Banking across Borders with Heterogeneous Banks[*]

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Abstract

Individual banks differ substantially in their foreign operations. This paper introduces heterogeneous banks into a general equilibrium framework of banking across borders to explain the documented variation. While the model matches existing micro and macro evidence, novel and unexplored predictions of the theory are also strongly supported by the data: The efficiency of the least efficient bank active in a host country increases the greater the impediments to banking across borders and the efficiency of the banking sector in the host country. There is also evidence of a tradeoff between proximity and fixed costs in banking. Banks hold more assets and liabilities in foreign affiliates relative to cross-border positions if the target country is further away and the cost of foreign direct investment is low. These results suggest that fixed costs play a crucial role in the foreign activities of banks.

Keywords: cross-border banking, heterogeneity, multinational banks, FDI, trade in services

JEL-Codes: F12, F21, F23, G21

1 Introduction

Banks differ substantially with respect to their foreign operations. Larger and more efficient banks are more likely to lend and borrow abroad (see table 1).[1] They also engage more often in foreign direct investment. Similarly, bank size and efficiency have a positive effect on the intensive margins. Larger banks hold more foreign assets and liabilities on their domestic balance sheets as well as on the balance sheets of their foreign affiliates.[2]

This paper develops a general equilibrium model of trade and foreign direct investment (FDI) in banking to explain this heterogeneity. Building on Niepmann (2012), I establish a link between bank efficiency, size and the foreign operations of banks in a model where banking across borders arises from differences in banking sector efficiencies and differences in relative factor endowments between countries. Beyond matching the observed covariation of the extensive and the intensive margins to bank size and efficiency, the model predicts how the foreign activities of individual banks vary with host country characteristics. Drawing on German bank-level data, I find strong support for these new implications of the theory.

In the model, banks have two roles. First, they channel capital from depositors to firms. Second, banks monitor firms at a cost. Monitoring costs differ across banks that are not observable by depositors, similar to the structure in Holmstrom and Tirole (1997). To credibly commit to monitor, banks invest their own capital in the client firms. Banks with higher monitoring efficiency are able to intermediate more external capital for the same amount of equity capital and make higher profits.[3]

This microstructure carries over to the open economy where countries differ in their relative endowments of capital and labor and in aggregate banking sector efficiency. These differences cause the return on loans that banks earn and the rate on deposits they have to pay to vary across countries. When capital accounts and banking sectors are open, banks

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[1]For details on table 1, see the discussion on page 23.

[2]Equivalent relationships have been documented in depth for manufacturing firms. See Bernard et al. (2012) for a recent survey of empirical works on firm heterogeneity and international trade. Buch, Koch and Koetter (2011) show that size and efficiency also matter for the cross-border lending activities and FDI of banks. Table 1 confirms these findings providing additional evidence on the intensive and extensive margins of foreign borrowing.

[3]In the model, bank capital is fixed and cannot relocate from one bank to the other preventing the most efficient bank from serving the entire market.

lend and borrow across borders to maximize the return on loans and to minimize funding costs.

Banks have the choice between two different modes to serve foreign markets. They can either lend and borrow across borders, or they can invest in FDI. It is assumed that the fixed costs of cross-border lending and borrowing are lower than the fixed cost of FDI and that banks save on variable costs by opening up a foreign branch. As more efficient banks have larger lending volumes and make higher profits, only they are able to cover the higher fixed costs. Sorting similar to Melitz (2003) and Helpman, Melitz and Yeaple (2004) emerges: the most efficient banks establish foreign affiliates abroad, while less efficient banks only engage in cross-border lending and borrowing. Banks at the lower end of the efficiency distribution remain domestic.

When the two banking sectors become integrated and banks borrow and lend across borders, banking sector efficiencies and returns to capital equilibrate. Capital relocates from the capital abundant to the capital scarce country. In the country that hosts the more efficient banking sector, new banks enter. In the other country, the least efficient banks exit and are replaced by foreign banks. Through these mechanisms, banking across borders affects the equilibrium bank size distribution. Because banks that go global can increase the return on loans and lower funding costs, their balance sheets expand. As a consequence, the bank size distribution becomes more unequal.

The theory delivers rich predictions on the foreign positions of single banks. These depend on bank characteristics (efficiency) as well as home and host country variables. I focus on novel bank-level implications of the model that can be tested using disaggregated data. In particular, I analyze how the cross-border lending cutoff, the cross-border borrowing cutoff and the FDI cutoff vary with the costs of operating abroad as well as with factor endowments and banking sector efficiency in the host country.

For the empirical analysis, I draw on data from the so-called Auslandsstatus-Report provided by Deutsche Bundesbank, which collects information on the foreign activities of all German banks and their affiliates in a large number of countries. In order to measure the efficiency of single banks, three different proxies are used: a bank's overhead costs to total

assets, its size and its labor productivity.

The first set of empirics shows that sorting on host country characteristics is consistent with the model: the efficiency of the least efficient bank that engages in cross-border borrowing and lending increases the further away the host market and the higher the fixed costs of operating abroad measured inversely by the bureaucratic quality and the financial freedom in the host country. While this pattern may also arise in alternative models with corresponding cost structures, the empirical findings support specific implications of the presented theory: the efficiency of the least efficient bank that holds cross-border liabilities in a market increases with bank efficiency and the return to capital in the host market. Complementing Niepmann (2012), this provides additional evidence for the relevance of banking sector efficiencies and relative factor endowments in determining foreign bank positions and supports an approach to banking across borders drawing on concepts from international trade in goods.

In the second part of the empirical analysis, I analyze the firms' decision between operating cross-border and operating through FDI. The results indicate that banks face a proximity-fixed cost tradeoff: they operate more through foreign affiliates, the further away the host market and the lower the cost of serving foreign customers through FDI.

These empirical findings suggest that fixed costs play a crucial role for the foreign activities of banks. In the broader context of the current debate among policy makers and researchers on optimal bank size, the results imply that banks have to have a certain size to channel capital across borders. Moreover, larger banks are the ones that may bring better technology to host markets.[4]

Related Literature   This research contributes to the growing literature on cross-border banking. Similar to Niepmann (2012), this paper takes a trade approach modeling Heckscher-Ohlin endowment differences and Ricardian technology differences, which drive banking across borders. In contrast to the aforementioned work, the framework presented here exhibits imperfect competition and allows for bank-level heterogeneity.

The paper also relates to Ennis (2001) who incorporates a moral hazard problem at the

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[4]See, e.g., an article in the New York Times from October 2012: http://dealbook.nytimes.com/2012/10/15/fed-governor-offers-a-way-to-limit-bank-size/

side of bankers in a multi-regional banking model, focussing on the effect of integration on the size distribution of banks. In his model, banks differ with respect to equity, in contrast to the efficiency differences modeled here. Banking across regions allows the bank with the largest equity to diversify lending, which relaxes information problems and increases profits.

De Blas and Russ (2010, 2012) study the effects of financial liberalization on banks' loan pricing and the distribution of markups in a general equilibrium framework with heterogeneous banks.[5] The former paper relies on a structure where banks offer differentiated services in line with Bernard et al. (2003). In the latter work, banks with different efficiencies co-exist, as not all firms can visit the most efficient bank. Cross-border lending arises because firms apply for loans also at foreign banks to minimize expected costs. FDI and cross-border lending are analyzed as separate scenarios. Sorting does not occur.

More broadly my research adds to the literature on heterogeneous firms in international trade and investment. The proposed theoretical structure differs substantially from existing work-horse models with firm heterogeneity. In the class of models following Melitz (2003), heterogeneous manufacturing firms produce differentiated goods as a result of consumers' love for variety. These models predict trade flows of goods. In this paper instead, banks provide a homogenous intermediation service across borders with implications for banks' foreign asset and liability holdings. In this regard, this work also contributes to services trade research (see Francois and Hoekman (2010) for a literature review).

The assumptions on fixed and variables costs that banks face follow Helpman, Melitz and Yeaple (2004) and result in a similar concentration-fixed-cost tradeoff here. Buch, Koch and Koetter (2009) and Lehner (2009) model such a tradeoff for banks in partial equilibrium frameworks in contrast to the general equilibrium approach in this paper.

This work also extends the empirical literature on cross-border banking. Several papers have analyzed how country characteristics affect the foreign activities of banks (see, e.g., Papaioannou (2009); Buch (2003); Buch (2005); Focarelli and Pozzolo (2005)). Niepmann (2012) shows that the foreign positions of banks are determined by differences in endowments and differences in banking sector efficiencies between countries. Buch, Koch and Koetter (2009) and Buch, Koch and Koetter (2011) document that the cross-border lending activities

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[5]De Blas and Russ (2010) is an earlier version of De Blas and Russ (2012).

and FDI of German banks vary systematically with their size and efficiency.

The empirical analysis in this paper complements these works in particular by analyzing the sorting behavior of banks with respect to host country characteristics. While existing research studies the extensive margin, that is, the number of banks that are active abroad, this paper investigates the behavior of the cross-border lending, the cross-border borrowing and the FDI cutoff using the efficiency of the least efficient bank that operates in a given country as the measure. The empirical approach is along the lines of Yeaple (2009) who explores the sorting of manufacturing firms into FDI.

In addition, this papers tests for a proximity-fixed cost tradeoff in banking. While several papers consider the choice of banks between cross-border operations and FDI (see, e.g., Buch and Lipponer (2007)), this paper is the first to show empirical evidence for the relevance of this tradeoff.[6]

The paper is structured as follows. Section 2 presents the theoretical model. First, the closed economy is introduced. Then the open economy model and the results of comparative statics are discussed. Section 3 provides empirical evidence, and section 4 concludes.

2 A Banking Model with Heterogeneity

2.1 Closed Economy

2.1.1 Setup

There is a continuum of capitalists of measure K, who can become bankers or depositors, and a continuum of workers of measure L. Each capitalist is endowed with one unit of capital. Each worker supplies inelastically one unit of labor. Furthermore, there is a continuum of potential entrepreneurs who can run firms. Firms are perfectly competitive and produce a single consumption good using capital and labor. Each firm operates under the same constant returns to scale technology. The production function takes the form $F(l, z)$. It is assumed to be continuous, strictly increasing and concave in l. The capital input per firm z

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[6]See also Helpman, Melitz and Yeaple (2004) for empirical evidence on the relevance of such a tradeoff in goods trade.

is fixed.[7]

There are two periods: in the first period, investments are made. In the second period, firms produce. With probability λ, production is successful so that capitalists and workers are paid and consume. It is useful to determine equilibrium factor prices first. In equilibrium, all capital is employed in production, which implies that the measure of operating firms is $N = K/z$. As firms compete for labor and are symmetric, they employ the same amount of labor l. Labor market clearing implies that $l = L/N$. Under perfect competition, the returns to the production factors are pinned down by their marginal products. The gross return to capital is $R = (1 + F_z(1, z/l)) = (1 + F_K(1, K/L))$. The wage rate is given by $w = F_L(1, K/L)$.

Each capitalist decides whether to become a banker or a depositor in the first period. Bankers have two tasks in the economy: first, they channel capital from depositors to firms because depositors cannot lend to firms directly. Second, bankers monitor the firms they lend to at a cost to increase the probability that production is successful. As the suppliers of capital, bankers collect the gross return to capital R in the second period. Depositors invest their endowments in banks and obtain the return R^D, which is endogenously determined.[8] Before each capitalist makes his occupational choice, he learns about his efficiency as a banker. Each capitalist draws a monitoring cost $\gamma > 0$ from a continuous distribution $g(\gamma)$ with support $\gamma \in [\underline{\gamma}, \overline{\gamma}]$. The lower the cost draw the higher the capitalist's efficiency as a banker.

The role of monitoring and incentive problems in the model are similar to the framework in Holmstrom and Tirole (1997). The success probability of the firm depends on the effort exerted by the entrepreneur. With effort, the success probability is λ. Without effort, it is $\lambda_L < \lambda$. Production is only economically viable if the entrepreneur exerts effort, that is $\lambda_L R < 1 < \lambda R$. Furthermore, only monitoring by banks induces the entrepreneur to exert effort. Therefore, for investment and hence production to take place, banks have to monitor and all firms operate with a high probability of success in equilibrium. It is assumed that

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[7]Instead of fixing z exogenously, one could endogenously limit the size of a single firm by introducing a moral hazard problem at the side of the entrepreneur similar to Ju and Wei (2010).

[8]Parameters are such that depositors always prefer to invest their capital in banks over storing it at home, that is, $\lambda R^D > 1$.

monitoring costs are sufficiently low so that financial intermediation and monitoring are beneficial.[9]

Depositors do not observe whether a banker monitors but they can observe his monitoring cost (type) γ. To credibly commit to monitor, a banker invests his own capital in the firms he lends to.[10] A banker only monitors a firm if the expected return under monitoring is higher than the return without monitoring, which results in the following condition:

$$\lambda Rz - \lambda R^D(z - v) - \gamma z \geq \lambda_L Rz - \lambda_L R^D(z - v), \tag{1}$$

where γz are the total monitoring costs incurred and v represents the banker's capital (equity) invested in the firm. To maximize profits, each banker maximizes the number of firms he monitors and lends to. This implies minimizing v.[11] Therefore, in equilibrium, condition 1 holds with equality. Solving the condition for bank capital $v(\gamma)$ yields:

$$v(\gamma) = \left(1 - \frac{R}{R^D} + \frac{\gamma}{(\lambda - \lambda_L)R^D}\right) z. \tag{2}$$

Note that in equilibrium, each banker must invest a positive amount of bank capital to commit to monitor because $(\lambda - \lambda_L)(R^D - R) + \underline{\gamma} > 0$ so that $v(\gamma) > 0 \; \forall \; \gamma > \underline{\gamma}$.[12] As bank capital $v(\gamma)$ invested per firm is proportional to the capital input z of the firm, z is normalized to 1. The return of a banker with monitoring cost γ per firm that he monitors and lends to is then obtained as:

$$\lambda R - \lambda R^D(1 - v(\gamma)) - \gamma = \frac{\gamma \lambda_L}{\lambda - \lambda_L}. \tag{3}$$

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[9]There must be enough capitalists with sufficiently low cost draws such that it is beneficial to employ them as bankers. For all active bankers, the investment must still be viable even after the monitoring cost is incurred, i.e. $\lambda R - \gamma > 1 > \lambda_L R \; \forall \gamma < \gamma^*$. This condition automatically ensures that the bank capital $v(\gamma)$ that each banker has to invest in a single firm with capital input z is smaller than z. This, in turn, implies that the bank entry cutoff $\gamma^* < \overline{\gamma}$.

[10]It is assumed that the success of firms is perfectly correlated so that banks must invest their own capital to solve the moral hazard problems. See Holmstrom and Tirole (1997).

[11]To see this, substitute $n = 1/v$ in the expression for total profits to obtain $\pi = n(\lambda Rz - \lambda R^D z - \gamma z) + \lambda R^D$.

[12]To see this, plug in the equilibrium expression for R^D, which is derived later in the text. Then the condition becomes: $\underline{\gamma} - (\lambda - \lambda_L)\frac{\gamma^*}{\lambda} > 0$, which holds because $\gamma^* < \underline{\gamma}/(1 - \lambda_L/\lambda)$ as is shown in the proof of proposition 1.

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The number (measure) of firms that one banker endowed with one unit of capital can monitor is $n(\gamma) = \frac{1}{v(\gamma)}$.[13] The higher a banker's monitoring efficiency, i.e. the lower γ, the more external capital he channels from depositors to firms and the larger his balance sheet.[14] A banker of type γ operates under the following leverage:

$$\frac{\text{debt}}{\text{equity}} = \frac{\text{depositor capital}}{\text{bank capital}} = \frac{n(\gamma)x(\gamma)}{1} = \frac{1}{v(\gamma)} - 1, \tag{4}$$

where $x(\gamma) = 1 - v(\gamma)$ is the depositor capital that a banker of type γ lends to a single firm. Profits of the banker of type γ are given by:

$$\pi(\gamma) = n(\gamma)(\lambda R - \lambda R^D(1 - v(\gamma)) - \gamma) = \frac{1}{v(\gamma)}\frac{\gamma \lambda_l}{\lambda - \lambda_L} = \frac{1}{1 - \frac{R}{R^D} + \frac{\gamma}{(\lambda - \lambda_L)R^D}}\frac{\gamma \lambda_L}{\lambda - \lambda_L}. \tag{5}$$

The return that the banker makes per firm, which corresponds to the second term in expression (5), depends only on the banker's monitoring cost γ and on the success probabilities λ and λ^L. These parameters are exogenous and fixed. The lower γ, the higher λ and the lower λ^L are, the higher are the banker's profits. The endogenous variables of the model, R and R^D, affect profits only through the measure of firms $n(\gamma)$ that the banker serves, i.e. through the lending volume, and, as bank capital is fixed, through the leverage. The banker's lending volume and profits are higher, the higher the gross return to capital R and the lower the cost of external funding reflected in R^D.[15]

While the profits of a banker depend on his type γ, all depositors are paid the same return. This is because the monitoring cost draw of a depositor is assumed to remain private information in contrast to the draw of a banker.

2.1.2 Equilibrium

Two equilibrium conditions close the model. First, there is free entry into banking. Second, the market for financial intermediation clears, i.e. all operating bankers in the economy must

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[13]Integer problems are ignored. One firm may borrow from several banks.

[14]The relationship between bank size and leverage in the model is consistent with the empirical evidence. Kalemli-Ozcan, Sorensen and Yesiltas (2012) find that larger banks have a higher leverage.

[15]Under the assumption made previously that $\lambda R - \lambda_L R - \gamma > 0$ the derivative of $\pi(\gamma)$ with respect to R^D is always negative.

intermediate the available capital.

First, consider free entry into banking. Each capitalist has the choice between becoming a banker or a depositor. The marginal capitalist γ^* who is indifferent between the two occupational choices is determined by setting the expected profits of a capitalist as a banker equal to his expected profits as a depositor:

$$\pi(\gamma^*) = \frac{1}{1 - \frac{R}{R^D} + \frac{\gamma^*}{(\lambda - \lambda_L) R^D}} \frac{\gamma^* \lambda_L}{\lambda - \lambda_L} = \lambda R^D. \tag{6}$$

Because profits are strictly decreasing in γ, all capitalists for whom $\gamma > \gamma^*$ become depositors and those for whom $\gamma \leq \gamma^*$ become bankers.

All active bankers together must intermediate the existing capital in the economy. The economy is endowed with capital of measure K. A banker of type γ is able to supply a measure of $n(\gamma)$ firms with capital. Thus the market for financial intermediation clears if:

$$K \int_{\underline{\gamma}}^{\gamma^*} n(\gamma) g(\gamma) d\gamma = K. \tag{7}$$

Equations (6) and (7) constitute a system of two equations in two unknowns R^D and γ^*, which fully determine the equilibrium. Solving equation (6) with respect to R^D yields:

$$R^D = R - \frac{\gamma^*}{\lambda} = (1 + F_K(1, \frac{K}{L})) - \frac{\gamma^*}{\lambda}. \tag{8}$$

The return to depositors R^D depends on the marginal product of capital (MPK) and, therefore, on the relative factor endowments of the economy, as well as on banking sector efficiency reflected in γ^*. The lower the aggregate banking sector efficiency in the economy, the larger the wedge between the gross return to capital R and the return on deposits R^D.[16]

Plugging the expression for R^D into the market clearing condition (7) yields:

$$1 = \int_{\underline{\gamma}}^{\gamma^*} \frac{(R - \frac{\gamma^*}{\lambda})(\lambda - \lambda_L)}{\gamma - (\lambda - \lambda_L)\frac{\gamma^*}{\lambda}} g(\gamma) d\gamma. \tag{9}$$

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[16]This is similar to Antras and Caballero (2009) and Ju and Wei (2010).

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Expression (9) implicitly gives a solution for the bank entry cutoff γ^*.[17]

Proposition 1 *The solution γ^* to*

$$1 = \int_{\underline{\gamma}}^{\gamma^*} \frac{(R - \frac{\gamma^*}{\lambda})(\lambda - \lambda_L)}{\gamma - (\lambda - \lambda_L)\frac{\gamma^*}{\lambda}} g(\gamma) d\gamma \tag{10}$$

exists and is unique.

Proof. See appendix A. ∎

The lower the gross return to capital, the smaller the amount of external capital a single banker can intermediate. As a consequence, the bank entry cutoff increases with the capital-labor ratio K/L. In addition, the bank entry cutoff is affected by changes in the monitoring cost distribution. The more efficient the banking sector as a whole, the fewer banks are needed to intermediate the available capital in the economy. Ceteris paribus, the bank entry cutoff increases in $\underline{\gamma}$.

2.2 Characterization of the Open Economy

2.2.1 Open Economy Setup

In the open economy, there are two countries 1 and 2, which can differ in their relative endowments of capital and labor and in aggregate banking sector efficiency so that autarky returns to capital R and deposit rates R^D may vary across countries.

Workers, entrepreneurs and depositors are assumed to be immobile.[18] In contrast, banks can operate in both countries. They have the choice between raising deposits at home and abroad and between investing at home and abroad. Operating internationally is costly, however. If a banker in country $j \in \{1, 2\}$ wants to extend loans to firms in country $i \in \{1, 2\}$ where $i \neq j$, he has to incur the fixed cost $f_{ij}^L > 0$. If he wants to borrow from foreign depositors, he has to pay the fixed cost $f_{ij}^B > f_{ij}^L$. Once f_{ij}^B is incurred, the banker

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[17]Because the integral increases with the upper limit γ^* and $\frac{\partial n}{\partial \gamma^*} > 0$, equation 9 has a unique solution for continuous distributions with support $\gamma \in]0, \infty]$.

[18]In reality, a share of financial investors is mobile. However, some investor capital may become mobile only through banks. This should in particular be true for deposits, which represent an important funding source for banks.

does not have to pay an extra cost to extend cross-border loans.[19] In addition to fixed costs, the banker also faces variable costs, which take the form of "iceberg" costs. If the gross return R_i is collected in country i, only a fraction of the return, τR_i, where $\tau < 1$, arrives at the bank in country j. At the same time for the return R_i^D to go to depositors in country i, ϕR_i^D units have to be transported, where $\phi > 0$.[20]

Banks can eliminate variable costs by opening up an affiliate abroad. However, foreign direct investment requires paying a higher fixed cost $f_{ij}^F > f_{ij}^B$.

The profits of a banker in country j who raises deposits at home and invests them in country i through cross-border lending are given by:

$$\pi_{ij}^{X,j}(\gamma_j) = n(\gamma_j, \tau R_i, R_j^D)\frac{\gamma_j \lambda_L}{\lambda - \lambda_L} - f_{ij}^L = \frac{1}{1 + \frac{1}{R_j^D}(\frac{\gamma}{\lambda - \lambda_L} - \tau R_i)}\frac{\gamma_j \lambda_L}{\lambda - \lambda_L} - f_{ij}^L. \tag{11}$$

The first subscript in $\pi_{ij}^{X,j}$ stands for the country to which the banker lends. The second subscript indicates where capital is raised. Superscript j captures the nationality of the banker. Superscript X indicates that the banker operates cross-border rather than through FDI which is denoted by superscript F. $n(\gamma_j, R_i, R_j^D)$ reflects the total capital that the banker of type γ_j intermediates, which depends on his monitoring cost γ_j, the gross return to capital he collects and the deposit rate he has to pay.

Accordingly, a banker that raises deposits abroad to finance lending at home collects:

$$\pi_{ji}^{X,j}(\gamma_j) = n(\gamma_j, R_j, \phi R_i^D)\frac{\gamma_j \lambda_L}{\lambda - \lambda_L} - f_{ij}^B = \frac{1}{1 + \frac{1}{\phi R_i^D}(\frac{\gamma}{\lambda - \lambda_L} - R_j)}\frac{\gamma_j \lambda_L}{\lambda - \lambda_L} - f_{ij}^B. \tag{12}$$

If instead the banker borrows from depositors abroad and lends to firms abroad (local intermediation), his profits are:

$$\pi_{ii}^{X,j}(\gamma_j) = \frac{1}{1 + \frac{1}{\phi R_i^D}(\frac{\gamma}{\lambda - \lambda_L} - \tau R_i)}\frac{\gamma_j \lambda_L}{\lambda - \lambda_L} - f_{ij}^B. \tag{13}$$

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[19]Alternative fixed cost structures could be modeled. This structure implicitly assumes that there are synergies between borrowing and lending.

[20]In models of goods trade, iceberg costs reflect variable trade costs that increase in the distance between the importing and the exporting country. Degryse and Ongena (2005) find that distance-related transportation costs matter also in banking, in support of the modeling choice here. See Brevoort and Wolken (2009) for a summary of the literature on the role of distance in banking.

Finally, the entrepreneur can invest in FDI. In this case, τ and ϕ are equal to one, and the fixed cost is replaced by f_{ij}^F in the last three equations.

Each banker chooses between the seven options (π_{jj}^j, $\pi_{ij}^{X,j}$, $\pi_{ii}^{X,j}$, $\pi_{ji}^{X,j}$, $\pi_{ij}^{F,j}$, $\pi_{ii}^{F,j}$, and $\pi_{ji}^{F,j}$) taking the gross returns to capital R_i and R_j, the returns on deposits R_i^D and R_j^D as well as costs as given.

If banks lend capital to foreign firms or raise capital abroad for investment at home, capital flows across borders. This affects the gross return to capital in both countries. Similar to the notation for profits, K_{ij}^j represents the aggregate capital that banks from country j raise at home and invest abroad. Equivalently, K_{ij}^i stands for the aggregate capital that banks from country i raise in country j for investment at home. The gross return to capital in country i is then given by:

$$R_i = 1 + F_K \left(1, \frac{K_i + K_{ij}}{L_i} \right), \tag{14}$$

where $K_{ij} = K_{ij}^i + K_{ij}^j$.

2.2.2 Sorting

It is useful to establish a key result of the model before defining the equilibrium in the open economy: bankers sort into cross-border lending, borrowing and FDI according to their monitoring cost γ.

Consider the general profit function:

$$\pi(R, R^D, \gamma, \tau, \phi) = \frac{1}{1 - \frac{\tau R}{\phi R^D} + \frac{\gamma}{(\lambda - \lambda_L)\phi R^D}} \frac{\gamma \lambda_L}{\lambda - \lambda_L}. \tag{15}$$

Substitute $\tilde{R}^D = \phi R^D$ and $\tilde{R} = \tau R$. The function $\pi(\tilde{R}, \tilde{R}^D, \gamma)$ is supermodular in γ and $-\tilde{R}$ and in γ and $\tilde{R}^D$, i.e. $\pi_{-\tilde{R},\gamma} > 0$ and $\pi_{\tilde{R}^D,\gamma} > 0$. Mrazova and Neary (2011) show that supermodularity is a sufficient condition for sorting in a way that the high-efficiency banks engage in the activity that requires paying the (higher) fixed cost, whereas low-efficiency banks engage in the activity with no (the lower) fixed cost. This result facilitates the equilibrium computation because once the banker who is indifferent between two activities

is found, the decisions of all other active bankers follow immediately.

Proposition 2 *If bankers of different types engage in different activities in equilibrium, then sorting is such that the most efficient bankers sort into the activity that requires paying the (higher) fixed cost while the low efficiency bankers engage in the activity with no (the lower) fixed cost.*

Proof. See appendix A. ∎

In the following, γ_j^L (γ_j^B) denotes the cross-border lending (borrowing) cutoff, i.e. all bankers with $\gamma_j \leq \gamma_j^L(\gamma_j^B)$ find it profitable to lend (borrow) across borders. Similarly, all bankers with $\gamma_j \leq \gamma_j^F$ find it profitable to operate in country i by establishing a foreign affiliate. A banker is only willing to pay a fixed cost if he can collect a higher return on the loan or obtain cheaper funding abroad. Once the cost is incurred, it is optimal for the banker to invest the entire capital in the high return location and to raise all deposits in the low-interest country. Similarly, if a bank opens up a foreign representation, it conducts all business through the foreign affiliate to save on variable costs.[21] As more efficient banks operate under a higher leverage, that is, they borrow and lend more, they hold more cross-border assets, cross-border liabilities as well as more assets and liabilities in their foreign affiliates. The model therefore predicts that not only the extensive margins of banking across borders increase with efficiency but also the different intensive margins.

2.2.3 Equilibrium Definition

The equilibrium in the open economy is defined as follows:

Definition 1 *An equilibrium in the open economy is characterized by the bank entry cutoff γ_j^*, the cross-border lending cutoff γ_j^L, the cross-border borrowing cutoff γ_j^B, the FDI cutoff γ_j^F, returns to depositors R_j^D and gross returns to capital R_j for $j \in \{1,2\}$, $i \in \{1,2\}$ and $j \neq i$ for which the following conditions hold:*

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[21]Bankers will always choose to raise deposits either at home or abroad. They will also, in general, either invest at home or abroad. These results could be relaxed by introducing heterogeneous firms/depositors leading to assortative matching or by including a motive of banks and depositors to diversify lending and borrowing.

(i) Capitalists in each country optimally choose whether to become depositors or bankers.

(ii) Bankers in each country optimally choose to lend at home and abroad.

(iii) Bankers in each country optimally choose to raise capital at home and abroad.

(iv) Bankers in each country optimally choose between the two modes of operating abroad (cross-border versus FDI).

(v) Capital flows are consistent with the choice of bankers to invest and to raise capital abroad.

(vi) Labor markets clear.

(vii) All capital is employed in production (capital market clearing).

(viii) The market for financial intermediation clears.

The solution to the general model is complex as different equilibrium cases exist. Which case occurs depends on the exact parameter values. Niepmann (2012) analyzes the different equilibrium cases and resulting cross-border flows in detail in a similar model. In this paper, I focus on the novel, bank-level implications of the theory. To that end, the analysis is narrowed to one equilibrium case, in which banking sector j invests domestic capital in firms in country i and banking sector i raises funding from depositors in country j for investment at home. This allows me to derive and provide intuition for the results of comparative statics that are tested in the empirical part of the paper.[22] Appendix B provides more details on the general model illustrating the different equilibrium cases that exists.

2.3 Equilibrium with Cross-border Lending, Borrowing and FDI

2.3.1 Equilibrium

Assume in the following that factor endowments are such that in autarky $R_i > R_j$. Furthermore, banking sector i is more efficient than banking sector j.[23]

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[22]The logic of the model presented here follows Niepmann (2012) who shows that comparative statics hold within and across equilibrium cases.

[23]To illustrate, think of country i as the United States. Country j may correspond to Germany. In 2000, Germany had a higher capital-labor ratio and less efficient banks than the United States. The human-capital adjusted capital-labor ratio of Germany was 51.16 compared to 39.58 in the U.S. The average overhead costs to total assets for the German banking sector were 0.0435, in contrast to a value of 0.0346 for the U.S. banking sector.

For simplicity, I assume that capitalists in the two countries draw from a uniform monitoring cost distribution with different lower supports, that is, $\underline{\gamma}_i < \underline{\gamma}_j$. This implies that even if gross returns to capital are equal in the two countries, $\gamma_i^* < \gamma_j^*$ so that $R_i^D > R_j^D$. In this case, because banks incur additional costs from operating abroad, banking across borders can only take two forms under the assumed parameter values: banking sector j lends to firms in country i and/or banking sector i borrows from depositors in country j. If differences in endowments between countries are large relative to differences in banking sector efficiencies, if variable and fixed costs are not prohibitively high and if country sizes are not too dissimilar, an interior equilibrium prevails where both banking sectors operate across borders and engage in FDI.

The results on sorting imply that, in such an equilibrium, capitalists below the cutoff γ_j^* become bankers. All bankers for whom $\gamma_j^L < \gamma_j \leq \gamma_j^*$ operate only at home. Bankers in the range $\gamma_j^F < \gamma_j \leq \gamma_j^L$ extend loans to firms in country i cross-border. Bankers with $\underline{\gamma}_j < \gamma_j \leq \gamma_j^F$ establish foreign affiliates in country i to lend to firms there. In country i, in turn, active bankers have monitoring costs $\gamma_i \leq \gamma_i^*$. All bankers for whom $\gamma_i^B < \gamma_i \leq \gamma_i^*$ engage only in domestic banking. Bankers in the range $\gamma_i^F < \gamma_i \leq \gamma_i^B$ raise funding in country j cross-border. Bankers of type $\underline{\gamma}_i < \gamma_i \leq \gamma_i^F$ establish foreign affiliates in country j to borrow from depositors in the host market.

According to definition 1, the following equations have to hold in equilibrium:

$$R_i = (1 + F_K'(1, (K_i + K_{ij})/L_i)) \qquad \text{[return to capital in } i\text{]}, \tag{16}$$

$$R_j = (1 + F_K'(1, (K_j - K_{ij})/L_j)) \qquad \text{[return to capital in } j\text{]}, \tag{17}$$

$$K_{ij} = K_{ij}^j + K_{ij}^i, \qquad \text{[capital flow]} \tag{18}$$

where

$$K_{ij}^j = K_j \int_{\underline{\gamma}_j}^{\gamma_j^F} n(\gamma_j, R_i, R_j^D) g_j(\gamma_j) d\gamma_j + K_j \int_{\gamma_j^F}^{\gamma_j^L} n(\gamma_j, \tau R_i, R_j^D) g_j(\gamma_j) d\gamma_j, \tag{19}$$

and

$$K_{ij}^i = K_i \int_{\underline{\gamma_i}}^{\gamma_i^F} n(\gamma_i, R_i, R_j^D) g_i(\gamma_i) d\gamma_i + K_i \int_{\gamma_i^F}^{\gamma_i^B} n(\gamma_i, R_i, \phi R_j^D) g_i(\gamma_i) d\gamma_i$$

$$- K_i \int_{\underline{\gamma_i}}^{\gamma_i^B} g_i(\gamma_i) d\gamma_i. \tag{20}$$

$$K_j - K_{ij}^i = K_j \int_{\underline{\gamma_j}}^{\gamma_j^F} n(\gamma_j, R_i, R_j^D) g_j(\gamma_j) d\gamma_j + K_j \int_{\gamma_j^F}^{\gamma_j^L} n(\gamma_j, \tau R_i, R_j^D) g_j(\gamma_j) d\gamma_j$$

$$+ K_j \int_{\gamma_j^L}^{\gamma_j^*} n(\gamma_j, R_j, R_j^D) g_j(\gamma_j) d\gamma_j \qquad \text{[market clearing j]}, \tag{21}$$

$$K_i + K_{ij}^i = K_{ij}^i + K_i \int_{\underline{\gamma_i}}^{\gamma_i^B} g_i(\gamma_i) d\gamma_i + K_i \int_{\gamma_i^B}^{\gamma_i^*} n_i(\gamma_i, R_i, R_i^D) g_i(\gamma_i) d\gamma_i \quad \text{[market clearing i]},$$

$$\pi_{kk}^k(\gamma_k^*) = \lambda R_k^D \quad \forall k \in \{1, 2\} \qquad \text{[free entry]}, \tag{22}$$

$$\pi_{ij}^{L,j}(\gamma_j^L) = \pi_{jj}^j(\gamma_j^L) \text{ if } \gamma_j^L > \underline{\gamma_j} \qquad \text{[lending cutoff j]}. \tag{23}$$

$$\pi_{ij}^{L,i}(\gamma_i^B) = \pi_{ii}^i(\gamma_i^B) \text{ if } \gamma_i^B > \underline{\gamma_i} \qquad \text{[borrowing cutoff i]}. \tag{24}$$

$$\pi_{ij}^{F,j}(\gamma_j^F) = \pi_{jj}^{L,j}(\gamma_j^F) \text{ if } \gamma_j^F > \underline{\gamma_j} \qquad \text{[FDI cutoff j]}. \tag{25}$$

$$\pi_{ij}^{F,i}(\gamma_i^F) = \pi_{ii}^{B,i}(\gamma_i^F) \text{ if } \gamma_i^F > \underline{\gamma_i} \qquad \text{[FDI cutoff i]}. \tag{26}$$

The first two equations above give the equilibrium gross return to capital in country i and in country j, which are both functions of the capital flow K_{ij}. The third condition determines the equilibrium capital flow which consists of two components that are explicitly stated in equations (19) and (20). The former equation delivers an expression for the capital K_{ij}^j that bankers in country j lend to firms in country i. The latter equation corresponds to the capital K_{ij}^i that bankers in country i raise from depositors in country j for investment at home. Note that the equity capital of bankers in country i that borrow from depositors in country j does not cross the border. It is therefore subtracted from the total capital that banks in country i invest in firms at home (The last term in equation (20) reflects this equity

capital).

Equations (21) and (22) are clearing conditions of the market for financial intermediation in country j and in country i, respectively. As banking sector i raises capital in country j, banking sector j has to intermediate only $K_i - K_{ij}^i$ units of capital. In turn, bankers in country i that get funding from abroad, have to intermediate the additional capital K_{ij}^i. The remaining conditions determine the entry cutoffs in the two countries, the cross-border lending cutoff in country j, the cross-border borrowing cutoff in country i and the FDI cutoffs of banks in country j and in country i. Together, the conditions constitute a system of 12 equations in 12 unknowns that has a unique solution.

Proposition 3 *The solution to equations 16 to 26 is unique.*

Proof. See appendix A. ∎

2.3.2 Open Economy versus Autarky

To illustrate the effects of banking across borders, I provide a numerical example. The upper panel of table 2 lists the exogenously chosen parameters. In the lower panel, solutions for the 12 variables are given for the cases of autarky and of the open economy. Figure 1 shows the corresponding size distribution of banks in the two countries.

In the open economy equilibrium, both banking sectors engage in banking across borders, channeling capital from country j to country i. Hence, the equilibrium gross return to capital is higher in country j and lower in country i than in autarky. In addition, integration leads to entry into banking in country i and exit in country j. Because banking sector i is more efficient, it expands by intermediating foreign deposits. As displayed in figure 1, the bank entry cutoff in country i moves up ($\gamma_i^{*AUT} > \gamma_i^*$) while it goes downs in country j ($\gamma_j^{*AUT} < \gamma_j^*$). A country's deposit rate is a function of the gross return to capital and the domestic bank entry cutoff. As a consequence, the deposit rate R^D decreases in country i and increases in country j.

Figure 1 shows the effect of integration on the size distribution of banks in the two countries. In both countries the more efficient banks that borrow and lend abroad, either

cross-border or through FDI, are able to enlarge their balance sheets. Because they can obtain a higher return on loans (country j) or reduce funding costs (country i), their capacity to intermediate external capital is augmented.

The size of banks that only operate at home is also affected because domestic gross returns to capital and deposit rates change as well. The equilibrium gross return and the deposit rate that prevail in country i are both lower in the open economy than in autarky. The opposite holds for country j. Increases in gross returns and deposit rates have opposite effects on the balance sheet capacity of purely domestic banks. It turns out that, in the numerical example, domestic banks in country i become bigger. In country j, the balance sheets of domestic banks shrink.

In summary, financial integration equilibrates gross returns, banking sector efficiencies and deposit rates and affects the balance sheet capacity of banks. Larger and more efficient banks become even larger so that the bank size distribution becomes more unequal.

2.3.3 Comparative Statics

The previous section has discussed how allocations change when countries move from autarky to an integrated world. In the following section, I analyze how the open economy equilibrium varies with the characteristics of the trading partners. In the model, countries may differ in their banking sector efficiencies, their relative factor endowments and in their impediments to cross-border lending, cross-border borrowing and FDI. As these exogenous factors change, all endogenous variables in the model, such as the equilibrium gross return to capital, the capital flow, the aggregate foreign assets of a banking sector, etc., respond. The analysis here focuses on the effects of varying country characteristics on four endogenous objects: the cross-border lending cutoff γ_j^L, the cross-border borrowing cutoff γ_i^B and the FDI cutoffs γ_j^F and γ_i^F. These comparative statics are tested in the empirical part of the paper.

As the data that are available for the empirical analysis vary across host countries while the home country is always the same, comparative statics are derived with respect to host country variables only. I start by analyzing how the cross-border lending cutoff of country j is affected by changes in the characteristics of (host) country i. Then, I show how the

cross-border borrowing cutoff of country i varies with alternative characteristics of (host) country j. Finally, I discuss how the FDI cutoffs in the two countries respond to alternative host country characteristics.

The effect of host country characteristics on the cross-border lending cutoff In the model presented, banking across borders is driven by Ricardian technology differences and Heckscher-Ohlin endowment differences. This is a distinct feature of the theory and differs from many models in the literature that are based on portfolio theory. Consider how the cross-border lending cutoff γ_j^L responds as the efficiency of the banking sector in the host country declines. From the perspective of country j, the host country is country i. An increase in $\underline{\gamma_i}$ implies that the average monitoring cost of banks in country i goes up. As a consequence, the deposit rate in country i decreases. Together this implies that more banks in country i prefer to raise funding at home. As fewer banks in country i take deposits in country j, the capital flow goes down so that the gross return to capital R_i is higher, everything else equal. This, in turn, makes it more attractive for banks in country j to invest in firms in country i. The cross-border lending cutoff γ_j^L increases.

Changes in the capital endowment of a country affect the mass of banks in the country and, hence, the capacity of the banking sector to channel capital across borders. Therefore, I only consider variation in the capital-labor ratio of the host country in the form of changes in its labor endowment, keeping the capital endowment fixed.[24] The lower country i's labor endowment L_i is, the lower the gross return to capital in country i is and the less profitable it is for banks in country j to lend to firms abroad. Therefore, the cross-border lending cutoff γ_j^L decreases as L_i goes down.

Host countries may also vary with respect to the costs that banks incur from operating there. With a higher variable cost, reflected in a lower τ, and a higher fixed cost of cross-

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[24]This point is related to the effect of changes in host country size through changes in K, which depend on the underlying functional forms and parameters of the model. Consider an increase in K_j and L_j so that K_j/L_j is unchanged. An increase in K_j increases the mass of bankers in country j that find it profitable to lend to firms abroad. At the same time, the capital flow necessary to equilibrate gross returns in the two countries increases. The overall effects of size on the cross-border borrowing cutoff γ_i^B and the FDI cutoff γ_i^F depend on the relative magnitudes of these two effects. In cases where the host country's banking sector operates only domestically, the effect of size is unambiguous. Then cutoffs increase in the size of the host country.

border lending f_{ij}^L, fewer banks in country j find it optimal to extend cross-border loans. As a consequence, the lending cutoff γ_j^L goes down. An increase in the fixed cost of FDI has the opposite effect. The higher f_{ij}^F, the fewer banks invest in FDI and the less capital flows from country j to country i. This implies that the gross return to capital is higher in country i ceteris paribus, which increases the incentives for banks in country j to engage in cross-border lending. The cross-border lending cutoff γ_j^L increases in f_{ij}^F. Proposition 4 summarizes the results.

Proposition 4 *The extensive margin of cross-border lending γ_j^L*

(i) increases in $\underline{\gamma}_i$,

(ii) decreases in the capital abundance of host country i reflected in a decrease in L_i,

(iii) decreases in the fixed cost of cross-border lending f_{ij}^L,

(iv) increases in τ, the inverse of the variable cost of cross-border lending,

(v) and increases in the fixed cost of FDI f_{ij}^F.

Proof. See appendix A. ∎

The effect of host country characteristics on the cross-border borrowing cutoff
Now take the perspective of banks in country i. The host country for these banks is country j. As banking sector j becomes less efficient, i.e. as $\underline{\gamma}_j$ increases, the deposit rate in country j declines. Hence, it becomes more attractive for banks in country i to raise deposits in country j, and the cutoff γ_i^B increases. Comparing this result to the effect of lower banking sector efficiency in the host country on the lending cutoff, we see that they go in the same direction. Both the cross-border lending and the cross-border borrowing cutoff increase as the banking sector in the host country becomes less efficient.

In contrast, the effect of a higher labor endowment in the host country goes in the opposite direction for the cross-border lending cutoff and the cross-border borrowing cutoff. The lower country j's endowment of labor is, the lower are the gross-return to capital R_j and the deposit rate R_j^D. With lower funding costs in country j, more banks in country i want to borrow from depositors in country j. Thus, the cross-border borrowing cutoff γ_i^B increases as L_j decreases.

The effect of higher impediments to cross-border borrowing are straightforward. As ϕ and f_{ji}^B increase, the cross-border borrowing cutoff goes down because profits from borrowing abroad are lower. Similar to the mechanism for the cross-border lending cutoff, an increase in the cost of FDI has a positive effect on the cross-border borrowing cutoff. As fewer banks engage in FDI, less capital flows from country j to country i, which reduces the interest rate in country j. This makes it more attractive for banks in country i to borrow abroad. The cross-border borrowing cutoff γ_i^B increases as f_{ji}^F goes up. In summary:

Proposition 5 *The extensive margin of cross-border borrowing* γ_j^B

(i) increases in $\underline{\gamma}_j$,

(ii) increases in the capital abundance of host country j reflected in a decrease in L_j,

(iii) decreases in the fixed cost of cross-border lending f_{ij}^B,

(iv) decreases in the variable cost of cross-border borrowing ϕ,

(v) and increases in the fixed cost of FDI f_{ji}^F.

Proof. See appendix A. ∎

The effect of host country characteristics on the FDI cutoffs Finally, consider how the FDI cutoffs in the two countries vary with host country characteristics. Changes in banking sector efficiency and labor endowments in the host country move the FDI cutoffs γ_j^L and γ_i^B in parallel to their respective cross-border cutoffs. This is because all four cutoffs are altered due to changes in equilibrium gross returns and deposit rates, which affect the cross-border cutoffs and the FDI cutoffs in the same way. A decline in banking sector efficiency in the host country leads to a higher FDI cutoff in each of the two countries. An increase in the labor endowment in the host country raises the FDI cutoff γ_j^F and lowers the FDI cutoff γ_i^F. Because FDI can be a means of both lending and borrowing, the effect of changes in relative factor endowments on the FDI cutoff is, in general, ambiguous.

The responses of the FDI cutoffs to changes in transaction costs stated in proposition 6 are intuitive. Banks face a proximity-fixed cost tradeoff when choosing between the two modes of banking across borders. This tradeoff is similar to the proximity-concentration tradeoff modeled and documented for manufacturing firms in Helpman, Melitz and Yeaple

(2004) and Yeaple (2009). Higher costs to cross-border operations make it relatively more attractive for banks to operate through foreign affiliates and increase the FDI cutoffs. Higher costs to FDI make it less attractive, thus lowering the two cutoffs.

Proposition 6 *The extensive margin of FDI* γ_j^F *(*γ_i^F*)*

(i) increases in $\underline{\gamma}_i$ *(*$\underline{\gamma}_j$*),*

(ii) decreases in τ *(increases in* ϕ*),*

(iii) increases in the fixed cost of cross-border lending f_{ij}^L *(cross-border borrowing* f_{ji}^B*),*

(iv) and decreases in the fixed cost of FDI f_{ij}^F *(*f_{ji}^F*).*

Proof. See appendix A. ∎

Combining these results with the previous discussion shows that changes in variable and fixed costs have the exact opposite effects on the cross-border cutoffs and the FDI cutoffs. The gap between the FDI and the cross-border cutoff is smaller when the cost of FDI is lower and when the costs of cross-border activities are higher, and vice versa.

The focus of the paper is on the bank-level predictions of the presented theory. Note, however, that the model has similar aggregate implications as Niepmann (2012).[25] Aggregate foreign assets and liabilities of a banking sector increase in the efficiency advantage of the home country relative to the host country. Aggregate foreign assets increase and aggregate foreign liabilities decrease in the capital abundance of the home country relative to the host country. The theory therefore matches not only the empirical evidence on sorting, but is also consistent with the observed variation of aggregate foreign bank positions.

3   Empirical Analysis

3.1   Data

In order to test the theoretical implications of the model, I use bank-level data on the foreign activities of German banks collected by Deutsche Bundesbank. The so called Auslandsstatus-Report provides information on the foreign assets and liabilities of all German banks and

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[25]While aggregate implications are the same, the model in this paper does not reduce to the one in Niepmann (2012) if all banks had the same efficiency because the microstructures differ substantially.

their foreign affiliates around the globe.[26] The full dataset that comprises the universe of German banks is available to me for 2005. In that year, there are 1998 banks, the total assets and total liabilities of which are observed in 178 countries.

In addition to the foreign positions data, I draw on balance sheet and income and loss data, also available at Bundesbank, to compute efficiency measures for single banks. Three different simple proxies are employed. First, efficiency of bank k is measured as the average size of the domestic balance sheet of bank k in year $t-1$. This is in line with the theoretical model where the efficiency of a bank determines its size. Second, overhead costs to total assets in year $t-1$ are calculated for each bank. Third, as a robustness check, the labor productivity of bank k is measured as the average size of bank k's domestic balance sheet over the number of employees.[27] Table 3 shows the correlations between the three measures.

The dataset is complemented by information on host country i characteristics such as distance and GDP.[28] As profit and loss data is not available for all banks in the sample and as host country variables are only observed in a limited number of countries, the sample size reduces depending on the exact specification.

Table 1 illustrates the positive effect of size and efficiency on the extensive and the intensive margins of banking across borders. To examine the relationship between size and efficiency and the extensive margin, I estimate several logit specifications (columns (1) to (3)). In column (1), the dependent variable takes value 1 if a bank k has cross-border assets, in column (2), if it has cross-border liabilities and, in column (3), if it has FDI in a given country i. In addition, I test for the effects of size and efficiency on the volume of banks' foreign operations using OLS regressions. In columns (4) and (6), the dependent variables are the cross-border assets and liabilities, respectively, of bank k in country i. In column (5) (column (7)), the assets (liabilities) on the balance sheets of foreign affiliates are used as the regressand.[29] Each of the dependent variables is regressed on size and, alternatively,

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[26]For a detailed description of the data source, see Buch, Koch and Koetter (2011).

[27]Profit and loss data and data on the number of employees is for the parent bank including its branches abroad. However, subsidiaries are excluded. Data for parent banks only is not available.

[28]For more details on variables and data sources, see the data appendix.

[29]In this case, assets/liabilities correspond to the positions of all affiliates of bank k located in country i toward residents of country i (so called local assets/liabilities). They comprise only the local business of the affiliates excluding the activities that these entities conduct with residents from other countries.

on the ratio of overhead costs to total assets. All specifications include country-fixed effects and dummies for the type of bank.[30] Standard errors are clustered at the bank level. The highly significant regression coefficients clearly show that the probability that a bank has foreign assets, foreign liabilities and FDI increases with the size of its domestic business and its efficiency. Larger banks also hold more foreign assets and liabilities on their domestic balance sheets as well as on the balance sheets of their foreign affiliates.

3.2 Sorting on Host Country Characteristics

Propositions 4 and 5 predict that the cross-border lending cutoff and the cross-border borrowing cutoff decrease ceteris paribus in the efficiency of the banking sector in the host country, in variable transactions costs, and in the fixed costs attributed to lending and borrowing in the host country. Moreover, the cross-border lending cutoff is expected to be higher and the cross-border borrowing cutoff to be the lower, the lower the capital-labor ratio in the host country is.

I test these hypotheses in the narrowest possible way by focussing on the behavior of the different cutoffs measured by the least efficient bank that holds cross-border assets or liabilities in a given market. To explore whether cutoffs vary with host country characteristics as the theory prescribes, I regress the log of the overhead costs of the least efficient bank that has positive cross-borders assets or liabilities in a given host country on host country variables. As an alternative to the log of overhead costs, I also employ the two other efficiency measures and use the log of size and the log of the labor productivity of the least efficient bank as the dependent variable.

Efficiency of the banking sector in the host country is proxied by the average overhead costs to total assets of all banks residing in the country. This measure comes from the Financial Structure Database provided by the World Bank. As it is endogenous to the operations of foreign banks because it is computed including foreign banks, the variable is lagged by 5 years. Capital abundance of country i is measured by the human-capital

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[30]Nine dummy variables indicate whether an entity is a i) commercial bank, ii) state bank, iii) savings bank, (iv) cooperative central bank, v) cooperative savings bank, vi) building credit society, vii) bank with special functions, viii) savings and loan association, iv) other.

adjusted capital-labor ratio of country i. A country's capital-labor ratio is endogenous to foreign borrowing and lending so this measure is also lagged by five years. In the regression, I include the negative of the log of the capital-labor ratio of country i and interpret it as a measure of the return to capital. Variable transaction costs are proxied by distance between the home and the host country. Financial freedom, which captures bank entry barriers, and the bureaucratic quality in the host country are used as proxies for fixed costs. Ideally, one would like to have separates measures for the fixed cost of cross-border operations and the fixed cost of FDI. These are, however, not available. Overhead costs, GDP, GDP per capita as well as distance enter the regression in logs.

Table 4 summarizes the signs of the different coefficients that are expected from the model. Signs depend on whether the cross-border lending or the cross-border borrowing cutoff is analyzed as well as on the dependent variable that is used. The upper panel of table 4 summarizes the effects of host country characteristics on the cross-border lending cutoff. The lower panel shows the effects on the cross-border borrowing cutoff. In both panels, column (1) indicates the expected signs if the dependent variable collects maximum overhead costs. Signs should switch when bank size or labor productivity is used (see column (2)). As a robustness check, I also run regressions on the number of banks that are active in a given host market. The expected signs of the coefficient are the same as in column (1).

Table 6 shows the results for the cross-border lending cutoff. Summary statistics of the underlying sample are reported in table 5. There is one observation for each country in the sample resulting in a total of 86. Column (1) of table 6 displays the estimated coefficients when the dependent variable collects maximum overhead costs. With the exception of the coefficient on the return to capital, all estimates are highly significant and consistent with the model predictions. The positive coefficient on host country overhead costs implies that the efficiency of the least efficient bank that holds positive cross-border assets decreases with the efficiency of the banking sector in the host country. The estimates related to financial openness and bureaucratic quality indicate that lower fixed costs increase the cross-border lending cutoff. Distance has a negative effect: banks that operate in a country that is further away are more efficient. Finally, the larger the host market is, the higher the overhead costs of the least efficient bank are that holds positive cross-border assets.

Columns (2) and (3) show the effects on minimum size and minimum labor productivity. The signs of the coefficients are exactly the opposite of those in column (1), as expected. In column (4), the number of active banks in a host country is used as the dependent variable, confirming again the hypotheses of the model. The R^2 is remarkably high throughout. Around 70% of the variation in the cross-border lending cutoff is explained by the covariates.

In table 7, the same exercise is conducted as in table 6 but now for the cross-border borrowing cutoff. As before, the dependent variable reflects maximum overhead costs in column (1). Column (2) uses size, and column (3) uses the labor productivity of the least efficient banks that holds positive liabilities. In column (4), the number of banks with positive cross-border liabilities is the regressand. Coefficients are highly significant and strongly support the model. As for cross-border assets, the efficiency of the least efficient bank that is active abroad is higher in countries that host more efficient banking sectors. In contrast to the regressions based on assets, the return coefficient is now significant. It indicates that the efficiency of banks that have cross-border liabilities is higher in host countries that exhibit higher returns to capital, consistent with the theory.

The regressions in table 6 and 7 show a negative effect of GDP per capita on both the extensive margin of cross-border lending and the extensive margin of cross-border borrowing. Only the most efficient banks lend and borrow in higher income countries. This is in contrast to evidence on manufacturing firms in Yeaple (2009) who finds that only the most productive manufacturing firms have FDI in lower income countries.

Note that all results for both cutoffs also hold when the average efficiency of all banks operating in a given country is used as the dependent variable instead of the efficiency of the least efficient bank. With all coefficients showing the expected signs for both cutoffs, the analysis provides strong evidence that banks sort into cross-border lending and borrowing based on host country characteristics as the model prescribes. Evidence in line with sorting according to the return to capital and banking sector efficiency in the host country is particularly relevant. These findings suggest that differences in factor endowments and differences in technology drive banking across borders, consistent with the theory and in support of the trade perspective proposed in this paper.

According to proposition 6, the efficiency of the least efficient bank with FDI in a given country decreases in the fixed and variable costs of cross-border operations, increases in the fixed cost of FDI and increases in the efficiency of the banking sector in the host country. The effect of the return to capital in the host country is ambiguous because FDI can be a means of both borrowing and lending abroad. I repeat the exercise in tables 6 and 7 for FDI including all control variables as before to make the regression results comparable. Table 8 shows the results. Coefficients are mostly insignificant. This may be due to the small number of observations in the underlying sample, which is reduced to 37.[31] The values of the R^2 displayed are very similar to those obtained from the previous regressions however, suggesting that the model fits equally well.

The distance coefficient is significant in all columns. It exhibits signs that are in opposition to what the theory predicts. The estimates imply that the efficiency of the least efficient bank that engages in FDI declines with distance. This result is not surprising though as distance may also be correlated with the fixed cost of FDI. I show in the next section that results do support a proximity-fixed cost tradeoff, when the relative effect on the margins is considered.

3.3   Cross-border Lending and Borrowing versus FDI

Another way to test the predictions of the model is to analyze the behavior of the FDI cutoff relative to the the cross-border lending or the cross-border borrowing cutoff. The model predicts that the gap between the FDI cutoff and the cross-border cutoffs decreases as variable costs increase. The gap should be larger if the fixed costs related to establishing a presence in the foreign market are higher.

I test for this hypothesis explicitly by regressing the log difference between the average efficiency of banks that do FDI and the average efficiency of banks that engage in cross-border lending in a given country on the proxies of variable costs and fixed costs. Distance should have a negative effect on the log difference. Bureaucratic quality and financial freedom should have a negative effect if little financial freedom and a low bureaucratic quality impede

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[31]In 2005, German banks had FDI in 58 countries compared to positive cross-border assets (liabilities) in 177 (178) countries.

FDI more than cross-border operations. Table 9 reports the results. While coefficients on bureaucratic quality and financial freedom are insignificant, the distance coefficient in column (2) is significant and exhibits a negative sign consistent with the theory. This suggests that the average efficiency of banks that engage in FDI versus banks that extend loans cross-border is more similar if the variable costs of operating from home are high.[32] The R^2 is high, taking a value of 0.495.

In the following, alternative evidence for the presence of a proximity-fixed cost tradeoff is presented, which goes beyond the theoretical framework developed in this paper. I test for a proximity-cost tradeoff on the intensive margin as opposed to the extensive margin. By regressing the ratio of local assets to cross-border assets of bank k on country variables, I investigate whether banks that are engaged in cross-border lending and FDI, operate more through foreign affiliates if variable costs are high and fixed costs are low. As an alternative to local and cross-border assets, I also use the ratio of banks' local liabilities to cross-border liabilities and the ratio of the sum of assets and liabilities as dependent variables. The log of GDP and the log of GDP per capita are added to control for systematic differences in the ratios arising from differences in economic development and size similar to before.

The number of banks that engage in FDI in any given year is small.[33] In order to increase sample size, a pseudo cross-section is constructed. While the universe of German banks is only observed in the year 2005, panel data is available for those banks that have at least one branch or subsidiary abroad in the period from 2002 and 2009. The sample uses the base year 2005 and includes bank-country observations of the other years if these are not already in the sample. Bank-country observations are unique in the pseudo cross-section.[34] Columns (1) to (3) show the results based on the enlarged sample. Regressions in columns (4) to (6) are based on the full panel where the same bank-country pair is observed over several years. In columns (1) and (4) of table 10, the dependent variable is based on assets, in column (2) and (5) on liabilities. Columns (3) and (6) use the sum of assets and liabilities. All regressions include year-fixed effects and bank-fixed effects. Standard errors are clustered on

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[32]Coefficient are mostly insignificant when the average efficiency of banks that have positive liabilities in any given country or if the log difference between minimum efficiencies is used.

[33]In 2005, only 52 out of 1998 banks have at least one affiliate in at least one country.

[34]I start with the base year 2005 and add all bank-country observations of the year 2006 that are not already in the sample. Then additional pairs are included that are observed in 2004, 2007, 2003 and so on.

host countries.

The distance coefficient is positive and significant at a 10% significance level in all six columns of table 10. Banks hold more assets and liabilities on the balance sheet of their affiliates than on their own in more distant countries, that is, if variable transaction costs are higher. The coefficients related to bureaucratic quality and financial freedom are all positive. Standard errors are in part large but overall the regressions show a negative effect of fixed costs on the ratio. This suggests that bureaucratic quality and financial freedom decrease the costs related to FDI more than the fixed costs of cross-border operations. Note that the effect of GDP per capita is highly significant and negative indicating that banks operate more through foreign affiliates in less developed countries similar to the effect of GDP per capita on the extensive margins. Together, the empirical findings provide strong evidence for the presence of a proximity-fixed cost tradeoff in banking. Such a tradeoff has been modeled and discussed before, but this paper provides the first evidence for its empirical relevance.[35]

4 Conclusions

Banks differ substantially in their foreign activities. In this paper, I allow for within-country heterogeneity in bank efficiency in a general equilibrium model of banking across borders to explain this variation. The model is consistent both with recent evidence on sorting of banks into cross-border lending and FDI, and with aggregate patterns of foreign bank positions. It also delivers predictions regarding the extensive margin of bank assets and liabilities that go beyond the existing evidence. I focus theoretically and empirically on these new bank-level implications. In line with the theory, I find that the efficiency of the least efficient bank that is active in a given country is higher the higher the efficiency of the banking sector in that country, the further away the market and the higher the costs of operating there. I also present evidence for a proximity-fixed cost tradeoff in banking.

While several implications of the model also follow from alternative frameworks with

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[35]Several robustness checks have been conducted. In particular, additional gravity controls have been added as well as dummies for different regions. Results remain qualitatively the same.

corresponding cost structures, sorting with respect to banking sector efficiency and relative factor endowments is a unique feature of the model, supported by the data. This finding is additional evidence for the two driving forces of banking across borders, differences in banking sector efficiencies and differences in returns to capital.

Altogether, the empirical results suggest that fixed costs play a key role for the foreign operations of banks. Only larger banks are able to overcome these costs, channel capital across borders and potentially supply low cost intermediation services to entrepreneurs and depositors in foreign markets. Global banks are necessarily bigger than purely domestic banks.

In the theoretical framework presented, a single bank either invests abroad or at home. Similarly, it either raises deposits at home or abroad. This result is altered if the success of firms is not perfectly correlated and capitalists are risk averse. Another characteristic of the model is that banks are capacity constrained. As a consequence, the volume of foreign lending and borrowing adjusts primarily through the extensive margin. This would change if equity was traded. Introducing diversification into the model and allowing for mergers and acquisitions are promising avenues for future research.

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Appedix A: Proofs

Proof of Proposition 1

The bank entry cutoff is the solution to the following equation:

$$1 = \int_{\underline{\gamma}}^{\gamma^*} \frac{(R - \frac{\gamma^*}{\lambda})(\lambda - \lambda_L)}{\gamma - (\lambda - \lambda_L)\frac{\gamma^*}{\lambda}} g(\gamma) d\gamma, \tag{4.27}$$

The RHS of the equation is continuously increasing in γ^* because the integral increases in γ^* and $\partial n(.)/\partial \gamma^* > 0$. For $\gamma^* = \underline{\gamma}$, the RHS of the above equation is 0. For $\gamma^* \to \underline{\gamma}/(1 - \lambda_L/\lambda)$, RHS $\to \infty$. Thus the function has a unique solution where $\gamma^* \in]\underline{\gamma}, \underline{\gamma}/(1 - \lambda_L/\lambda)[$, which shows that $\gamma^* < \underline{\gamma}/(1 - \lambda_L/\lambda)$ so that the ICC of all active bankers always binds in equilibrium.

Proof of Proposition 2

$\pi^B(-\tilde{R}, \tilde{R}^D, \gamma)$ is supermodular in $-\tilde{R}$ and γ and in $\tilde{R}^D$ and γ. Supermodularity of $\pi^B(-\tilde{R}, \gamma)$ corresponds to $\pi^B_{-\tilde{R}, \gamma} > 0$.

$$-\frac{\partial \pi^2}{\partial - \tilde{R} \partial \gamma} = \frac{\tilde{R}^D(\lambda - \lambda_L)\lambda_L}{(\tilde{R}^D(\lambda - \lambda_L) - \tilde{R}(\lambda - \lambda_L) + \gamma)^3} \left(-\tilde{R}^D(\lambda - \lambda_L) + \tilde{R}(\lambda - \lambda_L) + \gamma \right). \quad (4.28)$$

The first term, the fraction, is positive given that $v(\gamma)$ is positive, i.e. that the ICC of the banker binds. The second term in brackets is also positive if $\tilde{R}^D < \tilde{R}$. Both conditions holds in equilibrium. Therefore $\pi_{-\tilde{R}, \gamma} > 0$.

Supermodularity of $\pi(\tilde{R}^D, \gamma)$ corresponds to $\pi_{\tilde{R}^D, \gamma} > 0$.

$$-\frac{\partial \pi^2}{\partial \tilde{R}^D \partial \gamma} = \frac{\lambda_L(\lambda - \lambda_L)}{(\tilde{R}^D(\lambda - \lambda_L) - \tilde{R}(\lambda - \lambda_L) + \gamma)^3} \left((\tilde{R}(\lambda - \lambda_L) - \gamma)(\tilde{R} - \tilde{R}^D) + \gamma \tilde{R}^D \right). \quad (4.29)$$

The first term, the fraction, is positive given that $v(\gamma)$ is positive. The second term in brackets is also positive if $\tilde{R}^D < \tilde{R}$ and $\tilde{R}(\lambda - \lambda_L) - \gamma > 0$. The three conditions hold in equilibrium. Therefore $\pi^B_{\tilde{R}^D, \gamma} > 0$.

Assume $R_j < \tau R_i$. Supermodularity of $\pi(-\tilde{R}, \gamma)$ implies that for any two bankers of type γ_1 and $\gamma_2 < \gamma_1$:

$$\pi(R_j, \gamma_1) - \pi(R_j, \gamma_2) > \pi(\tau R_i, \gamma_1) - \pi(\tau R_i, \gamma_2) \tag{4.30}$$

$$\Rightarrow \quad \pi(\tau R_i, \gamma_2) - \pi(R_j, \gamma_2) > \pi(\tau R_i, \gamma_1) - \pi(R_j, \gamma_1) \tag{4.31}$$

$$\Rightarrow \quad \pi(\tau R_i, \gamma_2) - f_{ij}^L - \pi(R_j, \gamma_2) > \pi(\tau R_i, \gamma_1) - f_{ij}^L - \pi(R_j, \gamma_1) \tag{4.32}$$

$$\Rightarrow \quad \pi_{ij}^{X,j}(\gamma_2) - \pi_{jj}^{X,j}(\gamma_2) > \pi_{ij}^{X,j}(\gamma_1) - \pi_{jj}^{X,j}(\gamma_1) \tag{4.33}$$

This relationship holds for any pair of bankers. Let $\gamma_j^{L,X}$ denote the banker who is indifferent

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between investing at home and abroad. If some bankers invest abroad while others invest only at home, then this implies that all bankers of type $\gamma_j \leq \gamma_j^{L,X}$ invest abroad while all bankers for whom $\gamma_j > \gamma_j^{L,X}$ invest at home. A similar logic applies to sorting into cross-border borrowing and sorting into FDI.

Proof of Proposition 3

To show: The solution to the system is unique.

Note that the equations that determine the different cutoffs, which are quadratic equations, have at most one solution that is permissible. Therefore equations 16 and 17 as well as equation 22 to 26 give the following variables as functions of K_{ij}, γ_i^* and γ_j^*. $R_j(K_{ij})$, $R_i(K_{ij})$, $R_i^D(K_{ij}, \gamma_i^*)$, $R_j^D(K_{ij}, \gamma_j^*)$, $\gamma_i^B(\gamma_i^*, \gamma_j^*, K_{ij})$, $\gamma_i^F(\gamma_i^*, \gamma_j^*, K_{ij})$, $\gamma_j^L(\gamma_j^*, K_{ij})$ and $\gamma_j^F(\gamma_j^*, K_{ij})$.

It is easy to derive the following partial derivatives using implicit function theorems. $\frac{\partial R_i}{\partial K_{ij}} < 0$, $\frac{\partial R_j}{\partial K_{ij}} > 0$, $\frac{\partial R_i^D}{\partial K_{ij}} < 0$, $\frac{\partial R_j^D}{\partial K_{ij}} > 0$, $\frac{\partial R_i^D}{\partial \gamma_i^*} < 0$, $\frac{\partial R_j^D}{\partial \gamma_j^*} < 0$, $\frac{\partial \gamma_j^L}{\partial \gamma_j^*} > 0$, $\frac{\partial \gamma_j^L}{K_{ij}} < 0$, $\frac{\partial \gamma_j^F}{\partial \gamma_j^*} > 0$, $\frac{\partial \gamma_j^F}{K_{ij}} < 0$, $\frac{\partial \gamma_i^B}{\partial \gamma_i^*} < 0$, $\frac{\partial \gamma_i^B}{\partial \gamma_j^*} > 0$, $\frac{\partial \gamma_i^B}{\partial K_{ij}} < 0$, $\frac{\partial \gamma_i^F}{\partial \gamma_i^*} < 0$, $\frac{\partial \gamma_i^F}{\partial \gamma_j^*} > 0$, $\frac{\partial \gamma_i^F}{\partial K_{ij}} < 0$.

The system reduces to a system of three equations in three unknown, K_{ij}, γ_i^* and γ_j^*:

$$
\begin{aligned}
K_{ij} &= K_j \int_{\underline{\gamma_j}}^{\gamma_j^F} n(\gamma_j, R_i, R_j^D) g_j(\gamma_j) d\gamma_j + K_j \int_{\gamma_j^F}^{\gamma_j^L} n(\gamma_j, \tau R_i, R_j^D) g_j(\gamma_j) d\gamma_j \quad (4.34) \\
&+ K_i \int_{\underline{\gamma_i}}^{\gamma_i^F} n(\gamma_i, R_i, R_j^D) g_i(\gamma_i) d\gamma_i + K_i \int_{\gamma_i^F}^{\gamma_i^B} n(\gamma_i, R_i, \phi R_j^D) g_i(\gamma_i) d\gamma_i \\
&- K_i \int_{\underline{\gamma_i}}^{\gamma_i^B} g_i(\gamma_i) d\gamma_i.
\end{aligned}
$$

$$
K_j - K_{ij} = K_j \int_{\gamma_j^L}^{\gamma_j^*} n(\gamma_j, R_j, R_j^D) g_j(\gamma_j) d\gamma_j. \quad (4.35)
$$

$$
1 = \int_{\underline{\gamma_i}}^{\gamma_i^B} g_i(\gamma_i) d\gamma_i + \int_{\gamma_i^B}^{\gamma_i^*} n_i(\gamma_i, R_i, R_i^D) g_i(\gamma_i) d\gamma_i. \quad (4.36)
$$

For any given γ_j^* and γ_i^*, equation (4.34) gives a unique solution of K_{ij}; $K_{ij}(\gamma_j^*, \gamma_i^*)$. While the LHS strictly increases going from zero to infinity for $K_{ij} \in [0, K_{ij}(R_i = R_j) < K_j]$, the RHS strictly decreases going from K_j to 0. (To see this note that the volume of lending n

in the first four terms decreases as K_{ij} increases. Furthermore all four cutoffs go down.).

Applying the implicit function theorem, $\frac{dK_{ij}}{d\gamma_i^*} < 0$ and $\frac{dK_{ij}}{d\gamma_j^*} > 0$. Note also that $\frac{d\gamma_j^L}{d\gamma_j^*} < 0$ and $\frac{d\gamma_i^B}{d\gamma_i^*} < 0$. An increase in K_{ij} only happens if $n(.)$ increases through changes in deposit rates and gross returns, which at the same time change γ_j^L and γ_i^B.

Equation 4.35 delivers a unique solution for γ_j^* as a function of γ_i^*. The LHS of equation 4.35 decreases in γ_j^* because $\frac{dK_{ij}}{d\gamma_j^*} > 0$ taking a positive value in the range $]0, K_j]$ because $0 \leq K_{ij} < K_j$. The RHS strictly increases in γ_j^* from 0 to a value above K_j for $\gamma_j^* \in [\underline{\gamma_j}, \overline{\gamma_j}]$ because $\frac{d\gamma_j^L}{d\gamma_j^*} < 0$, $\frac{\partial n_j(R_j, R_j^D)}{\partial K_{ij}} > 0$ and $\frac{\partial n_j(R_j, R_j^D)}{d\gamma_j^*} > 0$. Thus there exists a unique $\gamma_i^*(\gamma_j^*)$. Because $\frac{dK_{ij}}{d\gamma_i^*} < 0$, $\frac{d\gamma_j^*}{d\gamma_i^*} > 0$.

Equation 4.36 delivers a unique solution for γ_i^*. The RHS of equation 4.36 strictly increases in γ_i^* from 0 to a value that is greater than 1 for $\gamma_i \in [\underline{\gamma_j}, \overline{\gamma_j}]$ because $\frac{d\gamma_i^B}{d\gamma_i^*} < 0$, $\frac{dK_{ij}}{d\gamma_i^*} < 0$. Therefore the solution to the system is unique.

Proof of Proposition 4

(i) To show: $\frac{d\gamma_j^L}{d\underline{\gamma_i}} > 0$. $\frac{d\gamma_j^L}{d\underline{\gamma_i}} = \frac{\partial \gamma_j^L}{\partial \underline{\gamma_i}} + \frac{\partial \gamma_j^L}{\partial K_{ij}} \frac{dK_{ij}}{d\underline{\gamma_i}} + \frac{\partial \gamma_j^L}{\partial \gamma_j^*} \frac{d\gamma_j^*}{d\underline{\gamma_i}}$. It is easy to see that $\frac{\partial \gamma_j^L}{\partial \underline{\gamma_i}} = 0$, $\frac{\partial \gamma_j^L}{\partial K_{ij}} < 0$ and $\frac{\partial \gamma_j^L}{\partial \gamma_j^*} > 0$. $\frac{dK_{ij}}{d\underline{\gamma_i}} < 0$. Suppose not, i.e. $\frac{dK_{ij}}{d\underline{\gamma_i}} \geq 0$. Then $\frac{dK_{ij}^j}{d\underline{\gamma_i}} = \frac{\partial K_{ij}^j}{\partial \underline{\gamma_i}} + \frac{\partial K_{ij}^j}{\partial K_{ij}} \frac{dK_{ij}}{d\underline{\gamma_i}} < 0$ and $\frac{dK_{ij}^i}{d\underline{\gamma_i}} = \frac{\partial K_{ij}^i}{\partial \underline{\gamma_i}} + \frac{\partial K_{ij}^i}{\partial K_{ij}} \frac{dK_{ij}}{d\underline{\gamma_i}} < 0$, which is a contradiction. Next, $\frac{d\gamma_j^*}{d\underline{\gamma_i}} > 0$. To see why, consider the capital market clearing condition of country j:

$$K_j - K_{ij} = \int_{\gamma_j^L}^{\gamma_j^*} n(\gamma_j, R_j, R_j^D) g_j(\gamma_j) d\gamma_j. \tag{4.37}$$

$\frac{dK_{ij}^*}{d\underline{\gamma_i}} < 0$ and $\frac{\partial \gamma_j^L}{\partial K_{ij}} > 0$, and $\frac{\partial n(\gamma_j, R_j, R_j^D)}{\partial K_{ij}} > 0 \Rightarrow \frac{d\gamma_j^*}{d\underline{\gamma_i}} > 0$. Therefore $\frac{d\gamma_j^L}{d\underline{\gamma_i}} > 0$.

(ii) $\frac{d\gamma_j^L}{d1/L_i} < 0$. $\frac{d\gamma_j^L}{d1/L_i} = \frac{\partial \gamma_j^L}{\partial 1/L_i} + \frac{\partial \gamma_j^L}{\partial K_{ij}} \frac{dK_{ij}}{d1/L_i} + \frac{\partial \gamma_j^L}{\partial \gamma_j^*} \frac{d\gamma_j^*}{d1/L_i}$. $\frac{\partial \gamma_j^L}{\partial 1/L_i} < 0$, $\frac{\partial \gamma_j^L}{\partial K_{ij}} < 0$ and $\frac{\partial \gamma_j^L}{\partial \gamma_j^*} > 0$. Suppose $\frac{d\gamma_j^L}{d1/L_i} \geq 0$. Then $\frac{dK_{ij}^j}{d1/L_i} > 0$ and also $\frac{dK_{ij}^i}{d1/L_i} > 0$. If $\frac{dK_{ij}^i}{d1/L_i} > 0$, then $\frac{d\gamma_j^*}{d1/L_i} < 0$. But then $\frac{d\gamma_j^L}{d1/L_i} < 0$, which is a contradiction.

(iii) To show: $\frac{d\gamma_j^L}{df_{ij}^L} < 0$. Suppose $\frac{d\gamma_j^L}{df_{ij}^L} \geq 0$. $\frac{d\gamma_j^L}{df_{ij}^L} = \frac{\partial \gamma_j^L}{\partial f_{ij}^L} + \frac{\partial \gamma_j^L}{\partial K_{ij}} \frac{dK_{ij}}{df_{ij}^L} + \frac{\partial \gamma_j^L}{\partial \gamma_j^*} \frac{d\gamma_j^*}{df_{ij}^L}$. Because $\frac{\partial \gamma_j^L}{\partial f_{ij}^L} < 0$, $\frac{\partial \gamma_j^L}{\partial K_{ij}} < 0$ and $\frac{\partial \gamma_j^L}{\partial \gamma_j^*} > 0$, for $\frac{d\gamma_j^L}{df_{ij}^L} \geq 0$, either $\frac{dK_{ij}}{df_{ij}^L} < 0$ and/or $\frac{d\gamma_j^*}{df_{ij}^L} > 0$. Given $\frac{d\gamma_j^L}{df_{ij}^L} \geq 0$, $\frac{dK_{ij}}{df_{ij}^L} > 0$ using $\frac{\partial \gamma_j^F}{\partial f_{ij}^L} > 0$, and hence $\frac{d\gamma_j^*}{df_{ij}^L} < 0$. This implies $\frac{d\gamma_j^L}{df_{ij}^L} < 0$ so there is a contradiction.

(iv) To show: $\frac{d\gamma_j^L}{d\tau} > 0$. Suppose $\frac{d\gamma_j^L}{d\tau} \leq 0$. $\frac{d\gamma_j^L}{d\tau} = \frac{\partial\gamma_j^L}{\partial\tau} + \frac{\partial\gamma_j^L}{\partial K_{ij}}\frac{dK_{ij}}{d\tau} + \frac{\partial\gamma_j^L}{\partial\gamma_j^*}\frac{d\gamma_j^*}{d\tau}$. Because $\frac{\partial\gamma_j^L}{\partial\tau} > 0$, $\frac{\partial\gamma_j^L}{\partial K_{ij}} < 0$ and $\frac{\partial\gamma_j^L}{\partial\gamma_j^*} > 0$, for $\frac{d\gamma_j^L}{d\tau} \leq 0$, either $\frac{dK_{ij}}{d\tau} > 0$ and/or $\frac{d\gamma_j^*}{d\tau} < 0$. But given $\frac{d\gamma_j^L}{d\tau} \leq 0$, $\frac{dK_{ij}}{d\tau} < 0$ using $\frac{\partial\gamma_j^F}{\partial\tau} < 0$, and hence $\frac{d\gamma_j^*}{d\tau} > 0$. This implies $\frac{d\gamma_j^L}{d\tau} > 0$. So there is a contradiction.

(v) To show: $\frac{d\gamma_j^L}{df_{ij}^F} > 0$. Suppose $\frac{d\gamma_j^L}{df_{ij}^F} \leq 0$. $\frac{d\gamma_j^L}{df_{ij}^F} = \frac{\partial\gamma_j^L}{\partial K_{ij}}\frac{dK_{ij}^*}{df_{ij}^F} + \frac{\partial\gamma_j^L}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ij}^F}$. Because $\frac{\partial\gamma_j^L}{\partial K_{ij}} < 0$ and $\frac{\partial\gamma_j^L}{\partial\gamma_j^*} > 0$, for $\frac{d\gamma_j^L}{df_{ij}^F} \leq 0$, either $\frac{dK_{ij}}{df_{ij}^F} > 0$ and/or $\frac{d\gamma_j^*}{df_{ij}^F} < 0$. Given $\frac{d\gamma_j^L}{df_{ij}^F} \leq 0$, $\frac{dK_{ij}}{df_{ij}^F} < 0$ using $\frac{\partial\gamma_j^F}{\partial f_{ij}^F} > 0$, and hence $\frac{d\gamma_j^*}{df_{ij}^F} < 0$. Then $\frac{d\gamma_j^L}{df_{ij}^F} > 0$, which is a contradiction.

Proof of Proposition 5

(i) To show: $\frac{d\gamma_i^B}{d\gamma_j} > 0$. Note that $\frac{\partial K_{ij}^j}{\partial\gamma_j} < 0$ and $\frac{\partial\gamma_j^*}{\partial\gamma_j} > 0$. Suppose $\frac{d\gamma_i^B}{d\gamma_j} \leq 0$. If $\frac{d\gamma_i^B}{d\gamma_j} \leq 0$, then $\frac{dK_{ij}^i}{d\gamma_j} \leq 0$ and $\frac{d\gamma_i^*}{d\gamma_j} \leq 0$. Yet if $\frac{dK_{ij}^i}{d\gamma_j} \leq 0 \Rightarrow \frac{dK_{ij}}{d\gamma_j} < 0 \Rightarrow \frac{d\gamma_j^*}{d\gamma_j} > 0$ and $\frac{d\gamma_i^*}{d\gamma_j} < 0$. But this implies $\frac{d\gamma_i^B}{d\gamma_j} > 0$, which is a contradiction.

(ii) To show $\frac{d\gamma_i^B}{d1/L_j} > 0$. $\frac{d\gamma_i^B}{d1/L_j} = \frac{\partial\gamma_i^B}{\partial 1/L_j} + \frac{\partial\gamma_i^B}{\partial K_{ij}}\frac{dK_{ij}^*}{d1/L_j} + \frac{\partial\gamma_i^B}{\partial\gamma_j^*}\frac{d\gamma_j^*}{d1/L_j} + \frac{\partial\gamma_i^B}{\partial\gamma_i^*}\frac{d\gamma_i^*}{d1/L_j}$. Suppose $\frac{d\gamma_i^B}{d1/L_j} \leq 0$, then $\frac{dK_{ij}}{d1/L_j} < 0 \Rightarrow \frac{d\gamma_j^*}{d1/L_j} > 0$ and $\frac{d\gamma_i^*}{d1/L_j} < 0$. But then $\frac{d\gamma_i^B}{d1/L_j} < 0$, which is a contradiction.

(iii) To show: $\frac{d\gamma_i^B}{df_{ji}^B} < 0$. Suppose $\frac{d\gamma_i^B}{df_{ji}^B} \geq 0$. $\frac{d\gamma_i^B}{df_{ji}^B} = \frac{\partial\gamma_i^B}{\partial f_{ji}^B} + \frac{\partial\gamma_i^B}{\partial K_{ij}}\frac{dK_{ij}}{df_{ji}^B} + \frac{\partial\gamma_i^B}{\partial\gamma_i^*}\frac{d\gamma_i^*}{df_{ji}^B} + \frac{\partial\gamma_i^B}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ji}^B}$. Because $\frac{\partial\gamma_i^B}{\partial f_{ji}^B} < 0$, $\frac{\partial\gamma_i^B}{\partial K_{ij}} < 0$, $\frac{\partial\gamma_i^B}{\partial\gamma_j^*} > 0$ and $\frac{\partial\gamma_i^B}{\partial\gamma_i^*} < 0$, for $\frac{d\gamma_i^B}{df_{ji}^B} \geq 0$, either $\frac{dK_{ij}}{df_{ji}^B} < 0$ and/or $\frac{d\gamma_j^*}{df_{ji}^B} > 0$ and/or $\frac{d\gamma_i^*}{df_{ji}^B} < 0$. But given $\frac{d\gamma_i^B}{df_{ji}^B} \geq 0$, $\frac{dK_{ij}^i}{df_{ji}^B} > 0$ using $\frac{\partial\gamma_i^F}{\partial f_{ji}^B} > 0$, and therefore $\frac{d\gamma_i^*}{df_{ji}^B} > 0$ and $\frac{d\gamma_j^*}{df_{ji}^B} < 0$. This implies $\frac{d\gamma_i^B}{df_{ji}^B} < 0$ so there is a contradiction.

(iv) To show: $\frac{d\gamma_i^B}{d\phi} < 0$. Suppose $\frac{d\gamma_i^B}{d\phi} \geq 0$. $\frac{d\gamma_i^B}{d\phi} = \frac{\partial\gamma_i^B}{\partial\phi} + \frac{\partial\gamma_i^B}{\partial K_{ij}}\frac{dK_{ij}}{d\phi} + \frac{\partial\gamma_i^B}{\partial\gamma_i^*}\frac{d\gamma_i^*}{d\phi} + \frac{\partial\gamma_i^B}{\partial\gamma_j^*}\frac{d\gamma_j^*}{d\phi}$. Because $\frac{\partial\gamma_i^B}{\partial\phi} < 0$, $\frac{\partial\gamma_i^B}{\partial K_{ij}} < 0$, $\frac{\partial\gamma_i^B}{\partial\gamma_j^*} > 0$ and $\frac{\partial\gamma_i^B}{\partial\gamma_i^*} < 0$, for $\frac{d\gamma_i^B}{d\phi} \geq 0$, either $\frac{dK_{ij}}{d\phi} < 0$ and/or $\frac{d\gamma_j^*}{d\phi} > 0$ and/or $\frac{d\gamma_i^*}{d\phi} < 0$. But given $\frac{d\gamma_i^B}{d\phi} \geq 0$, $\frac{dK_{ij}^i}{d\phi} > 0$ using $\frac{\partial\gamma_i^F}{\partial\phi} > 0$, and therefore $\frac{d\gamma_i^*}{d\phi} > 0$ and $\frac{d\gamma_j^*}{d\phi} < 0$. This implies $\frac{d\gamma_i^B}{d\phi} < 0$, which is a contradiction.

(v) To show: $\frac{d\gamma_i^B}{df_{ji}^F} > 0$. Suppose $\frac{d\gamma_i^B}{df_{ji}^F} \leq 0$. $\frac{d\gamma_i^B}{df_{ji}^F} = \frac{\partial\gamma_i^B}{\partial K_{ij}}\frac{dK_{ij}}{df_{ji}^F} + \frac{\partial\gamma_i^B}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ji}^F} + \frac{\partial\gamma_i^B}{\partial\gamma_i^*}\frac{d\gamma_i^*}{df_{ji}^F}$. Because $\frac{\partial\gamma_i^B}{\partial K_{ij}} < 0$, $\frac{\partial\gamma_i^B}{\partial\gamma_j^*} > 0$ and $\frac{\partial\gamma_i^B}{\partial\gamma_i^*} < 0$, for $\frac{d\gamma_i^B}{df_{ji}^F} \leq 0$, either $\frac{dK_{ij}}{df_{ij}^F} > 0$ and/or $\frac{d\gamma_j^*}{df_{ji}^F} < 0$ and/or $\frac{d\gamma_i^*}{df_{ji}^F} > 0$. Given $\frac{d\gamma_i^B}{df_{ji}^F} \leq 0$, $\frac{dK_{ij}}{df_{ji}^F} < 0$ using $\frac{\partial\gamma_i^F}{\partial f_{ji}^F} < 0$. Then $\frac{d\gamma_j^*}{df_{ji}^F} > 0$ and $\frac{d\gamma_i^*}{df_{ji}^F} < 0$, which implies $\frac{d\gamma_i^B}{df_{ji}^F} > 0$ so there is a contradiction.

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Proof of Proposition 6

(i) To show: $\frac{d\gamma_j^F}{d\underline{\gamma_i}} > 0$. $\frac{d\gamma_j^F}{d\underline{\gamma_i}} = \frac{\partial\gamma_j^F}{\partial\underline{\gamma_i}} + \frac{\partial\gamma_j^F}{\partial K_{ij}}\frac{dK_{ij}}{d\underline{\gamma_i}} + \frac{\partial\gamma_j^F}{\partial\gamma_j^*}\frac{d\gamma_j^*}{d\underline{\gamma_i}}$. It is easy to see that $\frac{\partial\gamma_j^F}{\partial\underline{\gamma_i}} = 0$, $\frac{\partial\gamma_j^F}{\partial K_{ij}} < 0$ and $\frac{\partial\gamma_j^F}{\partial\gamma_j^*} > 0$. Using $\frac{dK_{ij}}{d\underline{\gamma_i}} < 0$ and $\frac{d\gamma_j^*}{d\underline{\gamma_i}} > 0$ as shown in the proof of proposition 4 (i), $\frac{d\gamma_j^F}{d\underline{\gamma_i}} \geq 0$.

To show: $\frac{d\gamma_i^F}{d\underline{\gamma_j}} > 0$. As shown in the proof of proposition 5 (i), $\frac{d\gamma_i^B}{d\underline{\gamma_j}} > 0$ because of equilibrium changes in R_i and R_j^D. If the equilibrium gross return is higher and/or the equilibrium deposit is lower, then $\frac{d\gamma_i^F}{d\underline{\gamma_j}} > 0$ because $\frac{d\gamma_i^F}{dR_i} > 0$ and $\frac{d\gamma_i^F}{dR_j^D} < 0$.

(ii) To show: $\frac{d\gamma_j^F}{df_{ij}^L} > 0$. Suppose $\frac{d\gamma_j^F}{df_{ij}^L} \leq 0$. $\frac{d\gamma_j^F}{df_{ij}^L} = \frac{\partial\gamma_j^F}{\partial f_{ij}^L} + \frac{\partial\gamma_j^L}{\partial K_{ij}}\frac{dK_{ij}}{df_{ij}^L} + \frac{\partial\gamma_j^L}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ij}^L}$. Because $\frac{\partial\gamma_j^F}{\partial f_{ij}^L} > 0$, $\frac{\partial\gamma_j^F}{\partial K_{ij}} < 0$ and $\frac{\partial\gamma_j^F}{\partial\gamma_j^*} > 0$, for $\frac{d\gamma_j^F}{df_{ij}^L} \leq 0$, either $\frac{dK_{ij}}{df_{ij}^L} > 0$ and/or $\frac{d\gamma_j^*}{df_{ij}^L} < 0$. Given $\frac{d\gamma_j^F}{df_{ij}^L} \leq 0$, $\frac{dK_{ij}}{df_{ij}^L} < 0$ using $\frac{\partial\gamma_j^L}{\partial f_{ij}^L} < 0$, and $\frac{d\gamma_j^*}{df_{ij}^L} > 0$. So there is a contradiction.

To show: $\frac{d\gamma_i^F}{df_{ji}^B} < 0$. Suppose $\frac{d\gamma_i^F}{df_{ji}^B} \leq 0$. $\frac{d\gamma_i^F}{df_{ji}^B} = \frac{\partial\gamma_i^F}{\partial f_{ji}^B} + \frac{\partial\gamma_i^F}{\partial K_{ij}}\frac{dK_{ij}}{df_{ji}^B} + \frac{\partial\gamma_i^F}{\partial\gamma_i^*}\frac{d\gamma_i^*}{df_{ji}^B} + \frac{\partial\gamma_j^B}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ji}^B}$. Because $\frac{\partial\gamma_i^F}{\partial f_{ji}^B} > 0$, $\frac{\partial\gamma_i^F}{\partial K_{ij}} < 0$, $\frac{\partial\gamma_i^F}{\partial\gamma_j^*} > 0$ and $\frac{\partial\gamma_i^F}{\partial\gamma_i^*} < 0$, for $\frac{d\gamma_i^F}{df_{ji}^B} < 0$, either $\frac{dK_{ij}^*}{df_{ji}^B} > 0$ and/or $\frac{d\gamma_i^*}{df_{ji}^B} < 0$ and/or $\frac{d\gamma_i^*}{df_{ji}^B} > 0$. But given $\frac{d\gamma_i^F}{df_{ji}^B} \leq 0$, $\frac{dK_{ij}^{i;*}}{df_{ji}^B} < 0$ using $\frac{\partial\gamma_i^B}{\partial f_{ji}^B} < 0$, and therefore $\frac{d\gamma_i^*}{df_{ji}^B} < 0$ and $\frac{d\gamma_j^*}{df_{ji}^B} > 0$. So there is a contradiction.

(iii) To show: $\frac{d\gamma_j^F}{d\tau} < 0$. Suppose $\frac{d\gamma_j^F}{d\tau} \geq 0$. $\frac{d\gamma_j^F}{d\tau} = \frac{\partial\gamma_j^F}{\partial\tau} + \frac{\partial\gamma_j^F}{\partial K_{ij}}\frac{dK_{ij}}{d\tau} + \frac{\partial\gamma_j^F}{\partial\gamma_j^*}\frac{d\gamma_j^*}{d\tau}$. Because $\frac{\partial\gamma_j^F}{\partial\tau} < 0$, $\frac{\partial\gamma_j^F}{\partial K_{ij}} < 0$ and $\frac{\partial\gamma_j^F}{\partial\gamma_j^*} > 0$, for $\frac{d\gamma_j^F}{d\tau} \geq 0$, either $\frac{dK_{ij}}{d\tau} < 0$ and/or $\frac{d\gamma_j^*}{d\tau} > 0$. But given $\frac{d\gamma_j^F}{d\tau} \geq 0$, $\frac{dK_{ij}}{d\tau} > 0$ using $\frac{\partial\gamma_j^L}{\partial\tau} > 0$, and $\frac{d\gamma_j^*}{d\tau} < 0$. So there is a contradiction.

To show: $\frac{d\gamma_i^F}{d\phi} > 0$. Suppose $\frac{d\gamma_i^F}{d\phi} \leq 0$. $\frac{d\gamma_i^F}{d\phi} = \frac{\partial\gamma_i^F}{\partial\phi} + \frac{\partial\gamma_i^F}{\partial K_{ij}}\frac{dK_{ij}}{d\phi} + \frac{\partial\gamma_i^F}{\partial\gamma_i^*}\frac{d\gamma_i^*}{d\phi} + \frac{\partial\gamma_i^F}{\partial\gamma_j^*}\frac{d\gamma_j^*}{d\phi}$. Because $\frac{\partial\gamma_i^F}{\partial\phi} > 0$, $\frac{\partial\gamma_i^F}{\partial K_{ij}} < 0$, $\frac{\partial\gamma_i^F}{\partial\gamma_j^*} > 0$ and $\frac{\partial\gamma_i^F}{\partial\gamma_i^*} < 0$, for $\frac{d\gamma_i^F}{d\phi} < 0$, either $\frac{dK_{ij}}{d\phi} > 0$ and/or $\frac{d\gamma_j^*}{d\phi} < 0$ and/or $\frac{d\gamma_i^*}{d\phi} > 0$. But given $\frac{d\gamma_i^F}{d\phi} \leq 0$, $\frac{dK_{ij}}{d\phi} < 0$ using $\frac{\partial\gamma_i^B}{\partial\phi} < 0$ and therefore $\frac{d\gamma_i^*}{d\phi} < 0$ and $\frac{d\gamma_j^*}{d\phi} > 0$. So there is a contradiction.

(iv) To show: $\frac{d\gamma_j^F}{df_{ij}^F} < 0$. Suppose $\frac{d\gamma_j^F}{df_{ij}^F} \geq 0$. $\frac{d\gamma_j^F}{df_{ij}^F} = \frac{\partial\gamma_j^F}{\partial f_{ij}^F} + \frac{\partial\gamma_j^F}{\partial K_{ij}}\frac{dK_{ij}}{df_{ij}^F} + \frac{\partial\gamma_j^F}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ij}^F}$. Because $\frac{\partial\gamma_j^F}{\partial f_{ij}^F} < 0$, $\frac{\partial\gamma_j^F}{\partial K_{ij}} < 0$ and $\frac{\partial\gamma_j^F}{\partial\gamma_j^*} > 0$, for $\frac{d\gamma_j^F}{df_{ij}^F} \geq 0$, either $\frac{dK_{ij}}{df_{ij}^F} < 0$ and/or $\frac{d\gamma_j^*}{df_{ij}^F} > 0$. Given $\frac{d\gamma_j^F}{df_{ij}^F} \geq 0$, $\frac{dK_{ij}}{df_{ij}^F} > 0$ and $\frac{d\gamma_j^*}{df_{ij}^F} < 0$. So there is a contradiction.

To show: $\frac{d\gamma_i^F}{df_{ji}^F} < 0$. Suppose $\frac{d\gamma_i^F}{df_{ji}^F} \geq 0$. $\frac{d\gamma_i^F}{df_{ji}^F} = \frac{\partial\gamma_i^F}{\partial f_{ji}^F}\frac{\partial\gamma_i^F}{\partial K_{ij}}\frac{dK_{ij}}{df_{ji}^F} + \frac{\partial\gamma_i^F}{\partial\gamma_j^*}\frac{d\gamma_j^*}{df_{ji}^F} + \frac{\partial\gamma_i^F}{\partial\gamma_i^*}\frac{d\gamma_i^*}{df_{ji}^F}$. Because $\frac{\partial\gamma_i^F}{\partial f_{ji}^F} < 0$, $\frac{\partial\gamma_i^F}{\partial K_{ij}} < 0$, $\frac{\partial\gamma_i^F}{\partial\gamma_j^*} > 0$ and $\frac{\partial\gamma_i^F}{\partial\gamma_i^*} < 0$, for $\frac{d\gamma_i^F}{df_{ji}^F} > 0$, either $\frac{dK_{ij}}{df_{ij}^F} < 0$ and/or $\frac{d\gamma_j^*}{df_{ji}^F} > 0$ and/or $\frac{d\gamma_i^*}{df_{ji}^F} < 0$. Given $\frac{d\gamma_i^F}{df_{ji}^F} \geq 0$, $\frac{dK_{ij}}{df_{ji}^F} > 0$, $\frac{d\gamma_j^*}{df_{ji}^F} < 0$ and $\frac{d\gamma_i^*}{df_{ji}^F} > 0$. So there is a contradiction.

Appendix B: General Model with $\tau = \phi = 1$

In the following, I characterize the general model. I discuss the different equilibrium cases that can occur for various parameter values and provide intuition for how the equilibrium case changes with key parameters of the model. To reduce the dimensionality, I assume that there are no variable costs to operating cross-border, i.e. $\tau = \phi = 1$. This removes the decision of firms between operating from home or through FDI.

The following equilibrium cases can occur:

Proposition 7 *Assume $\phi = \tau = 1$. Then the following equilibrium cases are conceivable where $i, j \in \{1, 2\}$ and $i \neq j$:*

(i) **No trade**.

(ii) **Cross-border lending by banking sector** **j**: *Some banks from country j invest domestic deposits in country i. γ_j^L exists.*

(iii) **Cross-border lending and local intermediation by banking sector** **j**: *Some banks from country j invest domestic deposits in country i; others raise foreign deposits and invest them in the foreign market. γ_j^L and γ_j^B both exist.*

(iv) **Local intermediation by banking sector** **j**: *Some banks from country j raise foreign deposits and invest them in the foreign market. γ_j^B exists and $R_i > R_j$.*

(v) **Local intermediation and cross-border borrowing by banking sector** **j**: *Some banks from country j raise deposits in country i and invest them at home and abroad. γ_j^B exists and $R_i = R_j$.*

(vi) **Cross-border lending by banking sector** **j** **and cross-border borrowing by banking sector** **i**: *Some banks from country j invest domestic deposits abroad, while some banks from country i raise deposits in country j and invest them at home. γ_j^L and γ_i^B both exist.*

(vii) **Cross-border borrowing by banking sector** **i**: *Some banks from country i raise deposits in country j and invest them at home. γ_i^B exists and $R_i > R_j$.*

Proof. Assume $\Delta(K/L) \geq 0$ without loss of generality.

(a) $\Delta(K/L) \geq 0$ implies that in equilibrium $R_i \geq R_j$. To see this note that if $R_i > R_j$ in autarky, it must be the case that $R_i \geq R_i$ in equilibrium. It is possible that banks source

so much foreign capital from abroad that rates of return to capital equalize in equilibrium. If $R_i = R_j$ in autarky, then in equilibrium $R_i = R_j$. This leaves the following combinations possible:

(1) $R_i > R_j$ & $R_i^D < R_j^D$

(2) $R_i > R_j$ & $R_i^D > R_j^D$

(3) $R_i > R_j$ & $R_i^D = R_j^D$

(4) $R_i = R_j$ & $R_i^D < R_j^D$

(5) $R_i = R_j$ & $R_i^D > R_j^D$

(6) $R_i = R_j$ & $R_i^D = R_j^D$

(b) There are no upper limits on f_{ij}^L, f_{ji}^L, f_{ij}^B and f_{ji}^B. So any of these fixed costs can be prohibitively high.

(c) In each country $j \in \{1,2\}$, there are four possibilities: γ_j^L and γ_j^B both do not exist , only γ_j^L exists, only γ_j^B exists, both γ_j^L and γ_j^B exist.

(d) Investing at home is costless in any case. Therefore if $R_i > R_j$, all banks in country i must invest in country i.

(e) Capital must always flow in one direction, i.e. it cannot be the case that banks from country j invest in country i and banks from country i invest in j.

(f) If $R_i = R_j$, no banker incurs the fixed cost of cross-border lending in equilibrium.

(g) It is not possible that banks in both countries raise deposits abroad in equilibrium. If $R_i^D > R_j^D$ only banks in country i have incentives to invest in the fixed cost of FDI.

(h) If $R_i^D = R_j^D$, no banker incurs the fixed cost of cross-border borrowing in equilibrium.

Combining (a)-(h), we have that:

(1) If $R_i > R_j$ & $R_i^D < R_j^D$, γ_i^L does not exit and γ_i^B does not exist.

(2) If $R_i > R_j$ & $R_i^D > R_j^D$, γ_i^L does not exit and γ_i^B does not exist. Banks in country i all invest in country i.

(3) If $R_i > R_j$ & $R_i^D = R_j^D$, γ_i^L does not exit and γ_i^B and γ_j^B do not exist.

(4) If $R_i = R_j$ & $R_i^D > R_j^D$, γ_i^L, γ_j^L and γ_j^B do not exist. Banks in both countries are indifferent where to invest.

(5) If $R_i = R_j$ & $R_i^D < R_j^D$, γ_i^L, γ_j^L and γ_i^B do not exist. Banks in both countries are indifferent where to invest.

(6) If $R_i = R_j$ & $R_i^D = R_j^D$, γ_i^L, γ_j^L, γ_i^B and γ_j^B do not exist. The equilibrium corresponds to autarky.

Therefore, it can be that:

(A) There is no trade. Possible in all cases.

(B) Only γ_j^L exists. Possible for cases (1) and (2).

(C) γ_j^L and γ_j^B both exist: Possible for case (1).

(D) γ_j^L and γ_i^B both exist: Possible for case (2).

(E) γ_j^B exists: Possible for case (1) and (5).

(F) γ_i^B exists: Possible for case (2) and (4).

Now distinguish (E) and (F) again by the equilibrium values that R_i and R_j take:

(E1) γ_j^B exists and (1): banks that pay f_{ij}^B invest in country i.

(E2) γ_j^B exists and (5): banks in country j invest at home and abroad.

(F1) γ_i^B exists and (2): banks that pay f_{ji}^B invest in country i.

(F2) γ_i^B exists and (4): banks in country i invest at home and abroad.

Note that even if $R_i = R_j$ in autarky, banks that raise deposits abroad must in the aggregate invest at home and abroad to offset their bank capital export when lending to foreign firms.

Then, we obtain the eight cases as stated in the proposition. ∎

Figure 4.1, which is obtained from simulating the model numerically, illustrates the different equilibrium cases. It shows how the equilibrium changes with the capital-labor ratio of country 1 K_1/L_1 and with the support of the monitoring cost distribution of country 1, i.e. with changes in $\underline{\gamma}_1$ keeping the characteristics of country 2 fixed. As the size of the capital stock affects the realized monitoring cost distribution, the capital-labor ratio of country 1 is varied by modifying the labor endowment instead of the capital endowment.

Consider figure 4.1 and focus on the case where country 1 is relatively capital scarce. Start from a situation where country 1 has a very efficient banking sector relative to country 2, i.e. begin in the right lower corner of the graph. Under the assumed parameters, equilibrium case (vii) prevails, that is, banking sector 1 borrows capital from depositors in country 2 for investment at home, hence importing capital from country 2. Banking sector 2 operates only at home.

Figure 4.1: Equilibrium types as a function of K_1/L_1 and $\underline{\gamma}_1$
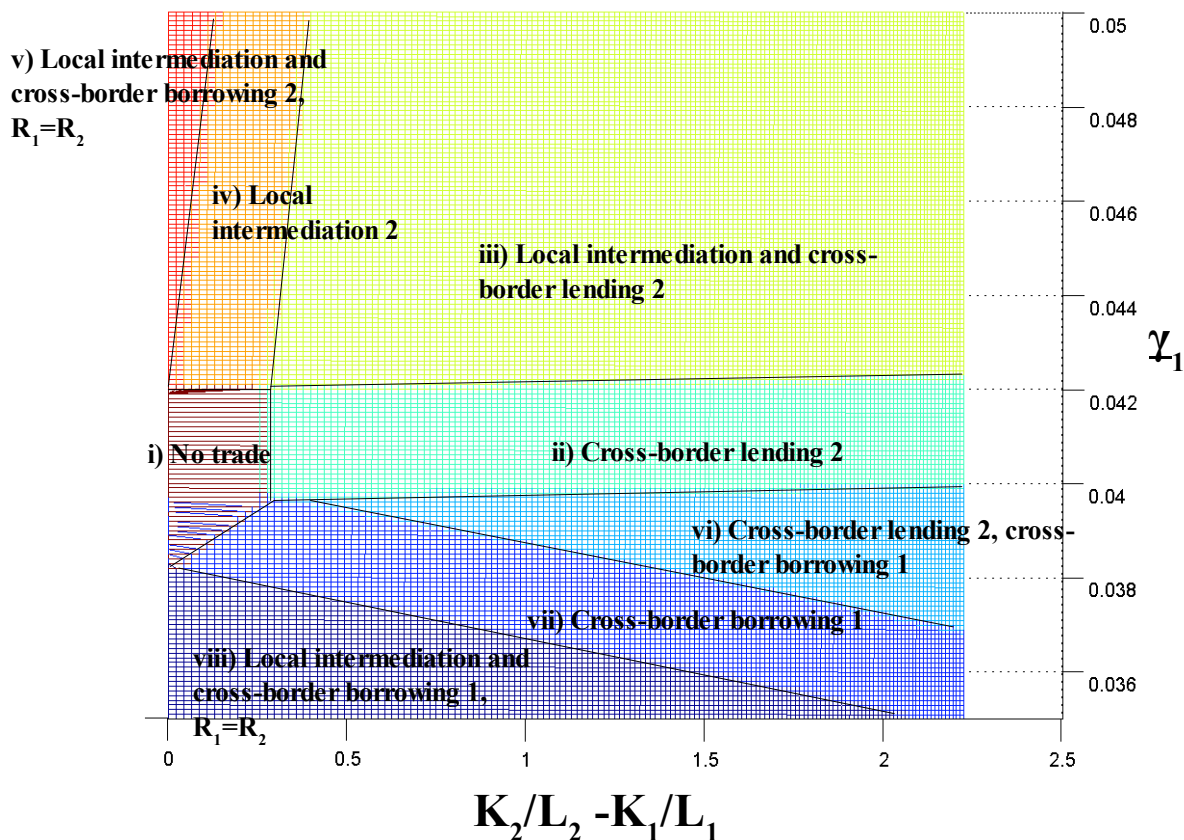
The graph is obtained from simulating the model for the following parameter values: Cobb-Douglas production function with a labor share of 0.3, $\lambda^L = 0.5$, $\lambda = 0.985$, $f^L = 0.13$, $f^B = 0.16$, uniform distribution, $\underline{\gamma}_2 = 0.04$ and $\overline{\gamma}_1 = \overline{\gamma}_2 = 0.4$, $K_2/L_2 = 20/3$, $K_1/L_1 \in [20/3, 20/4.5]$, $\underline{\gamma}_1 \in [0.035, 0.05]$.

Next move upward along the y-axis. As $\underline{\gamma}_1$ increases and banking sector 1 becomes less efficient, banks in country 2 start to engage in cross-border lending simultaneously (case (vi)). Because the interest rate in country 1 decreases and because banks in country 1 become less efficient, fewer banks in country 1 borrow from depositors abroad. This implies that the spread in gross returns to capital grows larger ceteris paribus, which makes it attractive for banks in country 2 to invest abroad. This situation corresponds to the equilibrium case discussed in the main text.

As the efficiency of banking sector 1 decreases even more, banks in country 1 are, at some point, not efficient enough and differences in deposit rates are not large enough to make any bank in country 1 incur the fixed cost of cross-border borrowing. In this case, only banking sector 2 is active across borders and lends to firms in country 1 (case (ii)).

With a further decline in $\underline{\gamma}_1$, the deposit rate in country 1 can decrease to the point where it is profitable for banks in country 2 not only to lend to firms in country 1 but also to borrow from depositors in country 1. Then, banking sector 2 engages in both cross-border lending and borrowing in equilibrium, exporting capital on net (case (iii)).

Next, consider how the equilibrium varies along the x-axis, that is, with changes in K_1/L_1. Start where countries have equal capital endowments so that there is no reason why capital should flow across borders. If differences in efficiencies are also small ($\underline{\gamma}_i \approx 0.04$), there is no trade in banking services at all. The equilibrium corresponds to autarky. If, however, one banking sector is sufficiently more efficient than the other, that banking sector expands by intermediating foreign deposits locally. With equal gross returns to capital in the two countries, banks incur the fixed cost of cross-border borrowing and invest at home and abroad to keep returns equated. Which banks lend to firms at home and abroad, is not determined in this case. Because gross returns to capital are equal, all banks that pay the fixed cost are indifferent between investing at home and abroad.

Now let country 1 become capital scarce, that is, move to the right along the x-axis. As the capital-labor ratio of country 1 declines, additional banks become internationally active. Whether these are banks in country 1 or in country 2 depends on which banking sector is more efficient. In a nutshell: differences in capital-labor ratios determine the direction of the

cross-border capital flow. Differences in banking sector efficiencies fix which banks channel capital across borders.

Appendix C: Data Appendix

Auslandsstatus-Report: Total cross-borders assets and liabilities of bank k in country i are measured as the cross-border assets and liabilities of parent bank k minus the liabilities of its affiliates located in country i vis-a-vis the parent. Local assets (liabilities) comprise the assets (liabilities) of all affiliates of bank k located in country i towards residents of country i. Branches and subsidiaries are matched to the parent as of June 2005. Data come at a monthly frequency and are averaged over 12 months. If the panel is used that comprises only information on banks that have at least one foreign affiliate in at least one country over the period from 2002 until 2009, data are for the month of December in each year.

$\Delta \log(\mathbf{K}/\mathbf{L_{ijt}})$: The adjustment for human capital follows Hall and Jones (1999):

$$H_i = e^{\phi(E_i)}L_i, \tag{4.38}$$

where L_i stands for the labor force and E_i are average years of schooling. The function $\phi(E)$ is the efficiency of a unit of labor with E years of schooling relative to one with no schooling ($\phi(0) = 0$). As in Hall and Jones (1999), it is assumed that $\phi(E)$ is piecewise linear, with a slope of 0.134 up to 4 years of schooling, a slope of 0.101 for the years of schooling between 4 and 8, and 0.068 for any year beyond that. Data on average years of schooling for the population aged over 25 comes in 5-year frequencies from Barro and Lee (2010). Linear interpolation is used to generate missing data. Capital stocks and data on the labor force are from Penn World Tables 6.2.[36] Denoting the capital stock of country i by K_i, the proxy for differences in rates of return to capital is precisely calculated as:

$$\Delta \log(K/L)_{ijt} = \log(K_{j\ t-5}/H_{j\ t-5}) - \log(K_{i\ t-5}/H_{i\ t-5}). \tag{4.39}$$

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[36]Capital stocks for the base year 2000, which are not publicly available, were kindly provided by Penn World Tables.

Additional variables: GDP in current \$US and GDP per capita in current \$US are obtained from the World Development Indicators. Data on average overhead costs to total assets of a country are from the Financial Structure Data Base provided by the World Bank (see Beck, Demirgüç-Kunt and Levine (2009)). Bilateral distance comes from a dataset provided by CEPII (see Mayer and Zignago (2005)). The Financial Freedom Index is computed by the Heritage Foundation (see http://www.heritage.org/index/financial-freedom). Bureaucratic quality is from the International Country Risk Guide provided by the PRS Group.

Host countries i: In the following, host countries included in the samples underlying tables 6, 7 and 8 are listed. The liability sample comprises the same countries as the asset sample except from Gabon, which is not in the liability sample. Host countries that are included in the FDI sample (table 8) are indicated with asterisks: Algeria, Argentina*, Australia*, Austria*, Bangladesh, Bahrain, Belgium*, Bolivia, Botswana, Brazil*, Cameroon, Canada*, Chile*, China*, Columbia, Republic of Congo, Costa Rica, Cuba, Ivory Cost, Cyprus, Denmark, Ecuador, Egypt, El Salvador, Finland*, France*, Gabon, Ghana, Guatemala, Honduras, Hong Kong*, Hungary*, Iceland, India*, Indonesia*, Iran, Ireland, Israel, Italy*, Japan*, Jordan, Kenya, Republic of Korea* Kuwait, Luxembourg*, Malawi, Mali, Malaysia*, Malta, Mexico*, Mongolia, Morocco, Mozambique, the Netherlands*, Nicaragua, Niger, Norway, Pakistan*, Panama, Paraguay, Peru, Philippines*, Poland*, Portugal*, Qatar, Romania, Saudi Arabia, Senegal, Sierra Leone, Singapore*, South Africa*, Spain*, Sri Lanka*, Sweden*, Switzerland*, Thailand*, Trinidad and Tobago, Tunisia, Turkey*, Uganda, United Arab Emirates*, the United Kingdom* the United States of America*, Uruguay*, Venezuela, Zambia, Zimbabwe

Figure 1: Bank size in autarky and in the open economy
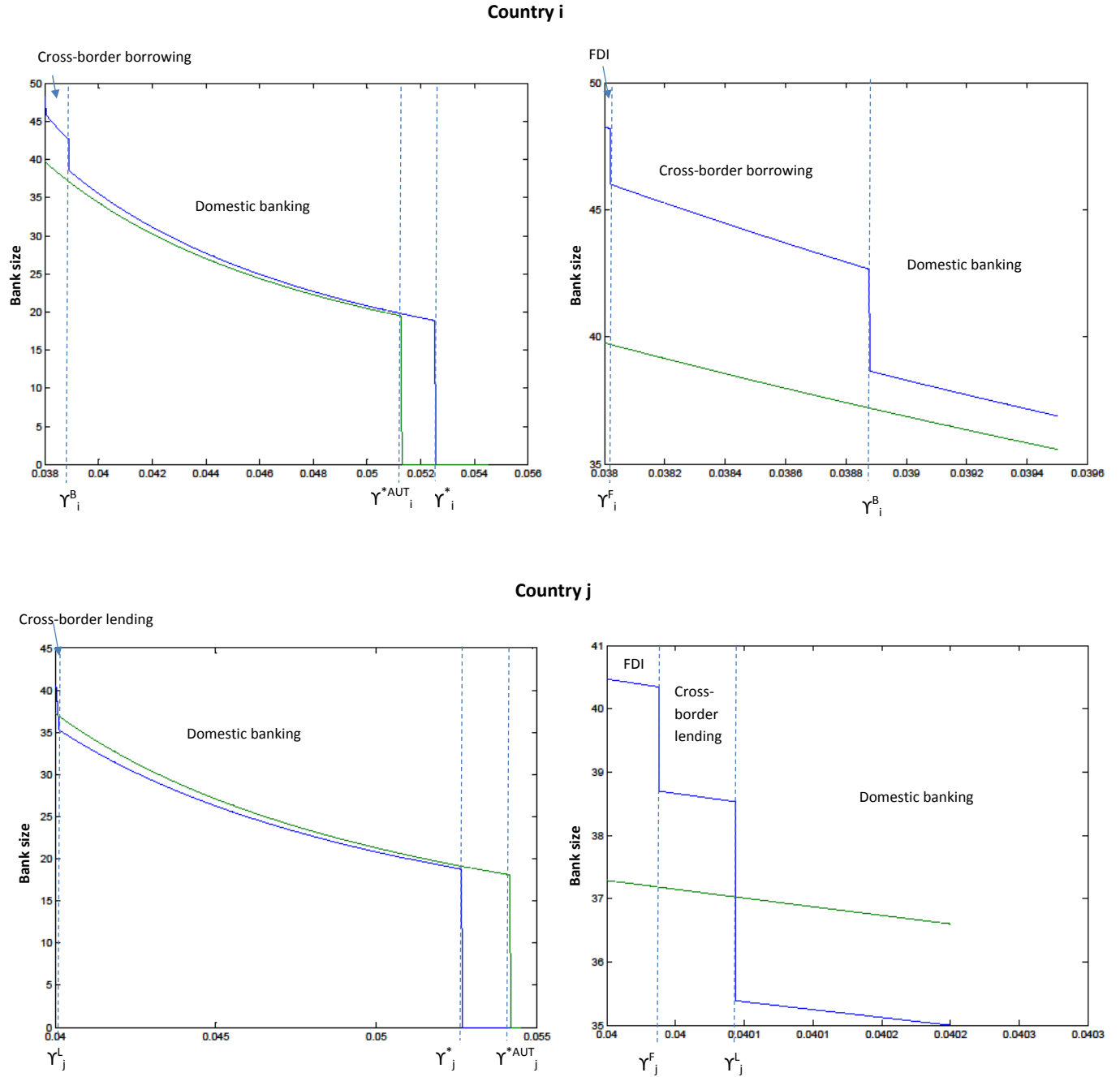
The upper two graphs show the size of banks in country i as a function of γ in autarky (green line) and in the open economy equilibrium (blue line). The upper right graph zooms into the upper left graph. The lower two graphs display the size of banks in country j.

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Table 1: Effect of size and efficiency on the extensive and intensive margins

| | Extensive Margin: Logit Model | | | Intensive Margin: OLS | | | |
| | cr. assets | cr. liabilities | FDI | cr. assets | local assets | cr. liabilities | local liabilities |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log(size$_k$)	1.023***	1.147***	1.277***	0.794***	0.443***	0.869***	0.877***
	(0.0275)	(0.0315)	(0.130)	(0.0395)	(0.136)	(0.0331)	(0.195)
Observations	342,130	344,074	112,056	36598	258	60623	248
(Pseudo) R^2	0.570	0.494	0.667	0.447	0.603	0.392	0.568
log(overhead costs$_k$)	-0.807***	-0.850***	-0.922***	-1.682***	-0.386	-1.347***	0.00515
	(0.135)	(0.126)	(0.253)	(0.232)	(0.390)	(0.232)	(0.889)
Observations	337,705	339,624	110,606	35758	251	59259	241
(Pseudo) R^2	0.483	0.375	0.458	0.408	0.571	0.271	0.476

Clustered standard errors in parentheses.
Regressions include country-fixed effects and dummies for bank type.
*** p<0.01, ** p<0.05, * p<0.1.

Table 2: Numerical example

Parameter values

Exogeneous parameters	Value
Size of capital input per firm z	1
Capital share α in Cobb-Douglas production function	0.3
Success probability without monitoring λ_L	0.5
Success probability with monitoring λ	0.985
Variable cost of lending abroad τ	0.999
Variable cost of borrowing abroad ϕ	1.001
Fixed cost of lending abroad f_{ij}^L	0.13
Fixed cost of borrowing abroad f_{ji}^B	0.16
Cost of FDI for banking sector j f_{ij}^F	0.198
Cost of FDI for banking sector i f_{ji}^F	0.245
Lower limit of uniform monitoring cost distribution $\underline{\gamma_j}$	0.04
Lower limit of uniform monitoring cost distribution $\underline{\gamma_i}$	0.038
Upper monitoring cost limit $\overline{\gamma_j} = \overline{\gamma_i}$	0.4
Capital-labor ratio K_j/L_j	20/3
Capital-labor ratio K_i/L_i	20/4

Solution

Endogenous parameters	Autarky value	Equilibrium value
Entry cutoff γ_j^*	0.054175	0.052671
Cross-border lending cutoff γ_j^L	-	0.04009
FDI cutoff γ_j^F	-	0.040038
Entry cutoff γ_i^*	0.051288	0.052543
Cross-border borrowing cutoff γ_i^B	-	0.038877
FDI cutoff γ_i^F	-	0.0380189
Capital flow through banks in j K_{ij}^j	0	0.2050368
Capital flow through banks in i K_{ij}^i	0	2.099895
Gross return to capital R_j	1.0795	1.0866183
Gross return to capital R_i	1.09724	1.0900913
Deposit rate R_j^D	1.0245	1.033145
Deposit rate R_i^D	1.04517	1.036748

Table 3: Correlation coefficients for different measures of bank efficiency

	log(overhead costs$_k$)	log(size$_k$)	log(labor productivity$_k$)
log(overhead costs$_k$)	1.0000		
log(size$_k$)	-0.5476	1.0000	
log(labor productivity$_k$)	-0.9264	0.5344	1.0000

Table 4: Expected signs

Cross-border lending cutoff			
	(1)	(2)	(3)
	max. overhead costs	min. size/ labor prod.	# banks
return to capital$_i$	+	-	+
overhead cost$_i$	+	-	+
distance$_{ij}$	-	+	-
financial freedom$_i$	+	-	+
bureaucratic quality$_i$	+	-	+

Cross-border borrowing cutoff			
	(1)	(2)	(3)
	max. overhead costs	min. size/ labor prod.	# banks
return to capital$_i$	-	+	-
overhead cost$_i$	+	-	+
distance$_{ij}$	-	+	-
financial freedom$_i$	+	-	+
bureaucratic quality$_i$	+	-	+

Table 5: Summary statistics for sample underlying table 6

	Obs	Mean	Std. Dev.	Min	Max
# banks with cr. assets$_i$	86	4.97309	1.45347	1.94591	7.552238
log(return to capital$_i$)	86	-9.365102	1.219936	-11.26792	-6.071978
log(overhead costs$_i$)	86	-3.277382	.6695559	-5.003277	-2.015182
log(distance$_{ij}$)	86	8.30332	1.060289	5.156315	9.71491
financial freedom$_i$	86	54.4186	22.67959	10	90
bureaucratic quality$_i$	86	2.442345	1.071736	0	4
log(GDP$_i$)	86	25.03863	1.960676	20.93789	30.16311
log(GDP per capita$_i$)	86	8.530896	1.670926	5.307277	11.3017

Table 6: Effects of host country characteristics on the cross-border lending cutoff

	log(max overhead) (1)	log(min size) (2)	log(min lab. prod.) (3)	log(# banks) (4)
log(return to capital$_i$)	0.0154	0.239	0.0501	-0.236
	(0.120)	(0.161)	(0.105)	(0.143)
log(overhead costs$_i$)	0.190**	-0.484***	-0.319***	0.325***
	(0.0846)	(0.116)	(0.0819)	(0.101)
log(distance$_{ij}$)	-0.262***	0.285***	0.248***	-0.376***
	(0.0749)	(0.0907)	(0.0813)	(0.0678)
financial freedom$_i$	0.00625**	-0.00450	-0.00758***	0.00788**
	(0.00296)	(0.00420)	(0.00264)	(0.00305)
bureaucratic quality$_i$	0.150**	-0.470***	-0.168***	0.377***
	(0.0686)	(0.118)	(0.0592)	(0.0839)
log(GDP$_i$)	0.208***	-0.244***	-0.181***	0.412***
	(0.0444)	(0.0617)	(0.0435)	(0.0437)
log(GDP per capita$_i$)	-0.0465	0.135	0.0287	-0.130
	(0.0950)	(0.149)	(0.0824)	(0.122)
Constant	1.924	15.62***	9.810***	-3.604***
	(1.222)	(1.621)	(1.201)	(1.167)
Observations	86	86	86	86
R^2	0.651	0.724	0.695	0.869

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 7: Effects of host country characteristics on the cross-border borrowing cutoff

	(1) log(max overhead)	(2) log(min size)	(3) log(min lab. prod.)	(4) log(# banks)
$\log(\text{return to capital}_i)$	-0.0233	0.491***	0.0732	-0.454***
	(0.120)	(0.175)	(0.0974)	(0.123)
$\log(\text{overhead costs}_i)$	0.257***	-0.354***	-0.257***	0.285***
	(0.0790)	(0.124)	(0.0737)	(0.0927)
$\log(\text{distance}_{ij})$	-0.0969*	0.150*	0.0474	-0.234***
	(0.0540)	(0.0805)	(0.0542)	(0.0609)
financial freedom$_i$	0.00616*	-0.0129***	-0.00622**	0.00701**
	(0.00320)	(0.00398)	(0.00262)	(0.00284)
bureaucratic quality$_i$	0.206***	0.00799	-0.101	0.302***
	(0.0686)	(0.106)	(0.0629)	(0.0795)
$\log(\text{GDP}_i)$	0.235***	-0.320***	-0.228***	0.380***
	(0.0311)	(0.0590)	(0.0320)	(0.0386)
$\log(\text{GDP per capita}_i)$	-0.105	0.364**	0.0453	-0.397***
	(0.0938)	(0.154)	(0.0757)	(0.104)
Constant	0.233	18.13***	12.51***	-2.844**
	(1.000)	(1.656)	(0.911)	(1.081)
Observations	87	87	87	87
R^2	0.628	0.554	0.665	0.835

Robust standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Effects of host country characteristics on the FDI cutoff

	(1) log(max overhead)	(2) log(min size)	(3) log(min lab. prod.)	(4) log(# banks)
log(return to capital$_i$)	-0.348**	1.518*	0.229*	-0.328
	(0.166)	(0.793)	(0.128)	(0.496)
log(overhead costs$_i$)	0.0619	-0.515	-0.0638	-0.0336
	(0.101)	(0.455)	(0.0706)	(0.262)
log(distance$_{ij}$)	-0.257***	0.856***	0.217***	-0.357***
	(0.0433)	(0.180)	(0.0300)	(0.116)
financial freedom$_i$	4.30e-05	-0.00698	-0.00110	0.00858
	(0.00274)	(0.0118)	(0.00211)	(0.00820)
bureaucratic quality$_i$	-0.0907	-0.181	0.0313	-0.100
	(0.0906)	(0.538)	(0.0794)	(0.232)
log(GDP$_i$)	0.0199	0.0399	-0.0254	0.152
	(0.0337)	(0.152)	(0.0226)	(0.0951)
log(GDP per capita$_i$)	-0.142	0.644	0.123	-0.00273
	(0.107)	(0.470)	(0.0842)	(0.331)
Constant	2.832*	18.13***	8.801***	-3.494
	(1.412)	(5.067)	(1.040)	(3.031)
Observations	37	37	37	37
R^2	0.669	0.601	0.664	0.616

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 9: Proximity-fixed cost tradeoff: extensive margin

	(1) Δ log(mean overhead costs)	(2) Δ log(mean size)	(3) Δ log(mean lab. prod.)
log(distance$_{ij}$)	-0.0288	-0.223*	-0.229**
	(0.0439)	(0.121)	(0.0694)
financial freedom$_i$	0.00405	-0.00210	-0.000532
	(0.00257)	(0.00601)	(0.00575)
bureaucratic quality$_i$	-0.0136	0.223	0.0535
	(0.0606)	(0.192)	(0.116)
log(GDP$_i$)	0.0497*	0.350**	0.188**
	(0.0312)	(0.0912)	(0.0460)
log(GDP per capita$_i$)	0.0365	0.0247	0.141
	(0.0408)	(0.119)	(0.121)
Constant	-1.008	-5.481**	-4.169**
	(0.781)	(1.634)	(1.487)
Observations	53	53	53
R^2	0.240	0.495	0.518

Robust standard errors in parentheses.
** $p<0.05$, * $p<0.1$.

Table 10: Proximity-fixed cost tradeoff: intensive margin

	(1) local assets cr. assets	(2) local liab cr. liab	(3) local as+liab cr. ass+liab	(4) local assets cr. assets	(5) local liab cr. liab	(6) local as+liab cr. ass+liab
log(distance$_{ij}$)	0.494*	0.465*	0.800*	0.375*	0.654**	1.003**
	(0.279)	(0.263)	(0.471)	(0.199)	(0.146)	(0.316)
financial freedom$_i$	0.0408*	0.00611	0.0254	0.0372**	0.0117	0.0447
	(0.0233)	(0.0296)	(0.0472)	(0.0145)	(0.0186)	(0.0285)
bureaucratic quality$_i$	0.350	1.065	1.707	0.141	0.610	0.611
	(0.669)	(0.692)	(1.208)	(0.508)	(0.426)	(0.730)
log(GDP$_i$)	0.241	-0.0175	0.00469	0.449**	0.00392	0.153
	(0.214)	(0.300)	(0.431)	(0.154)	(0.162)	(0.261)
log(GDP per capita$_i$)	-1.510**	-1.258*	-3.063**	-1.569**	-0.978**	-2.478**
	(0.444)	(0.649)	(0.966)	(0.344)	(0.362)	(0.646)
Observations	236	217	191	1088	1196	937
R^2	0.509	0.431	0.522	0.460	0.443	0.539

Clustered standard errors in parentheses.
Regressions include year- and bank-fixed effects.
** $p<0.05$, * $p<0.1$.