (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 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.[1] 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. However, many of existing DSGE models did not focus on important features in the recent crisis such as the synchronized decrease in cross-border lending, the synchronized rise in corporate bond spreads, and the deterioration in FIs' net worth as the propagator of the crisis to the world economy.

Notable exceptions are Dedola and Lombardo (2009) and Kollman et al. (2011). Bearing similar motivations, they construct a two-country DSGE model with credit-constrained lenders. They then reveal that financial shocks are a key to explaining strong business cycle synchronization in the recent financial crisis. In particular, Dedola and Lombardo (2009) are very close to ours in that both models are based on BGG.

Due to such similarities, differences deserve highlighting.[2] Compared with Dedola and Lombardo (2009), we point out three major differences. First, as a model difference, Dedola and Lombardo (2009) endogenize portfolio choices, and at the same time, use a reduced form regarding financial accelerator mechanism. Endogenous portfolio choices provide a richer perspective on business cycle synchronization, because they amplify or reduce the propagation of shocks. Dedola and Lombardo (2009) apply the second-order approximation method developed by Devereux and Sutherland (2011) to solve the endogenous portfolio choice problem. However, in order to apply the method, agents who optimize portfolios need to be risk averse, although agents who face financial constraint (borrowers) are risk neutral in the BGG model.[3] For that reason, Dedola and Lombardo (2009) borrow the key insight from BGG and assume a reduced-form relationship between an external financial premium and net worth. In our model, we aim to maintain a theoretical consistency by deriving a structural form regarding the relationship.[4] As a sacrifice, portfolio choices remain indeterminate in a non-stochastic steady state, and we assume exogenous portfolio choices. The second difference concerns the interpretation of agents associated with the common lender effect. Our paper focuses on entrepreneurs' liability side by capturing FIs which engage in cross-border lending to entrepreneurs at home and abroad. Dedola and Lombardo (2009) focus on a firm's asset side by capturing agents who purchase a claim on firms' capital at home and abroad. Third, as a model prediction difference, Dedola and Lombardo (2009) argue that business cycle synchronization is strong even if financial exposure is minimal. We find that higher financial exposure yields stronger business cycle synchronization,[5] although results may change if FIs can optimally diversify their portfolios.

[1] See BKK (1994), Baxter and Crucini (1995), Heathcote and Perri (2002, 2004), Kehoe and Perri (2002), Iacoviello and Minetti (2006), Faia (2007), Dedola and Lombardo (2009), Devereux and Yetman (2009), and Perri and Quadrini (2010).

[2] As other differences, our model incorporates credit constraints of both entrepreneurs and FIs. Therefore, both entrepreneurs' and FIs' net worth influence their borrowing premiums, FIs' cross-border lending and borrowing, and in turn, the real economy.

[3] Since borrowers are risk neutral, all aggregate risk is distributed to the borrowers. If borrowers are risk averse, borrowers need to modify their credit contracts taking account of the aggregate risk, which changes the optimal credit contract and developments in their net worth.

[4] Similar to Christiano et al. (2004), we derive a non-linear structural optimal contract and use this together with agents' participation constraint, instead of using a reduced form.

[5] Our result is consistent with some empirical studies (Kose et al., 2003; Morgan et al., 2004, and Imbs, 2004, 2006).

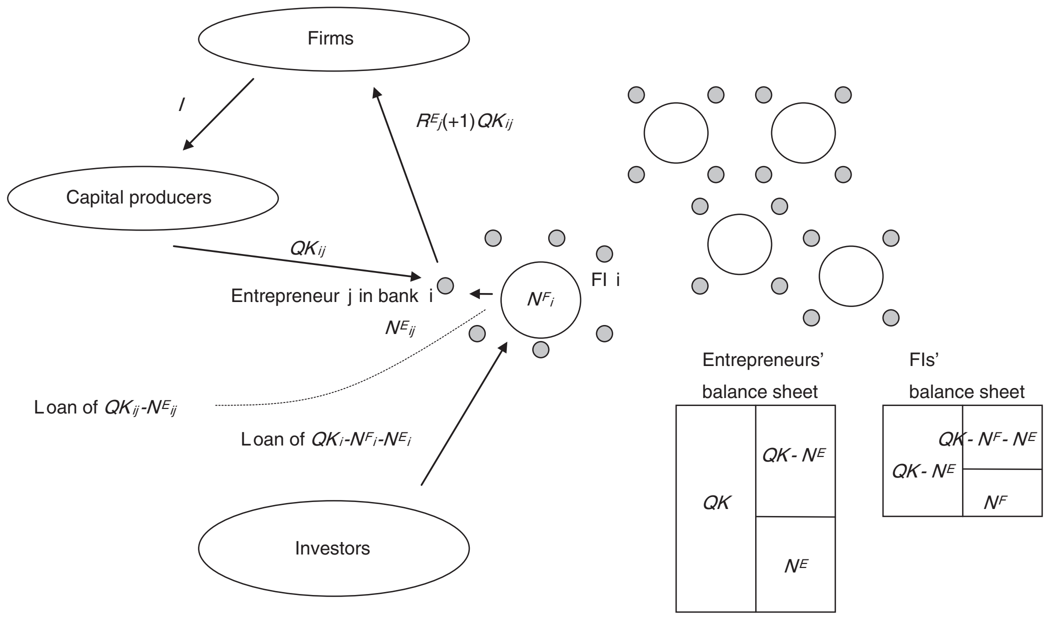

Fig. 2. Chained credit contracts.

In comparison with Kollman et al. (2011), a major model difference exists in the source of FIs' credit constraint. They assume that FIs can hold less capital than a required level, but that this entails cost. They argue that this cost captures regulatory requirements or, more broadly, market pressures, and formulate it as a decreasing and convex function with respect to FIs' excess capital. In our model, the source of FIs' credit constraint is information asymmetry between FIs and investors. We solve the optimal credit contract in an environment where investors, as a lender, have to pay monitoring costs to see an idiosyncratic shock associated with FIs. Regarding the degree of financial exposure, Kollman et al. (2011) assume a perfect financial exposure by modeling a representative global bank.

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 ten 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, forthcoming). As shown in Fig. 2, 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, 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.

Our model captures the function of FIs in intermediating funds from households to non-financial firms by managing risks and monitoring borrowers. FIs have the technology to monitor entrepreneurs and diversify their risks by lending funds to a number of entrepreneurs. This function characterizes banking, as is pointed out by Freixas and Rochet (2008). Admittedly, however, FIs perform other important functions in offering liquidity and payment services and transforming assets. Because credit contracts are basically static, our model misses maturity transformation. Consequently, despite its importance, a bank run is not present in our model unlike in Diamond and Dybvig (1983).

In the two-country model, the chained credit contracts are depicted as Fig. 3. Under banking globalization, FIs undertake cross-border lending to entrepreneurs through cross-border borrowing from investors.[6] The two parameters τ^F and τ^E represent exogenous 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, $1-\tau^E$ of their net worth N^E_t is used to borrow from the home FI and τ^E of their net worth to borrow from the foreign FI. FIs in the home country borrow a portion of $1-\tau^F$ from the home investors and τ^F from the foreign investors.[7] Put differently, $0<\tau^E$ and $\tau^F<1$ represent the degree of banking globalization from FIs' borrowing and lending sides: τ^F captures the degree of banking globalization from FIs' borrowing side, or the financial openness of the interbank market, and τ^E captures the degree of banking globalization from FIs' lending side or the financial openness of foreign direct investment.

3.1.1. 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 in the home country makes loan contracts with specific

[6] 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.

[7] 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 in a non-stochastic steady state, and we set the portfolio exogenously. Despite the exogenous portfolio choices, assets are diversified endogenously: external finance premiums to borrow funds from two countries are equalized to satisfy the no-arbitrage condition. 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. Such endogenous diversification as well as the common lender effect is the key to business cycle synchronization, as in Dedola and Lombardo (2009).

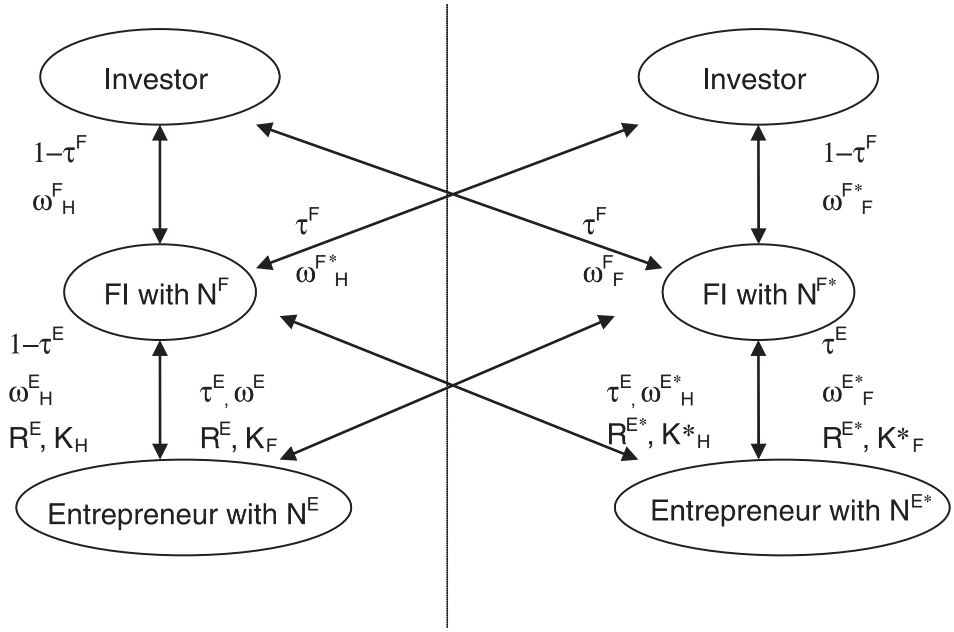

Fig. 3. Chained credit contracts in two countries.

group of entrepreneurs in the home country. Entrepreneurs are attached to the monopolistic FI,[8] owning net worth N_t^E. They use $1-\tau^E$ of the net worth to purchase capital of $(1-\tau^E)Q_tK_{H,t}$, where Q_t is the price paid to capital in units of the household consumption index. Following BGG, we assume that entrepreneurs are subject to an idiosyncratic productivity shock $\omega_{H,t+1}^E$[9] so that the net return to capital is $\omega_{H,t+1}^E R_{t+1}^E$, where R_t^E is the aggregate return to capital. The FE contract specifies the amount of debt that entrepreneurs borrow and the cut-off value for the idiosyncratic shock, which we denote by $\overline{\omega}_{H,t+1}^E$, such that entrepreneurs repay their debt for $\omega_{H,t+1}^E \geq \overline{\omega}_{H,t+1}^E$ and declare the default otherwise.

There is a participation constraint for entrepreneurs in the FE contract. Instead of participating in the FE contract, entrepreneurs can purchase capital goods using their own net worth N_t^E, without participating in loan contracts with FIs. The FE contract is agreed only when the following inequality is expected to hold:

$$\left[1-\Gamma^E\left(\overline{\omega}_{H,t+1}^E\right)\right]R_{t+1}^E Q_t K_{H,t} \geq R_{t+1}^E N_t^E, \tag{1}$$

where $\Gamma(\overline{\omega}) \equiv G(\overline{\omega}) + \overline{\omega}\int_{\overline{\omega}}^{\infty} dF(\omega)$ and $G(\overline{\omega}) \equiv \int_0^{\overline{\omega}} \omega dF(\omega)$. $1-\Gamma^E$ 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 entrepreneurs, and the right-hand side of the inequality (1) shows the expected return from investing the entrepreneurial net worth. Similarly, we model the FE contract between FIs in the home country and entrepreneurs in the foreign country.

Inequality (1) and its foreign equivalent give the expected earnings of the FI from each of the FE contract

$$\Phi^E\left(\overline{\omega}_{H,t+1}^E\right)\left(1-\tau^E\right)R_{t+1}^E Q_t K_{H,t} + \Phi^{E*}\left(\overline{\omega}_{H,t+1}^{E*}\right)\tau^E e_{t+1} R_{t+1}^{E*} Q_t^* K_{H,t}^*,$$

where e_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_{t+1}. Φ represents a net lender's share, defined as $\Phi(\overline{\omega}) \equiv \Gamma(\overline{\omega}) - \mu G(\overline{\omega})$. A parameter μ $(0<\mu<1)$ represents the parameter of monitoring costs.

For convenience, we define the expected return on the loans to entrepreneurs, R_{t+1}^F by

$$\begin{aligned} &\int_{j_i}\Phi^E\left(\overline{\omega}_{H,t+1}^E\right)\left(1-\tau^E\right)R_{t+1}^E Q_t K_{H,t} dj_i \\ &+\int_{j_i}\Phi^{E*}\left(\overline{\omega}_{H,t+1}^{E*}\right)\tau^E \frac{e_{t+1}}{e_t} R_{t+1}^{E*} e_t Q_t^* K_{H,t}^* dj_i \\ \equiv\; & R_{t+1}^F\left\{\left(1-\tau^E\right)\left(Q_t K_{H,t} - N_t^E\right) + \tau^E e_t\left(Q_t^* K_{H,t}^* - N_t^{E*}\right)\right\}. \end{aligned} \tag{2}$$

The left-hand side of Eq. (2) is the gross profit that the FI receives from a continuum number of FE contracts with entrepreneurs in the two countries. On the right-hand side of the equation, $\tau^E e_t(Q_t^* K_{H,t}^* - N_t^{E*})$ represents loans to entrepreneurs in the foreign country in units of the household consumption index in the home country.

3.1.2. IF contract

We next turn to the IF contract. The 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 FI in the home country owns the net worth N_t^F, and invests in the loans to entrepreneurs in the home and foreign countries. The FI then borrows the rest from investors in the home country by a portion of $1-\tau^F$ and investors in the foreign country by a portion of τ^F. It repays the loan using its profit from the FE contracts. On top of $\omega_{H,t+1}^E$ and $\omega_{H,t+1}^{E*}$, which are the idiosyncratic productivity shocks associated with entrepreneurs, we assume that the FI is subject to an idiosyncratic productivity

[8] In this two-country model, we assume that each entrepreneur faces two monopolistic FIs at 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.

[9] The ω^E is unit mean, lognormal random variables distributed independently over time and across entrepreneurs. We express its cumulative distribution functions as $F^E(\omega^E)$.

shock $\omega^F_{H,t+1}$[10] and its ex post gross return on the loans to entrepreneurs is given by $\omega_H, t+1^F R_t + 1^F$. Here, the IF contract specifies the amount of debt that the FI borrows from investors and the cut-off value for the idiosyncratic shock, which we denote by $\overline{\omega}_H, t+1^F$ and $\overline{\omega}_H, t+1^F*$, such that FIs repay their debt for $\omega_H, t+1^F \geq \overline{\omega}_H, t+1^F$ and declare the default otherwise.

Similar to the FE contract, there is a participation constraint for the investors in the IF contract. Given the risk-free rate of return in the economy R_t and R_t^*, investors' profit from the investment in the loans to the FIs must equal the opportunity cost of lending. That is,

$$\begin{aligned}\Phi^F\left(\overline{\omega}^F_{H,t+1}\right)R^F_{t+1}\left\{\left(1-\tau^E\right)\left(Q_tK_{H,t}-N^E_t\right)+\tau^E e_t\left(Q^*_tK^*_{H,t}-N^{E*}_t\right)\right\}\\ \geq R_t\left\{\left(1-\tau^E\right)\left(Q_tK_{H,t}-N^E_t\right)+\tau^E e_t\left(Q^*_tK^*_{H,t}-N^{E*}_t\right)-N^F_t\right\},\end{aligned} \tag{3}$$

$$\begin{aligned}\Phi^{F*}\left(\overline{\omega}^{F*}_{H,t+1}\right)R^F_{t+1}\left\{\left(1-\tau^E\right)\left(Q_tK_{H,t}-N^E_t\right)+\tau^E e_t\left(Q^*_tK^*_{H,t}-N^{E*}_t\right)\right\}\\ \geq \frac{e_{t+1}}{e_t}R^*_t\left\{\left(1-\tau^E\right)\left(Q_tK_{H,t}-N^E_t\right)+\tau^E e_t\left(Q^*_tK^*_{H,t}-N^{E*}_t\right)-N^F_t\right\}.\end{aligned} \tag{4}$$

Eqs. (3) and (4) represent the participation constraint for the home and foreign investors in the IF contract, respectively. The left-hand side is the expected profits from the investment in the loans to the FIs. The right-hand side is the expected profits from the investment in risk-free assets.

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

$$\begin{aligned}E_t\Big[\Big\{1-\Gamma^F\left(\overline{\omega}^F_{H,t+1}\right)\Big\}\left(1-\tau^F\right)\cdot R^F_{t+1}\Big\{\left(1-\tau^E\right)\left(Q_tK_{H,t}-N^E_t\right)\\ +\tau^E e_t\left(Q^*_tK^*_{H,t}-N^{E*}_t\right)\Big\}+\Big\{1-\Gamma^{F*}\left(\overline{\omega}^{F*}_{H,t+1}\right)\Big\}\tau^F\\ \cdot R^F_{t+1}\Big\{\left(1-\tau^E\right)\left(Q_tK_{H,t}-N^E_t\right)+\tau^E e_t\left(Q^*_tK^*_{H,t}-N^{E*}_t\right)\Big\}\Big].\end{aligned} \tag{5}$$

3.1.3. Optimal credit contract

Expected returns to capital $E_tR^E_{t+1}$ and $E_tR^{E^*}_{t+1}$ are derived by solving the optimal credit contract. They 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 $E_tR^E_{t+1}$ and $E_tR^{E^*}_{t+1}$ from the risk-free rate is called the external finance premium.

The FI in the home country maximizes its expected profit (5) by optimally choosing the variables $\overline{\omega}^F_H$, $\overline{\omega}^{F*}_H$, $\overline{\omega}^E_H$, $\overline{\omega}^{E*}_H$, K_H, K^*_H, subject to the investors' participation constraint (3) and (4) as well as entrepreneurial participation constraints (1) and its foreign equivalent. We obtain

$$\begin{aligned}0=E_t\Big[R^E_{t+1}\Big\{\left(1-\Gamma^E\right)\Phi^{E'}+\Gamma^{E'}\Phi^E\Big\}\cdot\Big\{\left(1-\tau^F\right)\left(1-\Gamma^F\right)+\tau^F\left(1-\Gamma^{F*}\right)\Big\}\\ +\frac{\left(1-\tau^F\right)\Gamma^{F'}}{\Phi^{F'}}\Big\{\left(1-\Gamma^E\right)\Phi^F\Phi^{E'}R^E_{t+1}+\Gamma^{E'}\Phi^F\Phi^ER^E_{t+1}-\Gamma^{E'}R_t\Big\}\\ +\frac{\tau^F\Gamma^{F*'}}{\Phi^{F*'}}\Big\{\left(1-\Gamma^E\right)\Phi^{F*}\Phi^{E'}R^E_{t+1}+\Gamma^{E'}\Phi^{F*}\Phi^ER^E_{t+1}-\Gamma^{E'}\frac{e_{t+1}}{e_t}R^*_t\Big\}\Big]\end{aligned} \tag{6}$$

$$\begin{aligned}0=E_t\Big[R^{E*}_{t+1}\Big\{\left(1-\Gamma^{E*}\right)\Phi^{E*'}+\Gamma^{E*'}\Phi^{E*}\Big\}\cdot\Big\{\left(1-\tau^F\right)\left(1-\Gamma^F\right)+\tau^F\left(1-\Gamma^{F*}\right)\Big\}\\ +\frac{\left(1-\tau^F\right)\Gamma^{F'}}{\Phi^{F'}}\Big\{\left(1-\Gamma^{E*}\right)\Phi^F\Phi^{E*'}R^{E*}_{t+1}+\Gamma^{E*'}\Phi^F\Phi^{E*}R^{E*}_{t+1}-\Gamma^{E*'}_tR\left(s^t\right)\Big\}\\ +\frac{\tau^F\Gamma^{F*'}}{\Phi^{F*'}}\Big\{\left(1-\Gamma^{E*}\right)\Phi^{F*}\Phi^{E*'}R^{E*}_{t+1}+\Gamma^{E*'}\Phi^{F*}\Phi^{E*}R^{E*}_{t+1}-\Gamma^{E*'}\frac{e_{t+1}}{e_t}R^*_t\Big\}\Big].\end{aligned} \tag{7}$$

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 the 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.

3.1.4. Simplified form of the external finance premium

From Eqs. (2), (3), and (4), the external finance premium $E_tR^E_{H,t+1}/R_t$ is simplified as[11]

$$\frac{E_tR^E_{t+1}}{R_t}=F\left(\frac{N^F_t}{Q_tK_{H,t}},\frac{N^E_t}{Q_tK_{H,t}},\frac{N^{F*}_t}{Q^*_tK^*_{H,t}},\frac{N^{E*}_t}{Q^*_tK^*_{H,t}}\right). \tag{8}$$

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.

3.1.5. Dynamic behavior of net worth

The net worths of FIs and entrepreneurs, N^F_t and N^E_t, 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_t and W^E_t. 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

$$N^F_t=\gamma^FV^F_t+W^F_t+\varepsilon^{nF}_t, \tag{9}$$

$$N^E_t=\gamma^EV^E_t+W^E_t, \tag{10}$$

with

$$\begin{aligned}V^F_t\equiv\Big[1-\Gamma^F\left(\overline{\omega}^F_{H,t}\right)\Big]\left(1-\tau^F\right)R^F_t\\ \cdot\Big\{\left(1-\tau^E\right)\left(Q_{t-1}K_{H,t-1}-N^E_{t-1}\right)+\tau^E e_{t-1}\left(Q^*_{t-1}K^*_{H,t-1}-N^{E*}_{t-1}\right)\Big\}\\ +\Big[1-\Gamma^{F*}\left(\overline{\omega}^{F*}_{H,t}\right)\Big]\ \tau^FR^F_t\\ \cdot\Big\{\left(1-\tau^E\right)\left(Q_{t-1}K_{H,t-1}-N^E_{t-1}\right)+\tau^E e_{t-1}\left(Q^*_{t-1}K^*_{H,t-1}-N^{E*}_{t-1}\right)\Big\},\end{aligned} \tag{11}$$

[10] 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 their cumulative distribution functions as $F^E(\omega^E)$ and $F^F(\omega^F)$. 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.

[11] 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.

$$V_t^E \equiv \left(1-\Gamma^E\left(\overline{\omega}_{H,t}^E\right)\right)\left(1-\tau^E\right)R_t^E Q_{t-1}K_{H,t-1} + \left(1-\Gamma^E\left(\overline{\omega}_{F,t}^E\right)\right)\tau^E R_t^E Q_{t-1}K_{F,t-1}. \tag{12}$$

FIs and entrepreneurs that fail to survive at period t consume $(1-\gamma^F)$ V_t^F and $(1-\gamma^E)$ V_t^E, respectively. Following Gilchrist and Leahy (2002), we consider ε_t^{nF}, a once-and-for-all change in the FI's 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 et al. (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.

3.2.1. Household

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

$$\max_{C_t,H_t,D_t,B_t^*} \sum_{l=0} \beta^{t+l} \mathrm{E}_t \left\{ \frac{C_{t+l}^{1-\sigma}}{1-\sigma} - \chi_2 \frac{H_{t+l}^{1+\frac{1}{\chi_1}}}{1+\frac{1}{\chi_1}} \right\}, \tag{13}$$

subject to the budget constraint:

$$C_t + D_t + e_t B_t^* \le W_t H_t + R_{t-1} D_{t-1} + R_{t-1}^* e_t B_{t-1}^* + \Pi_t - T_t.$$

C_t is final goods consumption given by

$$C_t = \left((1-\gamma)^{1/\eta} C_{H,t}^{(\eta-1)/\eta} + \gamma^{1/\eta} C_{F,t}^{(\eta-1)/\eta}\right)^{\eta/(\eta-1)}, \tag{14}$$

where $C_{H,t}$ and $C_{F,t}$ 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_t is hours worked. P_t is the aggregate price of the final goods given by

$$P_t = \left((1-\gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta}\right)^{1/(1-\eta)}. \tag{15}$$

W_t is the real wage in units of the household consumption index, and T_t is the lump-sum transfer. R_t and R_t^* are the real risk-free return from the deposit D_t and B_t^* 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.

Trade openness is captured by γ. The parameter γ represents the weight on foreign-produced goods or the inverse degree of a home bias.

3.2.2. Final goods producer

The final goods $Y_{H,t}$ are composites along a continuum of retail goods $Y_{H,t}(h)$. The final goods producer purchases retails goods in the competitive market and sells the output to a household and capital producers with price $P_{H,t}$.

3.2.3. Retail goods producer

The retail goods producers $h \in [0,1]$ are populated over a unit interval, each producing differentiated retail goods. The retail goods producers are price takers in the input market and choose their inputs taking the input price $P_t/X_{H,t}$ 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:

$$Y_{H,t}(h) = \left(\frac{P_{H,t}(h)}{P_{H,t}}\right)^{-\epsilon} Y_{H,t}.$$

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.

3.2.4. Wholesale goods producer

The wholesale goods producers produce wholesale goods $y_{H,t}$ and sell them to the retail goods producers with the relative price $1/X_{H,t}$. They hire three types of labor inputs H_t, H_t^F, and H_t^E, and capital K_{t-1}. Those labor inputs are supplied by household, FIs, and entrepreneurs. Capital is supplied by home (foreign) entrepreneurs with the same rental price R_t^E. At the end of each period, the capital is sold back to the entrepreneurs at price Q_t. The price of a unit of capital Q_t is the same for $K_{H,t-1}$ and $K_{F,t-1}$. The maximization problem for the wholesale goods producer is given by

$$\begin{aligned}\max_{y_{H,t},K_{t-1},H_t,H_t^F,H_t^E} & \frac{1}{X_{H,t}} y_{H,t} + Q_t\left\{\left(1-\tau^E\right)K_{H,t-1} + \tau^E K_{F,t-1}\right\}(1-\delta) \\ & - Q_{t-1}\left\{\left(1-\tau^E\right)R_t^E K_{H,t-1} + \tau^E R_t^E K_{F,t-1}\right\} \\ & - W_t H_t - W_t^F H_t^F - W_t^E H_t^E,\end{aligned} \tag{16}$$

subject to

$$K_t = \left(1-\tau^E\right)K_{H,t} + \tau^E K_{F,t}, \tag{17}$$

$$y_{H,t} = A\, exp\left(e_t^A\right) K_{t-1}^{\alpha} H_t^{(1-\Omega_F-\Omega_E)(1-\alpha)} H_t^{F\Omega_F(1-\alpha)} H_t^{E\Omega_E(1-\alpha)}, \tag{18}$$

where $A\, exp(e_t^A)$ 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.

3.2.5. 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_t amounts of final goods from the final goods producers in the home country. In addition, they purchase $K_{t-1}(1-\delta)$ of used capital goods from the entrepreneurs in the home country at price Q_t. They then produce new capital goods K_t, using the technology F_I, and sell them in the competitive market at price Q_t. Consequently, the capital goods producer's problem is to maximize the following profit function:

$$\max_{I_t} \sum_{l=0}^{\infty} \mathrm{E}_t \Lambda_{t+l}\left[Q_{t+l}\left(1-F_I\left(I_{t+l}, I_{t+l-1}\right)\right)I_{t+l} - I_{t+l}\right], \tag{19}$$

where F_I is defined as follows:

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

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

$$K_t = (1 - F_I(I_t, I_{t-1}))I_t + (1-\delta)K_{t-1}. \tag{20}$$

3.2.6. Resource constraint

The resource constraint for final goods is written as

$$Y_t = C_{H,t} + C^*_{H,t} + I_t + G_t + C^E_{H,t} + C^{E*}_{H,t}, \tag{21}$$

where $C^E_{H,t}$ and $C^{E*}_{H,t}$ represent the consumption of home-produced goods spent by entrepreneurs in the home country and the foreign country, respectively.

3.3. Rest of the economy

3.3.1. Government

The government collects lump-sum tax from the household T_t, and spends G_t. A budget balance is maintained for each period: $G_t = T_t$.

3.3.1.1. Monetary authority. The monetary authority sets the nominal interest rate R^n_t, according to a standard Taylor rule with inertia

$$R^n_t = \rho R^n_{t-1} + (1-\theta)\left(\phi_\pi \pi_{H,t} + \phi_y log(Y_t/Y)\right), \tag{22}$$

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 $log(Y_t/Y)$, respectively. $\pi_{H,t}$ denotes the inflation rate of home-produced goods at period t, that is, $\pi_{H,t} = P_{H,t}/P_{H,t-1}$.

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

$$R_t \equiv E_t(R^n_t/\pi_{t+1}). \tag{23}$$

π_t denotes the aggregate inflation rate at period t, that is, $\pi_t = P_t/P_{t-1}$.

3.3.1.2. Exogenous variables. The exogenous shocks to the model are the productivity shock and FIs' net worth shock. The productivity shock follows the process as

$$e^A_t = \rho_A e^A_{t-1} + \varepsilon^A_t, \tag{24}$$

where $\rho_A \in (0,1)s$ is the autoregressive root. ε^A_t and ε^{nF}_t are innovations that are mutually independent, serially uncorrelated, and normally distributed with mean zero, respectively.

4. Simulation

4.1. Calibration

We follow HSU and originally BGG for parameter values. The parameter values are symmetric in two countries. See Appendix A for details. Regarding the parameters of the two-country model, six parameters capture economic openness. First, we set benchmark trade openness $\gamma = 0.15$ following Faia (2007). Second, we set $\tau^F = 0$ and $\tau^E = 0$ in the benchmark for the parameters of banking globalization or financial openness. Ueda (2010) discusses that the latest ratio of foreign claims to non-financial firms' total liabilities equal, $0.5\tau^E + 0.4\tau^F$, are about 15% for the United States, 10% for Japan, and 35% for the euro area.

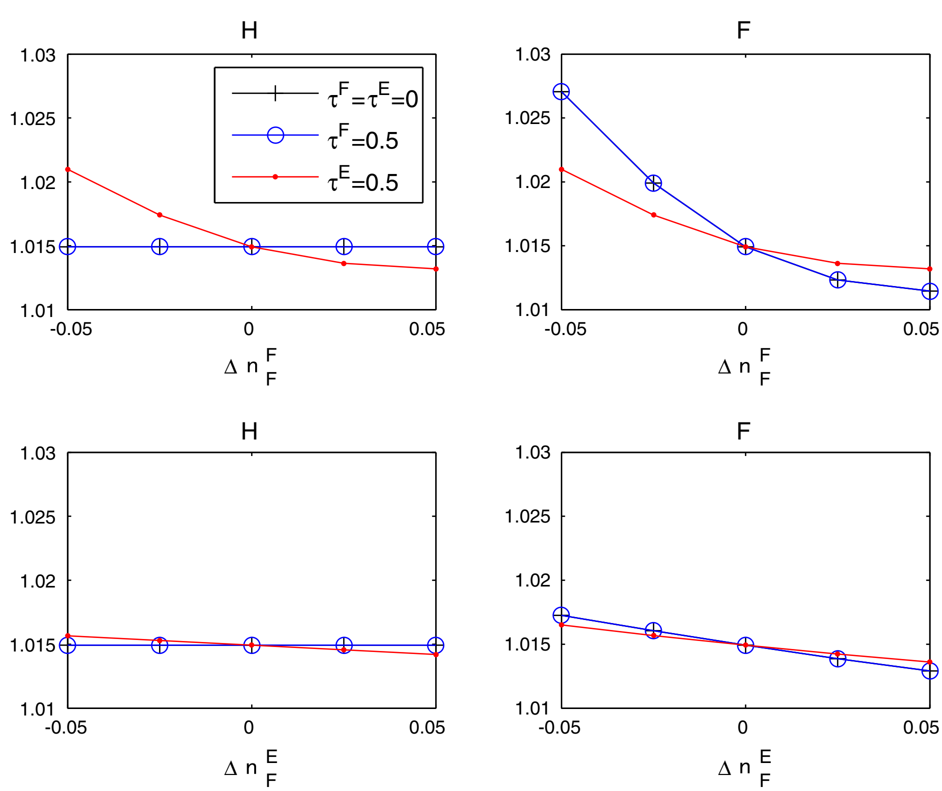

Fig. 4. Cost-of-funds versus net worth.

4.2. Net worth and cost-of-funds

To examine the property of the credit market, we analyze cost-of-funds $E_t R^E_{t+1}$ for entrepreneurs in the home and the foreign country. To begin with, we focus on the partial equilibrium only of the credit market.

For varying FIs' and entrepreneurial net worth ratios in the foreign country, we calculate how cost-of-funds moves. In Fig. 4, 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 Fig. 4, 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 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 two types of adverse shocks: (i) a productivity shock and

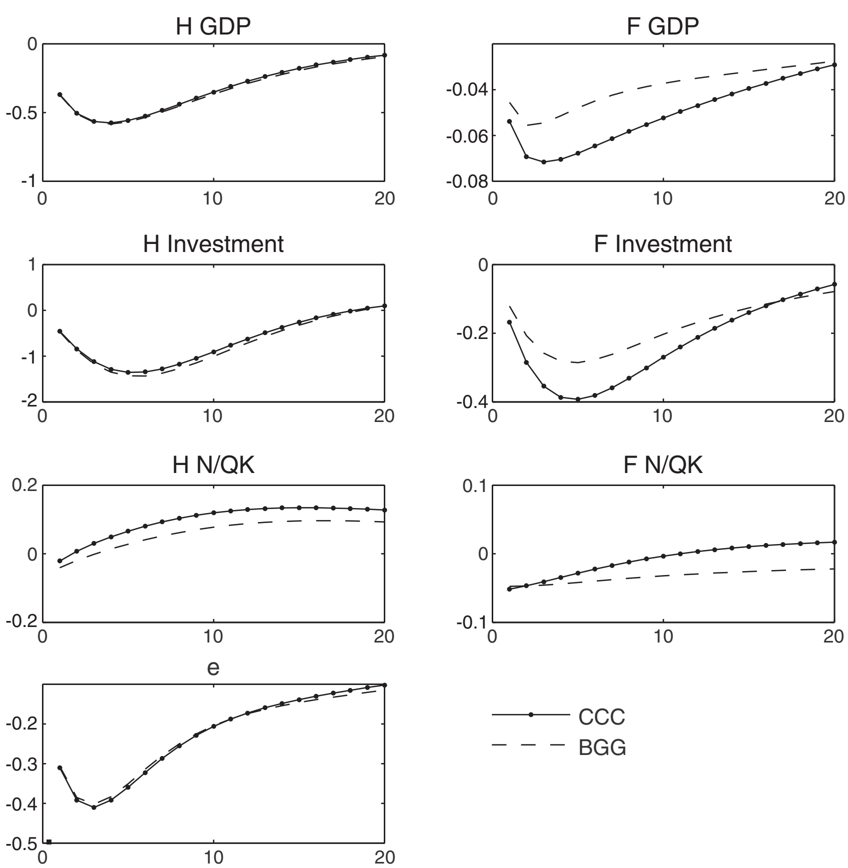

Fig. 5. Productivity shock in H without banking globalization.

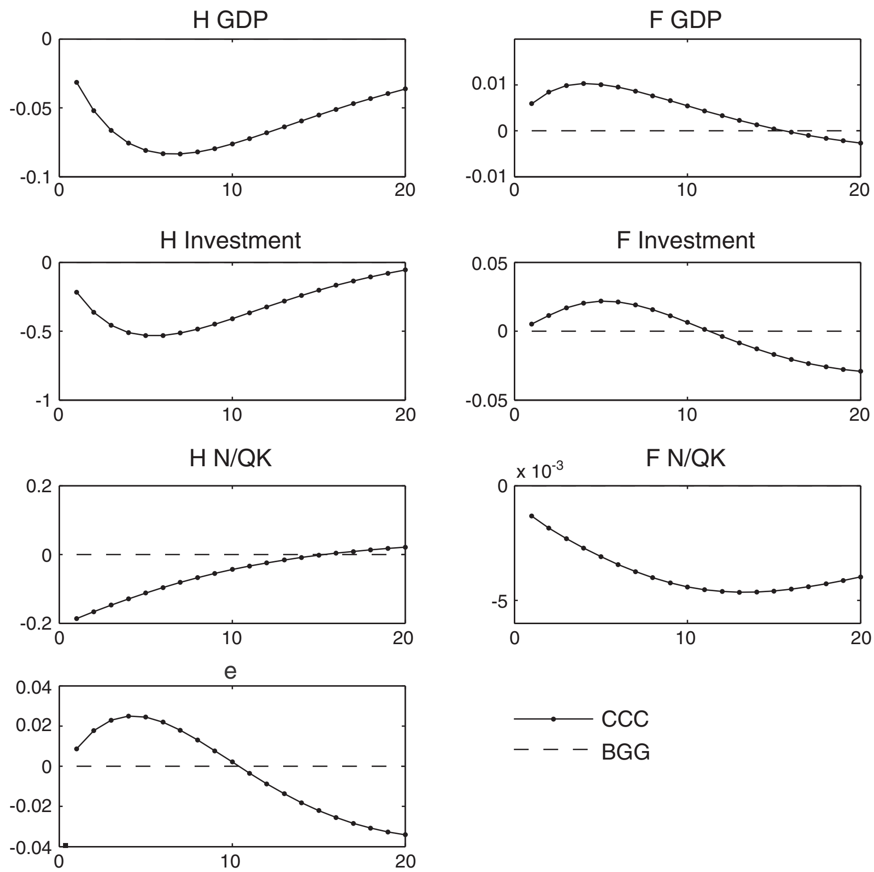

Fig. 6. FI net worth shock in H w/o banking globalization.

(ii) a net worth shock in the FI sector. The latter shock is introduced as an innovation in Eq. (9), 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. Impulse responses are shown in logarithm deviations from steady state, except for net worth ratios (and premiums in later figures). All responses are multiplied by 100.

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.[12]

[12] We use the same σ^E, μ^E, n^E, and R^E in our BGG model.

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.

4.3.1.1. Productivity shock. Fig. 5 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 show, 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.

The fact that the standard productivity shock can resolve the correlation puzzle is in line with Faia (2007). As she explains, credit market frictions as well as nominal stickiness play key roles. The adverse productivity shock raises 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. As this mechanism implies, monetary policy plays a crucial role in positive

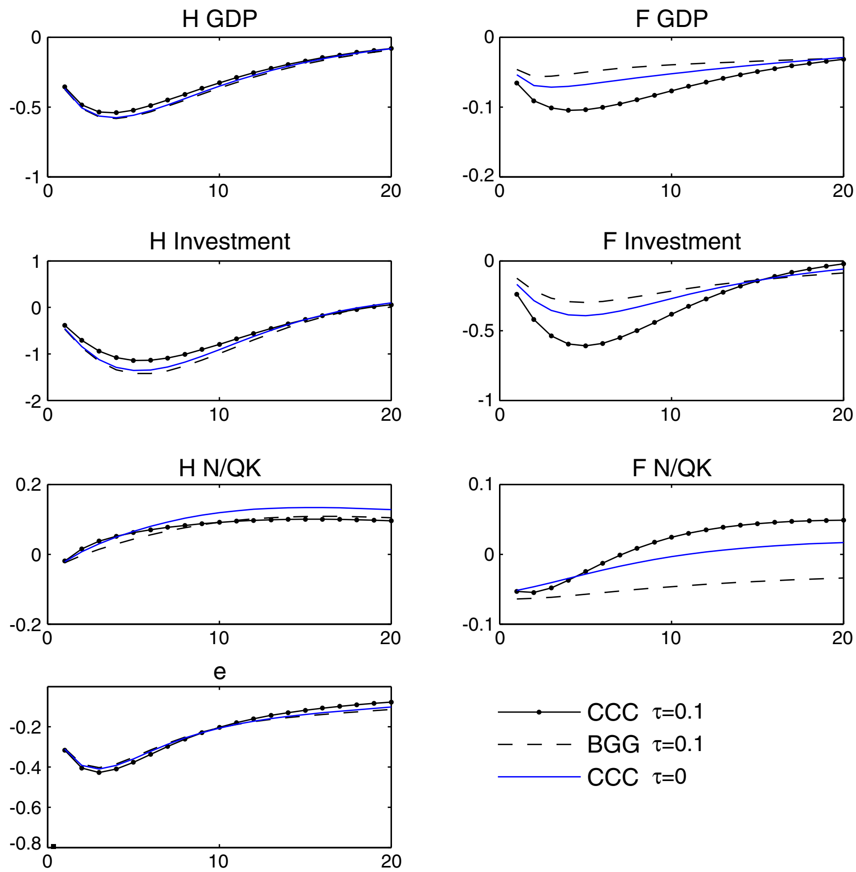

Fig. 7. Productivity shock in H under banking globalization 1.

bilateral correlations, although we just use a simple Taylor rule. Although this result remains a mere replication of Faia (2007), it is worth being compared with Dedola and Lombardo (2009). In their model, the standard productivity shock yields a negative bilateral correlation for GDP. In that respect, the financial accelerator model following BGG does not necessarily resolve the correlation puzzle.

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

4.3.1.2. FIs' net worth shock. Fig. 6 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.

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 two types of adverse shocks.

4.3.2.1. Productivity shock. Fig. 7 plots GDP, investment, the sum of FIs' and entrepreneurial net worth ratios in the two countries, and the real exchange rate. In addition, Fig. 8 plots the FIs' net worth ratios,

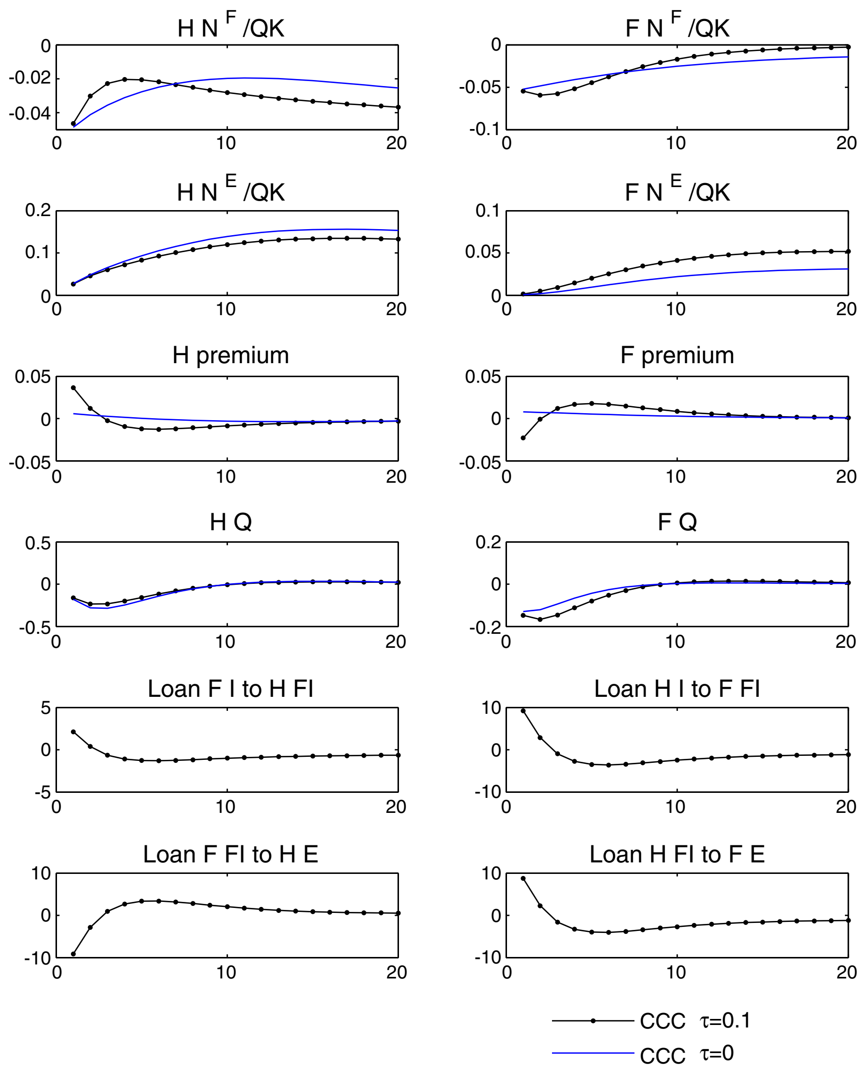

Fig. 8. Productivity shock in H under banking globalization 2.

the entrepreneurial net worth ratios, the external finance premiums, the price of capital (asset prices), and cross-border lending in the two countries.[13] Those figures illustrate that banking globalization, captured 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 model's prediction of simultaneous drops in financial and real variables is consistent with the recent financial crisis shown in Fig. 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.

4.3.2.2. FIs' net worth shock. Figs. 9 and 10 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

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

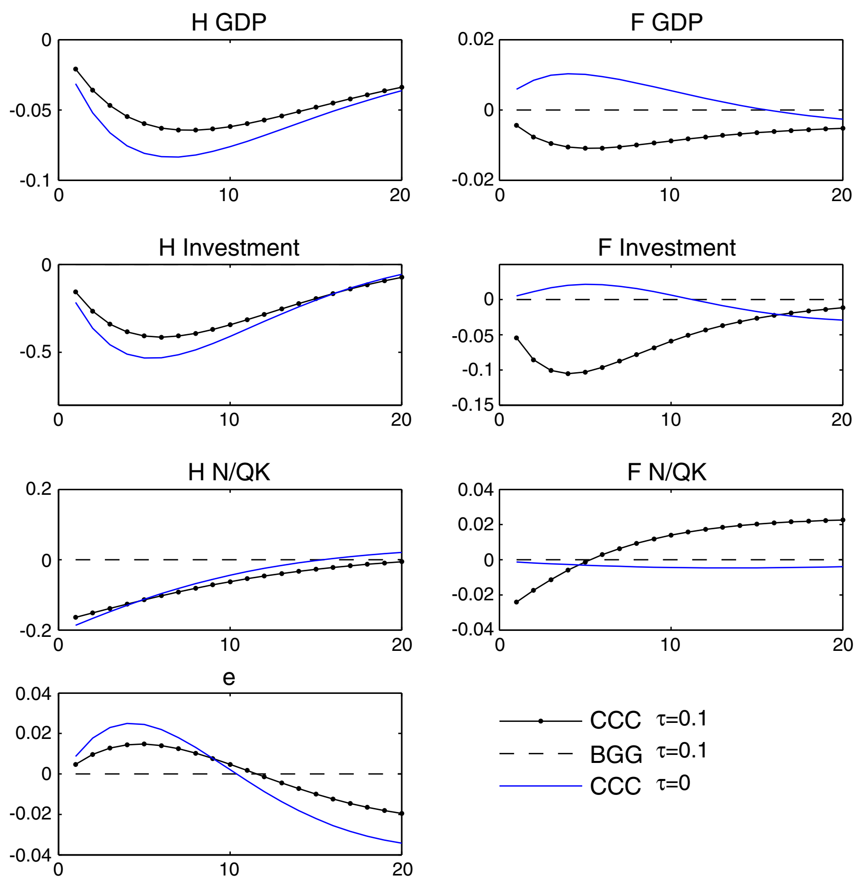

Fig. 9. FI net worth shock in H under banking globalization 1.

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 Fig. 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.

4.4. Bilateral correlations

Fig. 11 illustrates bilateral correlations for GDP between the two countries. As before, we consider the two kinds of adverse shocks: a productivity shock and a net worth shock in the FI 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.[14] 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 comparison, the figure also shows bilateral correlations predicted by the BGG model and by the RBC–CCC model. The RBC–CCC model is constructed without price stickiness.

For the productivity shock, bilateral correlations increase, as either trade or financial openness increases. That increase is steeper in the CCC model than in the BGG model and RBC–CCC model. In the RBC–CCC model, the bilateral correlation is negative without financial openness. Such effects of price stickiness have 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. Importantly, the figure further suggests that even without price stickiness, if financial openness is sufficiently high, the productivity shock yields positive bilateral correlations. That arises from the common lender effect and confirms our previous result that FIs' globalization and credit constraints are important factors in business cycle synchronization.

For the net worth shock, changes in trade and financial openness have small impacts on bilateral correlations, except for one case: when FIs' lending openness (τ^E) changes. When $\tau^E=0.5$, the bilateral correlation reaches one; GDPs in the two countries are perfectly correlated. Because FIs in one country lend the same amount of funds to entrepreneurs in the two countries, FIs' net worth shock has equal impacts on the two countries. In the BGG model, FIs' net worth shock yields no bilateral correlation, because FIs are not credit constrained. In the RBC–CCC model, FIs' net worth shock yields similar but slightly lower bilateral correlations, reflecting that the financial accelerator effect is amplified under sticky prices.

[14] 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).

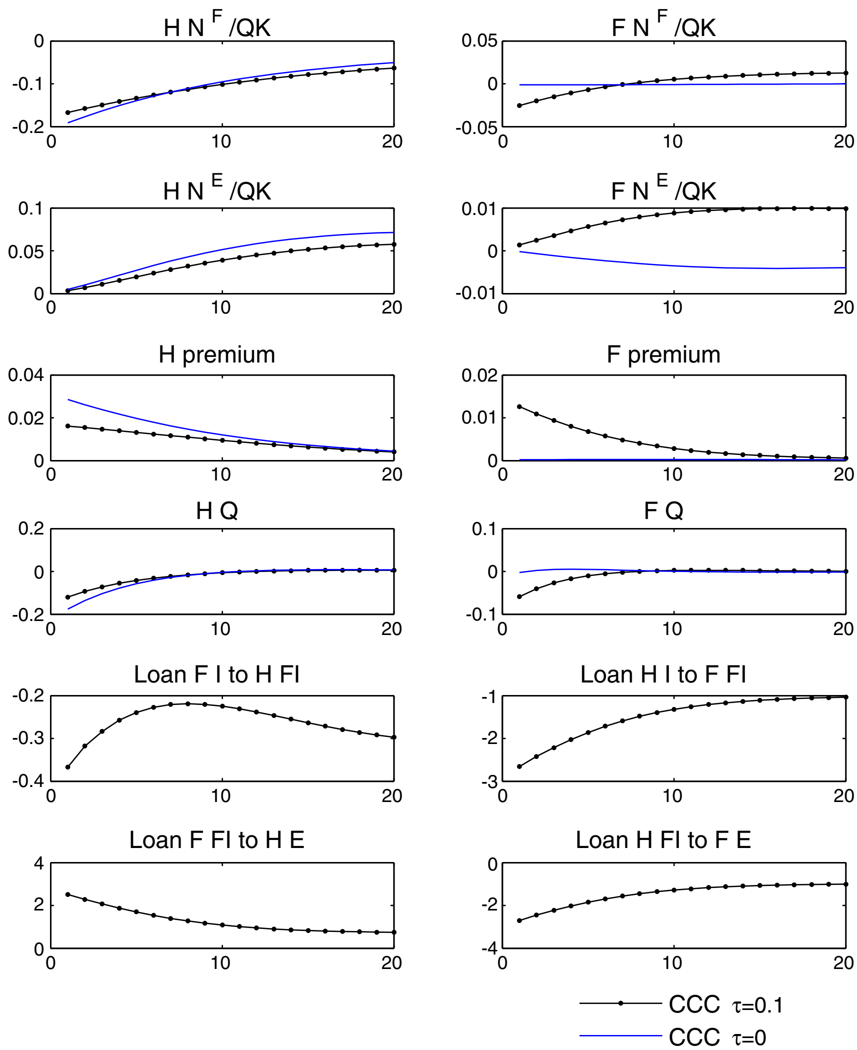

Fig. 10. FI net worth shock in h under banking globalization 2.

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 Fig. 1. Furthermore, our simulation suggests that globalization is another important factor. In the model, business cycle synchronization is enhanced as globalization intensifies.

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, using our model, one could investigate developments in foreign assets and global imbalances, and their effects on the financial market and the real economy.[15] It would be interesting for future research to investigate how welfare changes if two countries with different financial technologies are interconnected with different degrees of banking globalization.

Acknowledgments

The author would like to thank Charles Engel, two anonymous referees, Kosuke Aoki, Michael Devereux, Martin Eichenbaum, Sylvain Leduc, Giovanni Lombardo, Akito Matsumoto, Tomoyuki Nakajima, Keisuke Otsu, Makoto Saito, Etsuro Shioji, Mark Spiegel, Christopher Waller, Karl Walentin, other conference and seminar participants at the AEA 2011 meeting, the Bank of Japan, FRB San Francisco, Hitotsubashi University, Kyoto University, the NBER Summer Institute, and

[15] See Caballero et al. (2008) and Mendoza et al. (2009).

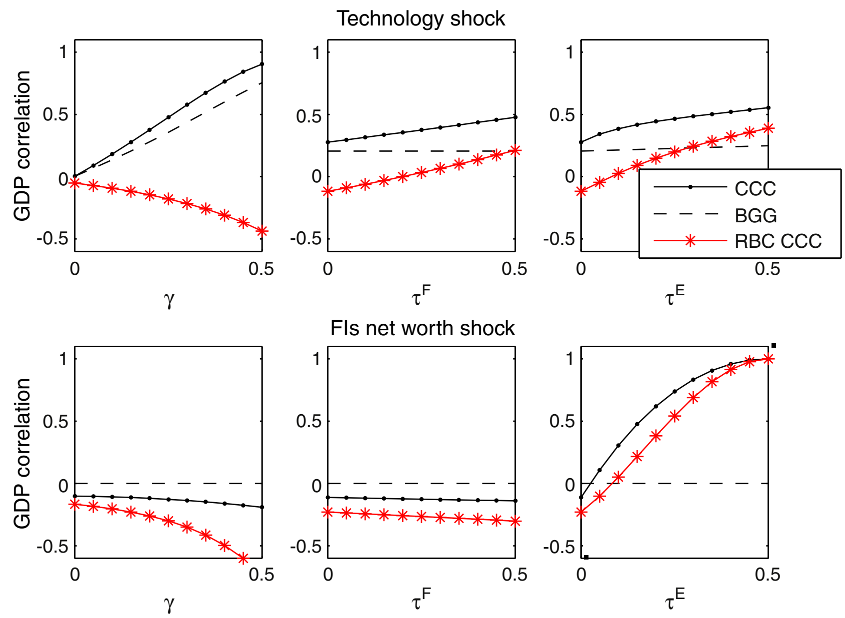

Fig. 11. GDP bilateral correlations.

the staff of the Institute for Monetary and Economic Studies (IMES), the Bank of Japan, for their useful comments. The author particularly thanks Lawrence Christiano and Simon Gilchrist at the outset of this research. Views expressed in this paper are those of the author and do not necessarily reflect the official views of the Bank of Japan.

Appendix A. Parameterization

Parameters are taken from precedent studies including BGG, Christiano et al. (2004), and HSU (2009).

Parameter	Value	Description
Parameters		
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
Calibrated parameters of the credit market		
σ_F	0.107	S.E. of FIs' idiosyncratic productivity
σ_E	0.313	S.E. of entrepreneurial idiosyncratic productivity
μ_H^F, μ_F^F	0.033	Monitoring cost associated with FIs
μ_H^E, μ_F^E	0.013	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
$0.023^{0.25}$	FIs' loan spread
$0.006^{0.25}$	FIs' borrowing spread
$F\left(\overline{\varpi}^F\right) = 0.02$	Default probability in the IF contract
$F\left(\overline{\varpi}^E\right) = 0.02$	Default probability in the FE contract
$n^F = 0.1$	FIs' net worth/capital ratio
$n^E = 0.5$	Entrepreneurial net worth/capital ratio

References

Backus, D.K., Kehoe, P.J., Kydland, F.E., 1992. International real business cycles. Journal of Political Economy 101, 745–775.
Backus, D.K., Kehoe, P.J., Kydland, F.E., 1994. Dynamics of the trade balance and the terms of trade: the J-curve? The American Economic Review 84 (1), 84–103.
Baxter, M., Crucini, M.J., 1995. Cycles and the asset structure of foreign trade. International Economic Review 36 (4), 821–854.
Bernanke, B.S., Gertler, M., Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework. In: Taylor, J.B., Woodford, M. (Eds.), Handbook of Macroeconomics, Vol. 1. North-Holland, Amsterdam, pp. 1341–1393.
Caballero, R.J., Farhi, E., Gourinchas, P.-O., 2008. An equilibrium model of 'global imbalances' and low interest rates. The American Economic Review 98 (1), 358–393.
Christiano, L., Motto, R., Rostagno, M., 2004. The Great Depression and the Friedman–Schwartz hypothesis. Journal of Money, Credit and Banking 35 (6), 1119–1197.
Clarida, R., Gali, J., Gertler, M., 2002. A simple framework for international monetary policy analysis. Journal of Monetary Economics 49 (5), 879–904.
Dedola, L., Lombardo, G., 2009. Financial Frictions, Financial Integration and the International Propagation of Shocks. Draft.
Devereux, M., Sutherland, A., 2011. Country portfolios in open economy macro-models. Journal of the European Economic Association 9 (2), 337–369.
Devereux, M., Yetman, J., 2009. Financial deleveraging and the international transmission of shocks. Bank for International Settlements Research Papers.
Diamond, D.W., Dybvig, P., 1983. Bank runs, deposit insurance, and liquidity. Journal of Political Economy 91, 401–419.
Faia, E., 2007. Finance and international business cycles. Journal of Monetary Economics 54, 1018–1034.
Freixas, X., Rochet, J., 2008. Microeconomics of Banking. MIT Press, Cambridge.
Gilchrist, S., Leahy, J.V., 2002. Monetary policy and asset prices. Journal of Monetary Economics 49 (1), 75–97.
Heathcote, J., Perri, F., 2002. Financial autarky and international business cycles. Journal of Monetary Economics 49 (3), 601–627.
Heathcote, J., Perri, F., 2004. Financial globalization and real regionalization. Journal of Economic Theory 199 (1), 207–243.
Hirakata, N., Sudo, N., Ueda, K., 2009. Chained Credit Contracts and Financial Accelerators. Discussion Paper Series E-30. Bank of Japan.
Hirakata, N., Sudo, N., Ueda, K., forthcoming. Do banking shocks matter for the U.S. economy? Journal of Economic Dynamics and Control.
Iacoviello, M., Minetti, R., 2006. International business cycles with domestic and foreign lenders. Journal of Monetary Economics 53 (8), 2267–2282.
Imbs, J., 2004. Trade, finance, specialization, and synchronization. The Review of Economics and Statistics 86 (3), 723–734.
Imbs, J., 2006. The real effects of financial integration. Journal of International Economics 68 (2), 296–324.
Kaminsky, G., Reinhart, C., 2000. On crises, contagion, and confusion. Journal of International Economics 51 (1), 145–168.
Kehoe, P., Perri, F., 2002. International business cycle and endogenous incomplete markets. Econometrica 70 (3), 907–928.
Kollman, R., Enders, Z., Muller, G.J., 2011. Global banking and international business cycles. European Economic Review 55 (3), 407–426.
Kose, M.A., Prasad, E.S., Terrones, M.E., 2003. How does globalization affect the synchronization of business cycles? American Economic Review Papers and Proceedings 93 (2), 57–62.

Mendoza, E.G., Quadrini, V., Rios-Rull, J.-V., 2009. Financial integration, financial development, and global imbalances. Journal of Political Economy 117 (3), 371–416.
Morgan, D., Strahan, P., Rime, B., 2004. Bank integration and state business cycles. Quarterly Journal of Economics 119 (4), 1555–1585.
Perri, F., Quadrini, V., 2010. International Recessions. Draft.
Ueda, K., 2010. Banking globalization and international business cycles. Globalization and Monetary Policy Institute Working Paper, No. 58. Federal Reserve Bank of Dallas.
Van Rijckeghem, C., Weder, B., 2003. Spillovers through banking centers: a panel data analysis of bank flows. Journal of International Money and Finance 22 (4), 483–509.