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Opinions expressed in this paper are those of the author(s) and do not necessarily reflect views of the institute.

#### IMPRESSUM

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# Financial Integration and Macroeconomic Stability: What Role for Large Banks?

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## **Abstract**

This study assesses how banking sector integration and especially cross-border lending affect macroeconomic stability. I use a two-country general equilibrium model with heterogeneous banks that are hit by idiosyncratic shocks. According to the concept of granularity, idiosyncratic shocks to large firms (or: banks) do not have to cancel out under a skewed distribution of firm sizes. Given the highly skewed distribution of bank sizes, macroeconomic stability may thus be affected by shocks to large banks. Hence, to grasp the impact of financial liberalization on aggregate fluctuations, the presence of large banks as measured by high concentration in the banking industry has to be accounted for. I study the role of different forms of banking sector integration - i.e. arms-length cross-border lending versus lending via foreign affiliates - for the stability of aggregate lending. I find that banking sector integration decreases the aggregate volatility of lending due to intensified competition. The model implies that international lending is more stable under lending via foreign affiliates than under arms-length cross-border lending.

**Keywords:** Cross-border banking, large banks, granularity, volatility.

**JEL Codes:** E44, F41, G21

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# 1 Motivation

Since the mid-1990s, the activities of Western European banks in Eastern Europe have significantly increased. Closer financial integration in Europe has basically two effects on macroeconomic stability in the region. On the one hand, it allows for better insurance against local shocks via the facilitated access to international credit. On the other hand, increased banking sector integration may raise the probability of spill-overs from adverse shocks that occur abroad.<sup>1</sup>

Taking the global financial crisis of 2008/2009 as an example for a large adverse shock hitting the banking sector, how was macroeconomic stability affected in Eastern and Western Europe? During the crisis, although Eastern European economies experienced a sharp reversal of cross-border lending, a full-fledged emerging market crisis associated with the typical sudden-stop situation held off; Western European parent banks maintained funding of their foreign affiliates in the East (EBRD, 2009). As a consequence, capital outflows from Eastern Europe were relatively modest. Cetorelli and Goldberg (2009) show that capital outflows were much larger in emerging economies like Latin America or Asia, where financial integration involves direct cross-border lending rather than the presence of foreign subsidiaries. More generally, the specific structure of banking sector integration in Europe seems to have had a positive effect on the stability of cross-border lending: Recent empirical studies point to the fact that local lending by foreign banks' presences in Eastern Europe has been more stable than direct cross-border lending (Bergloef, Korniyenko, Plekhanov, and Zettelmeyer (2009), McCauley, McGuire, and von Peter (2010), De Haas and Van Horen (2011))<sup>2</sup>. Theoretical modeling of the effects of different forms of cross-border banking on aggregate stability is still lagging behind.

[Table 1 about here.]

This study models international lending in a general equilibrium framework. The goal is to clarify the role that different forms of banking sector integration play for the

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<sup>1</sup>Contagion may occur via the interbank market as in Allen and Gale (2000) or via asset price effects as for example in Brunnermeier and Pedersen (2009). For a summary over the costs and benefits of cross-border banking, see for example Schoenmaker and Wagner (2011).

<sup>2</sup>Apart from the specific structure of integration, the "Vienna Initiative" has played a crucial role for the stabilization of capital flows between Eastern and Western Europe during the crisis. In January 2009, the IMF, the EBRD and the EC launched a series of meetings with large international banks operating in Eastern Europe. Banks agreed upon sticking to their exposures in Eastern Europe in order to prevent large withdrawals from emerging Europe. For details on the Vienna Initiative, see EBRD 2011 and Cetorelli and Goldberg (2010).

stability of aggregate credit. I distinguish direct cross-border lending and the cross-border provision of loans via foreign presences of commercial banks, that is foreign affiliates.

To understand the impact of banking sector integration on macroeconomic fluctuations, it has to be taken into account that the banking sector is highly concentrated with a few large, systemically important financial institutions (SIFIs) which are strongly involved in cross-border activity. Due to the coexistence of a small number of these very large banks and many small ones, the distribution of bank sizes is strongly skewed to the right. According to Gabaix (2011), under a fat-tailed power law distribution of firm sizes, idiosyncratic shocks to large firms do not have to cancel out, so that they may impact on aggregate volatility. In fact, Gabaix (2011) shows that idiosyncratic shocks to large firms can explain roughly one third of aggregate output fluctuations in the US.

This logic also applies to the banking industry. Using balanced panel data for the period 2000-2007 from the Bankscope database for the EU27 countries, Table 1 provides evidence for high concentration in the European banking sector. It shows that the largest 10 percent of banks in the sample hold nearly 80 percent of the assets since the mid-2000s. Evidence from the European Central Bank (ECB, 2007) points into the same direction: In 2005, 46 European banking-groups (out of a total of 8,000 banks) held nearly 70 percent of total EU banking assets. Plotting the empirical histograms for the EU27 countries, Figure 1 illustrates the bank size distribution in Europe in 2009. Bank size is measured by total assets as well as by total netloans. The bank size distributions shown here resemble a power law with a fat right tail: There are many small banks and a few very large ones which hold the majority of assets in the banking sector. We will see below that the size distributions can be well described by a Pareto distribution which follows a power law. Hence, the conditions for granularity presented by Gabaix (2011) should be met in the banking sector, too. A model which aims at examining the link between banking sector integration and volatility should thus account for the presence of large banks.

[Figure 1 about here.]

The two-country model used in this study is based on work by De Blas and Russ (2010, 2011a) who take both the market structure in the banking industry, and different forms of cross-border lending into account. They differentiate between two scenarios of international financial liberalization. On the one hand, the economy is opened up to direct cross-border lending. On the other hand, foreign direct investment (FDI) in the banking sector is allowed for, so that international lending via banks' foreign

presences can be studied. Building on this general equilibrium model, I assess, in a first step, how the two forms of integration affect the market structure in the banking industry. To that goal, I compute the banking sector's Herfindahl index to measure market concentration. The Herfindahl index is defined as the squared sum of bank's market shares, where market shares are given by the fraction of individual banks' credit supply in total credit.

In a second step, I apply the concept of granularity to the model following Di Giovanni and Levchenko (2009), in order to analyze how the change in market concentration in turn impacts on aggregate stability<sup>3</sup>. While Di Giovanni and Levchenko (2009) study the effects of *trade* integration on market structure and aggregate volatility, I focus on *financial* integration: How do shocks to large banks impact on the volatility of total and cross-border lending in the two regions? And how do the results differ for different forms of integration, namely (i) arms-length cross-border lending versus (ii) international lending via foreign subsidiaries? Buch, Koch, and Koetter (2011b) document that, unlike manufacturing firms, nearly all German banks (96%) are engaged in cross-border activities. Given the high degree of internationalization in the banking sector, a study of the effects of financial integration on macroeconomic volatility is highly relevant for the policy and regulatory debate.

Three key findings emerge from the model simulations. First, when opening up to direct cross-border lending, lending rates and concentration decrease while markups do not significantly change. Interpreting loan volumes as a proxy for banks' size, the model implies that opening up the economy to competition from abroad yields a somewhat less concentrated banking system. This, in turn, reduces the aggregate volatility of total lending, since according to the concept of granularity, the aggregate volatility of lending is determined as the product of idiosyncratic volatility and market concentration.

Second, when allowing for FDI in the banking sector, markups do not remain as under loan liberalization. They rather increase due to efficiency gains as in De Blas and Russ (2010). However, concentration and lending rates still fall when compared to the closed economy setup. Hence, the stability of total lending is again strengthened.

Third, the share of cross-border lending in total lending is smaller under FDI liberalization than under direct cross-border lending for two symmetric economies. When it comes to the stability of cross-border lending, the model implies a significantly lower volatility of cross-border lending under FDI liberalization than under arms-length cross-border lending.

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<sup>3</sup>Buch, Russ, and Schnitzer (2011a) implement the concept of granularity in a closed-economy search-model with heterogeneous banks.

The remainder of the paper is structured as follows. Section 2 lays out the benchmark model with heterogeneous banks under financial autarky. Section 3 discusses the model setup as well as the simulation results for the two forms of banking sector integration. In the first part, the implications of loan liberalization are discussed, while the findings for FDI liberalization are presented in the second part of the section. The last section concludes and suggests avenues for future research.

## 2 Benchmark: Heterogeneous banks and aggregate stability in the closed economy

Before having a look at the mechanisms at work in the two-country setup, I first consider the structure of the closed economy model as a benchmark. The general equilibrium model described below is based on work by De Blas and Russ (2010) who study the evolution of markups after financial liberalization. I adjust the model in order to study the implications of financial openness for (i) the market structure in the banking sector and (ii) for the aggregate stability of cross-border and total lending.

The model features three agents: households, firms and banks. Households consume a final good and supply labor and deposits to firms. Firms produce the final good under perfect competition using labor, and borrow a credit portfolio from banks in order to finance the wage bill paid to workers. The model replicates some important empirical regularities for the European banking industry: Banks supply different types of credit under imperfect competition<sup>4</sup>. They are heterogeneous with respect to their efficiency of lending. This heterogeneity in efficiency translates into a skewed distribution of banks' sizes as observed in the empirical data (see Figure 1).

### 2.1 Model setup

**Households.** In the model economy, there is a continuum of identical households on the interval  $[0, 1]$ . The representative consumer supplies labor,  $h_t$  in exchange for the nominal wage  $w_t$ , and deposits his savings,  $d_t$ , at the certain deposit rate  $\bar{r}$  at banks. The deposit rate is risk-free here, since full deposit insurance is assumed. Households are thus indifferent of where to deposit their savings. The consumer receives profit income from owning firms and banks,  $\Omega$  and  $\Pi$ , respectively. He consumes a single final good,  $q_t$ , which is defined as the numéraire so that its price  $p_t$  can be normalized

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<sup>4</sup>Using data for the period 1992-1996, De Bandt and Davis (2000) show that the banking industry in the Euro area is not fully competitive



to 1.

The representative consumer's optimization problem consists in maximizing life-time utility

$$u(q_t, h_t) = \sum_{t=0}^{\infty} \beta^t \left( \frac{q_t^{1-\rho}}{1-\rho} - \frac{h_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} \right)$$

subject to the budget constraint

$$d_{t+1} + q_t = (1 + \bar{r})d_t + w_t h_t + \Omega + \Pi \quad (1)$$

where  $\gamma$  is the elasticity of labor supply and  $\rho$  denotes the coefficient of relative risk aversion.

Solving the households' optimization problem with respect to the three choice variables  $q_t, h_t, d_{t+1}$  yields, together with the budget constraint (1), the following system of first order conditions for optimal consumption, labor supply and savings:

$$q_t^{-\rho} = \lambda_t \quad (2)$$

$$h_t^{1/\gamma} = \lambda_t w_t \quad (3)$$

$$\lambda_t = \beta \lambda_{t+1} (1 + \bar{r}) \quad (4)$$

where  $\lambda_t$  represents the additional utility of relaxing the budget constraint by one unit, i.e. the marginal utility of consumption.

Plugging marginal utility (2) into (4) yields the standard Euler equation

$$\left( \frac{q_t}{q_{t+1}} \right)^{-\rho} = (1 + \bar{r}) \beta \quad (5)$$

which determines the optimal intertemporal allocation of consumption. The marginal benefit of consuming one additional unit in period  $t$  equals the marginal cost of foregoing consumption in period  $t + 1$ .

To obtain labor supply, substitute (2) into (3) to get

$$q_t^\rho = w_t h_t^{-1/\gamma} . \quad (6)$$

**Firms.** The model features a continuum of identical firms on the interval  $[0, 1]$  which produce the final good,  $y$ , under perfect competition. The representative firm demands labor,  $h_t$ , and a portfolio of loans comprising  $J$  loan varieties  $\left[ \sum_1^J l^d(j)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} = l^d$ . Modeling loan demand using the Dixit-Stiglitz approach of bundling varieties is a reduced form for modeling the credit market which simplifies aggregation. Gerali, Neri, Sessa, and Signoretto (2010) and Huelsewig, Mayer, and Wollmershaeuser (2009) take a similar shortcut. Assuming that the representative firm demands a CES-basket of loan

varieties is equivalent to setting up the model such that a continuum of firms takes a single homogeneous loan from a particular bank under a discrete choice approach (see Anderson, De Palma, and Thisse (1987) and Bruggemann, Kleinert, and Prieto (2011))<sup>5</sup>. Loans are needed because firms have to pay out the wage bill to workers before they have actually earned sales revenues. Hence, the total volume of credit demanded by the representative firm amounts to its wage payments<sup>6</sup>.

Firms produce the final output good  $y$  using labor as the only input factor to the production function  $y = Ah^{1-\alpha}$ . Time subscripts are dropped in the remaining analysis as I focus on steady state analysis. The representative firm's profit maximization problem can thus be written as

$$\max_h \quad \Omega = Ah^{1-\alpha} - wh - r\ell^d$$

where  $r$  denotes the lending rate and  $\ell^d \equiv wh$ , so that

$$\Omega = Ah^{1-\alpha} - (1+r)wh.$$

The first order condition determines labor demand as a function of the aggregate lending rate and the wage rate as

$$h = \left( \frac{(1-\alpha)A}{(1+r)w} \right)^{1/\alpha}. \quad (7)$$

The optimal demand for loans from bank  $j$  results from the firm's cost minimization calculus

$$\min_{l^d(j)} \quad \mathcal{L} = \sum_1^J l^d(j)r(j) - \mu \left( \left[ \sum_1^J l^d(j)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} - \ell^d \right), \quad (8)$$

where  $\epsilon$  is the intratemporal elasticity of substitution between the  $J$  credit varieties. Derivation of the Lagrangian with respect to loan demand from bank  $j$ ,  $l^d(j)$ , yields the following first order condition

$$r(j) = \mu(\ell^d)^{1/\epsilon} l^d(j)^{-1/\epsilon}, \quad (9)$$

where  $\mu$  is the shadow price of the constraint, that is the amount that is spend more if total loan demand  $\ell^d$  increases by one unit. This amounts to the aggregate interest

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<sup>5</sup>For other general equilibrium models featuring imperfect competition in the banking sector and loan differentiation, see for example Mandelman (2010) and Ghironi and Stebunovs (2010).

<sup>6</sup>The focus of this paper is to analyze the implications of shocks to large banks for the aggregate stability of credit. Therefore, I do not explicitly model why financial intermediaries exist. The objective here is to take the observation of a skewed bank size distribution as given and study the implications for aggregate stability thereof.

rate on loans,  $r$ , such that  $\mu = r$ . Plugging  $r$  into (9) and simplifying, we obtain the demand for loans in niche  $j$

$$l^d(j) = \left[ \frac{r(j)}{r} \right]^{-\epsilon} \ell^d \quad (10)$$

with  $\ell^d = wh$ . Loan demand in niche  $j$  positively depends on total loan demand  $\ell^d$ . It negatively depends on the lending rate in niche  $j$  relative to the aggregate average lending rate  $r$ . The corresponding Dixit-Stiglitz aggregate interest rate is derived in Appendix A.1 and amounts to

$$r = \left[ \sum_1^J r(j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}.$$

**Banks.** While consumers and firms are assumed to be identical, banks are assumed to differ in terms of their efficiency and hence in their size. Similar to the modeling of the "love for variety" with Dixit-Stiglitz consumer preferences, there is a fixed number of credit niches  $j = 1, \dots, J$ . In each credit niche,  $n$  rival banks compete for supplying loans to firms. This market fragmentation is in line with the empirical evidence for European credit markets: Although international lending has steadily increased since the mid-1990s, small and medium enterprises still face significant differences in lending rates across the euro area (Allen, Beck, Carletti, Lane, Schoenmaker, and Wagner (2011)). Banks' loan differentiation can be interpreted as geographical fragmentation, or banks' specialization for specific market segments, e.g. with respect to firm size or industry (see Carletti, Hartmann, and Spagnolo (2007)). Moreover, one could think about differentiated loans as services of different type, like working capital loans versus real estate loan, or as different loan characteristics with respect to collateralization or maturity.

Banks differ in their efficiency of extending credit: Each of the  $n$  banks in niche  $j$  draws an efficiency parameter  $z_k(j)$  from a Pareto distribution

$$F(z) = Pr(z \leq y) = \frac{1 - b^\theta y^{-\theta}}{1 - \left(\frac{b}{B}\right)^\theta}$$

where  $z \in (b, B]$  is a bank's ability to transform deposits to loans. The inverse of the efficiency parameter  $z$ , namely the cost parameter  $c = 1/z$  represents any per-unit non-interest expenditure, for example the cost of management and technology or the bank's cost to monitor borrowers. The cost parameters  $c$  can take on values on the interval  $[1, \infty)$ . This ensures that the lending rate  $r(j)$  is never smaller than the deposit rate  $\bar{r}$ , since  $c \geq 1$  drives a wedge between the deposit and the loan rate. Consequently, the efficiency parameter  $z_k(j)$  can take on values on the interval  $(0, 1]$ , so that I set the

lower bound  $b$  close to zero and the upper bound  $B$  equal to one. The total cost per unit of loan amounts to  $\bar{r}c_k(j)$  where  $\bar{r}$  is the risk-free deposit rate.

In each niche  $j$ , banks have some degree of market power and compete in Bertrand fashion for loan demand, meaning that they undercut lending rates  $r(j)$  of their local rivals until the lowest-cost bank absorbs the entire loan demand  $l^d(j)$  in the niche. Ranking banks with respect to their cost draws in ascending order such that  $c_1(j) < c_2(j) < \dots < c_n(j)$ , unit costs in niche  $j$  are determined by the lowest-cost bank and are thus given by  $c_1(j) = \min \{c_k(j)\}$ .

The maximum possible markup that a bank can charge without losing all demand to its competitors from neighboring niches is given by the Dixit-Stiglitz-markup  $\bar{m} = \frac{\epsilon}{\epsilon-1}$ . However, this maximum markup can be charged only if the second best bank in niche  $j$  has a cost parameter which is sufficiently high. More precisely, the maximum markup can be charged only if  $c_2(j) \geq \bar{m}c_1(j)$ . Otherwise, the maximum markup the lowest-cost bank in niche  $j$  can charge is limited by  $c_2$  and given by the cost-ratio  $m(j) = \frac{c_2(j)}{c_1(j)}$ . As a consequence, banks' lending-to-deposit-rate spreads are endogenous and determined by the gap between the cost parameters of the first and the second best bank in each niche  $j$ .

Banks set optimal lending rates in niche  $j$  charging the endogenously determined markup over marginal costs:

$$r(j) = \min \left\{ \frac{c_2(j)}{c_1(j)}; \bar{m} \right\} \bar{r}c_1(j). \quad (11)$$

Profits consist in interest income net of funding costs

$$\Pi(j) = r(j)l^s(j) - \bar{r}d(j) \quad (12)$$

where  $l^s(j) = \frac{d(j)}{c_k(j)}$  is loan supply. Due to the cost parameter  $c \geq 1$  the higher the cost  $c_k(j)$ , the more deposits are needed to lend out a given amount  $l^s(j)$ .

Banks optimally set lending rates  $r(j)$  according to equation (11). Lending rates and wages determine loan demand  $l^d(j)$ . In equilibrium, the loan market clears, so that loan demand equals loan supply  $l^d(j) \equiv l^s(j)$ .

## 2.2 Steady State

From the consumer optimization problem, I get

$$\bar{r} = \frac{1 - \beta}{\beta} \quad (13)$$

$$h^{1/\gamma} = q^{-\rho}w \quad (14)$$

where (13) derives the constant deposit rate from the Euler equation, and (14) is labor supply in steady state.

In order to compute the steady state, all variables are expressed in terms of wages,  $w$ , and lending rates,  $r$ . Given that optimal lending rates can be computed directly from the cost parameters, the steady state values of the model variables can be obtained once they are expressed as functions of the lending rate and parameter values only. A step-by-step derivation of the steady state can be found in Appendix A.2.

Concerning aggregation, the loan basket demanded by firm  $i$  is given by the CES-aggregate over all niches  $j$ ,  $l_i^d = \left[ \sum_1^J l_i^d(j)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$ . Because firms are identical, I normalize the number of firms to  $N = 1$ . Consequently, the representative firm's loan demand  $l^d$  equals the aggregate loan volume  $\ell = \sum_i^N l_i^d = N l_i^d = l_i^d = wh$ .

Deposit markets are assumed to be perfectly competitive. Thus, the volume of deposits,  $d(j) = l(j)c_1(j)$ , results directly from optimal loan demand  $l(j)$  and costs  $c_1(j)$ . Since full deposit insurance is assumed, consumers are indifferent at which bank to place their savings. In the aggregate, total deposits are determined by the sum over all niches  $j$ ,  $D = \sum_j d(j)$ .

## 2.3 Granularity

In order to study the implications of idiosyncratic shocks to large banks for the aggregate stability of lending, I implement the concept of granularity into the model. The literature on financial frictions in general equilibrium models has so far mainly focused on frictions and shocks at the demand side of the credit market, i.e. at the level of firms<sup>7</sup>. However, shocks at the supply side of credit are at least as important for economic activity (see Gerali et al. (2010)). For example, Pesaran and Xu (2011) model a credit shock by formulating an exogenous autoregressive process for the loan to deposit ratio which is subject to an i.i.d. shock. However, in their model there is no role for heterogeneous banks and idiosyncratic shocks.

I follow Di Giovanni and Levchenko (2009) and assume that each niche  $j$  is disturbed by an i.i.d. sectoral cost-shock  $u(j)$  which shifts the economy away from its optimal equilibrium allocation. This cost shock  $u(j)$  can represent, for example, an unanticipated increase in the loan default rate in a certain market niche or geographic region. Including the shock  $u(j)$ , the marginal cost of lending is stochastic and given

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<sup>7</sup>For example, financial frictions at the firm side are motivated by the information asymmetry between borrowers and lenders which give rise to agency costs and collateral constraints for borrowers. See for example Bernanke, Gertler, and Gilchrist (1999) and Kiyotaki and Moore (1997).

by  $\bar{r}c_1(j)u(j)$ . As shown by Gabaix (2011), the economy will be granular if the distribution of bank sizes follows a power law with an exponent close to  $-1$ . In this case, the distribution has a fat tail and decays slower in the number of banks  $J$  than a normal distribution does (slower than  $J^{-(1/2)}$ ). With bank sizes following a fat-tailed power law, micro-level shocks do not cancel out in the aggregate but will be felt at the macro-level.

[Figure 2 about here.]

Figure 2 plots the empirical histograms from the Bankscope database together with the PDFs of the fitted Pareto distributions for the size distribution of banks in the EU27 countries. I also differentiate between the subgroup of Eastern and Western European countries. It can be seen that a Pareto distribution with a shape parameter  $\theta$  below one is well able to describe the bank size distributions in the EU. Given that the Pareto distribution follows a power law with shape parameter  $-\theta$ , Figure 2 provides evidence that the distribution of bank sizes in the EU indeed follows a fat-tailed power law distribution. Thus, the conditions for the European banking sector to be granular seem to be satisfied in the data.

Following Di Giovanni and Levchenko (2009) and Di Giovanni, Levchenko, and Ranciere (2010) who implement the concept of granularity in a Melitz (2003)-model of heterogeneous firms, the variance of the aggregate volume of credit is derived as follows. Credit demand for each bank is defined as

$$l(c_1, u) = \left( \frac{m \cdot c_1 \cdot u}{r} \right)^{-\epsilon} \ell = \left( \frac{m \cdot c_1}{r} \right)^{-\epsilon} \ell \underbrace{u^{-\epsilon}}_{=\tilde{u}}$$

where index  $j$  is dropped since demand dynamics are the same across all niches in the economy. Taking the expectation conditional on  $u$  and normalizing such that  $E_u[\tilde{u}] = 1$  yields

$$E_u[l(c_1, u)] = \left( \frac{m \cdot c_1}{r} \right)^{-\epsilon} \ell. \quad (15)$$

Hence, the relative deviation of credit demand from steady state is given by

$$\frac{\Delta l(c_1, u)}{E_u[l(c_1, u)]} = \frac{l(c_1, u) - E_u[l(c_1, u)]}{E_u[l(c_1, u)]} = \frac{l(c_1, u)}{E_u[l(c_1, u)]} - 1 = \tilde{u} - 1$$

and the variance of this expression is defined as

$$\text{var} \left( \frac{\Delta l(c_1, u)}{E_u[l(c_1, u)]} \right) = \text{var}(\tilde{u}) = \sigma_u^2. \quad (16)$$

The variance of the *aggregate* loan volume  $\ell$  can now be written as

$$\text{var} \left( \frac{\Delta \ell}{E_u[\ell]} \right) = \text{var} \left[ \sum_j \frac{\Delta l(c_1, u)}{E_u[l(c_1, u)]} \frac{E_u[l(c_1, u)]}{E_u[\ell]} \right] \quad (17)$$

$$= \sum_j \text{var}_u \left[ \frac{\Delta l(c_1, u)}{E_u[l(c_1, u)]} \frac{E_u[l(c_1, u)]}{E_u[\ell]} \right] \quad (18)$$

$$= \sum_j \left( \frac{E_u[l(c_1, u)]}{E_u[\ell]} \right)^2 \text{var}_u \left( \frac{\Delta l(c_1, u)}{E_u[l(c_1, u)]} \right) \quad (19)$$

$$= \sigma_u^2 \sum_j \left( \frac{E_u[l(c_1, u)]}{E_u[\ell]} \right)^2 \quad (20)$$

$$= \sigma_u^2 \cdot HHI \quad (21)$$

where  $\sigma_u^2 = \text{var}(\tilde{u})$  and  $HHI$  is the Herfindahl-index of concentration, which is defined as the sum of squared market shares. The market share of an individual bank  $j$  is given here by its share of credit in total credit. Equation (21) illustrates that the aggregate volatility of loans is the product of micro-level volatility - the variance of the sectoral shock  $u(j)$  that hits banks in each niche - and concentration measured by the  $HHI$ . Once concentration in the banking sector increases, that is if the distribution of bank sizes gets more unequal and thus the Herfindahl-index increases, shocks at the sectoral level get more important for the fluctuations of credit at the aggregate level. This is supported by empirical evidence from Buch and Neugebauer (2011) who find that idiosyncratic shocks at the bank-level have a significant impact on the volatility of aggregate lending volumes in Eastern European countries.

## 2.4 Calibration

Table 2 summarizes the parameter values used in the simulation exercises below. The elasticity of substitution between credit varieties,  $\epsilon$ , is backed-out from the maximum markups in the sample of EU27 banks. In analogy to the theoretical model, I use net interest income as a percentage of earning assets, i.e. the net interest margin, as a proxy for banks' markups<sup>8</sup>. The maximum net interest margin amounts to approximately 30 percent in the EU27 for the period 2000-2007. This yields an elasticity of substitution of  $\epsilon = \bar{m}/(1 - \bar{m}) = 1.3/0.3 = 4.3$ . Ghironi and Melitz (2005) and De Blas and Russ (2011b) lay out the theoretical conditions for the relation between the intratemporal elasticity of substitution between loan varieties,  $\epsilon$ , and the dispersion parameter of the Pareto distribution,  $\theta$ . They show that  $\theta \geq \epsilon - 1$  has to be satisfied to guarantee a

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<sup>8</sup>For the details on the relationship between the markup and the net interest margin, see De Blas and Russ (2010).

meaningful solution for the aggregate price, or in the here described setup the aggregate lending rate,  $r$ . In order to fulfill this theoretical condition, I set  $\theta = \epsilon = 4.3$  in the simulations reported below.

[Table 2 about here.]

Following Gabaix (2009), I compute bank-level volatility as the cross-sectional volatility of loan growth rates  $\Delta \ln(\text{Netloans}_{it})$ . For each year  $t = 2000 - 2007$ , I calculate the standard deviation of the growth rates of the largest 100 banks which is given by

$$\sigma_t = \left[ \frac{1}{K} \sum_{i=1}^K g_{it}^2 - \left( \frac{1}{K} \sum_{i=1}^K g_{it} \right)^2 \right]^{\frac{1}{2}}$$

where  $g_{it} = z_{it} - z_{it-1}$ ,  $z_{it} = \ln(\text{Netloans}_{it})$ , and  $K = 100$ .

Finally, I take the mean over time to get the average bank-level volatility as

$$\bar{\sigma}_i = \frac{1}{T} \sum_{t=1}^T \sigma_{it}$$

which is equal to 0.12 for the balanced panel (0.1 for the corresponding unbalanced panel) as shown in Table 3. Bank-level volatility is thus very similar to the number found by Gabaix (2009) for US manufacturing firms. As I want to concentrate on the effects of financial liberalization on granularity, I assume that the variance of bank-level shocks does not significantly change after opening up to international lending.

Table 3 shows that this assumption is mild: Bank-level volatility does not seem to change significantly after the EU-enlargement of 2004.

[Table 3 about here.]

The rest of the parameter values are standard and taken from De Blas and Russ (2010). I simulate the model 1000 times and average over the 1000 simulated economies for the results discussed in the following sections.

## 2.5 Results

Let us first have a look at the model implications for the distribution of the variables of interest. Second, the model will be extended by the concept of granularity in order to analyze the effects of a skewed distribution of bank sizes for market concentration and



the stability of aggregate lending. Table 1 presents evidence for a balanced panel of EU-banks which is purged from sample composition effects for the period 2000-2007. The numbers indicate that the average size of banks has increased over time. Concerning concentration, the top 1 percent of banks held roughly 60 percent of total EU banking assets in 2007. Furthermore, the mean-to-median ratio points to a highly skewed size-distribution with values around 5 - for a symmetric distribution, the mean-to-median ratio would equal one. The bank-level data underlines the importance of large banks in the EU and thus the potential role for granularity as a driver of aggregate fluctuations.

At the end of this section, the impact of facilitated entry into the banking sector on market concentration and aggregate volatility will be assessed under financial autarky.

### 2.5.1 The distribution of costs, markups, lending rates, and loan volumes

Figure 3 plots both the empirical probability density functions (PDFs) and the corresponding cumulative distribution functions (CDFs) for costs, markups, lending rates and the resulting loan volumes across niches  $j$ . The PDF of the costs of active banks in niche  $j$  shows that only a small fraction of active banks dispose of very low costs close to  $c = 1$ . However, the distribution of the lowest costs does not follow a power law itself. For lending rates - the product of marginal costs and markups - we observe a PDF which is somewhat skewed to the left. Its shape resembles the shape of the distribution of the lowest costs.

[Figure 3 about here.]

The distribution of loan volumes has a fat right tail and resembles the empirical distribution of loan volumes in Figure 1. Loan volumes are interpreted here as a proxy for banks' size. The model features a skewed distribution of bank sizes with the bulk of banks being small to mid-sized while some banks are very large and dispose of large market shares.

Under the Pareto-distributed efficiency parameters  $z_k(j)$ , Figure 3 reveals that markups have a Pareto-shape: The frequency of markups decays continuously as we go from low markups up to the maximum Dixit-Stiglitz markup  $\bar{m} = 1.3$ . At the maximum markup, the PDF displays a kink. The derivation of the theoretical distribution of the markup can be found in Appendix A.3. It shows that, indeed, markups follow a Pareto distribution as in Bernard, Eaton, Jensen, and Kortum (2003) which is given by

$$F(m) = Pr(M \leq m) \begin{cases} 1 - \left(\frac{1}{m}\right)^\theta & \text{if } 1 \leq m < \bar{m} \\ 1 & \text{if } m \geq \bar{m}. \end{cases} \quad (22)$$

In contrast to the distribution of markups in De Blas and Russ (2010) where efficiency parameters are drawn from a Fréchet distribution, the distribution of markups under Pareto-efficiency draws is independent of the number of rivals per niche,  $n$ . Hence, the distribution of markups should not significantly change in response to a change in the regulation of entry into the financial sector.

### 2.5.2 Increased contestability and stability in the closed economy

Which impact does regulatory policy have on the aggregate stability of lending in a closed economy? If entry barriers in the banking sector are reduced, how does the following increase in the number of rivals per niche - i.e. the increase in contestability - impact on the variance of aggregate credit?

Table 4 illustrates that as the number of rivals per niche increases from  $n = 2$  to  $n = 10$ , the Herfindahl-index falls by nearly 40 percent from 0.0275 to 0.0173. Accordingly, the volatility of aggregate loans drops by from 0.003 to 0.002 if the variance of the cost shock is set to  $\sigma_u^2 = 0.12$  as indicated by the Bankscope data summarized in Table 3. Hence, when competition gets more intense, the big banks get squeezed: Concentration in the banking sector falls, and market shares across niches become more similar. Due to the increase in competition, costs are reduced which leads to a drop in the overall lending rate  $r$ . The drop in lending rates makes borrowing cheaper for firms, such that aggregate loan demand increases.

[Table 4 about here.]

Note that in a setting with *constant* Dixit-Stiglitz markups  $\bar{m} = \frac{\epsilon}{\epsilon-1}$  as for example in Di Giovanni and Levchenko (2009), both aggregate lending rates,  $r$ , and concentration,  $HHI$ , are higher for each level of competition than in the setup with endogenous markups here. Loan volumes are lower, accordingly. As long as  $u(j)$  represents a *sectoral* shock, granularity is equally likely to hold in an economy with constant Dixit-Stiglitz markups and in an economy with endogenous markups as the one presented here. This is because in both kinds of models, sectoral cost shocks  $u(j)$  can be fully passed onto firms since all banks in a niche are affected by the shock alike. Thus, bank-level volatility is transmitted directly to the rest of the economy, because lending rates  $r(j)$  change in response to micro-level shocks. Hence, there should be a link between sectoral and aggregate volatility in both model setups.

However, *idiosyncratic* cost shocks that hit active banks are absorbed by lower markups in those niches where the markup is less than the Dixit-Stiglitz markup. Only in those niches where  $m(j) = \bar{m}$  will banks be able to pass on a change in their

cost parameters. The theoretical distribution of markups (equation (63)) shows that the probability of observing the maximum markup,  $Pr[m(j) \geq \bar{m}] = 1 - Pr[m(j) < \bar{m}] = \bar{m}^{-\theta}$ , decreases in the dispersion-parameter  $\theta$ . As dispersion increases ( $\theta$  falls) and banks' efficiency levels vary over a larger range, the probability of observing the maximum markup increases. This in turn raises the probability for granularity to hold. Moreover, the smaller the number of active banks in the economy,  $J$ , the more likely is the economy to be granular.

In contrast to this, all banks can entirely pass through cost shocks in a world with constant markups. Consequently, idiosyncratic shocks are transmitted to the rest of the economy to a smaller extent if markups are endogenous and if dispersion is low. The economy is thus less likely to be granular than an economy featuring constant markups.

### 3 Opening up to international lending: The two-country model

Having seen the key features and implications of the model under financial autarky, let us now have a look at the model implications for the effects of cross-border banking on the stability of aggregate lending. Recent empirical evidence points to the fact that, generally, the presence of foreign banks has strengthened financial sector stability in emerging economies (for a survey, see Cull and Martinez Peria (2010)). However, the specific organizational form of cross-border banking activities differs across regions. While Eastern European economies host a large amount of multinational banks which established local affiliates in the region, emerging economies in Latin America and Asia rather receive capital inflows in the form of direct cross-border lending. Empirical evidence suggests that the organizational form of international banking is important for aggregate stability: During the global financial crisis, capital outflows from emerging Europe were less severe than those from other emerging markets (see e.g. Herrmann and Mihaljek (2010)).

The present section theoretically discusses the effects of these two forms of banking sector integration on aggregate stability. First, the case of arms-length cross-border lending will be analyzed. In this scenario, loan liberalization is modeled such that domestic banks in each credit niche  $j$  face not only competition from their  $n - 1$  domestic rivals, but also from the  $n$  foreign rival banks that produce the corresponding credit variety  $j$  abroad. Second, the case of FDI in the financial sector, i.e. foreign bank presence, will be assessed. In this setup, foreign banks may merge with domestic ones

in their niche  $j$ , so that local lending via foreign subsidiaries of multinational banks is allowed for. This scenario reflects the dominant type of cross-border banking in Europe where Eastern European countries host multinational banks from Western Europe. For both liberalization scenarios, the stability implications of increased financial integration will be assessed using the theoretical model with banks of different size.

### 3.1 Loan Liberalization: Direct cross-border lending

The model economy is now opened up to cross-border activity. There are two regions, country  $H$  and country  $F$ , that are linked via financial markets, namely by direct cross-border lending between banks and firms. The model structure for the case of loan liberalization is illustrated in Figure 4. The two economies are setup as under financial autarky. However, banks in each niche face higher competition as they compete with foreign banks now.

[Figure 4 about here.]

#### 3.1.1 Model setup and equilibrium under loan liberalization

Let us concentrate for now on two symmetric countries  $H$  and  $F$ . In both countries, banks draw their efficiency parameters from a Pareto distribution as before, so that we can rank banks according to their efficiency (or:cost) draws which allows to single out the two lowest-cost banks in each country, namely  $c_{1h}(j)$  and  $c_{2h}(j)$  in country  $H$  and  $c_{1f}(j)$  and  $c_{2f}(j)$  in country  $F$ . Now, as all banks that offer variety  $j$  compete with each other, a new cost structure evolves in both countries after loan liberalization. Opening up the economy to international lending is thus similar to an increase in the number of rivals per niche,  $n$ , which was studied for the autarky-case above.

The lowest-cost bank in each country is determined by taking the minimum of the cost of the best domestic bank and the best foreign bank. The latter incurs an additional cost due to distance,  $\delta_i \geq 1$ . Buch (2005, 2003) shows that foreign lending is more costly than domestic lending due to additional costs that arise from information gathering in the foreign market and differences in regulatory frameworks. Including the additional cost from lending abroad, the cost parameter of the bank that supplies the whole niche  $j$  in country  $i$  is given by  $c_{1h}^{LL} = \min \{c_{1h}, \delta_f c_{1f}\}$  and analogously for country  $F$ . The second best bank in each niche in country  $H$ , which limits the size of the markup that can be charged by the active bank, is determined by  $c_{2h}^{LL} = \min \{\max [c_{1h}, \delta_f c_{1f}], \min [c_{2h}, \delta_f c_{2f}]\}$ . Thus, bank  $j$  can supply credit in zero, one, or

two niches depending on its cost relative to its foreign competitor and the distance factors  $\delta_h, \delta_f$ .

Using the new cost structure in both countries, markups and lending rates are computed as in the autarky case above. Note that if the distance factors are the same in both countries and if they are equal to one, i.e. if banks can lend to firms abroad at no additional cost, costs and hence markups and lending rates are exactly the same in both countries. The best bank always supplies the entire market  $j$ , that is in both Home and Foreign, and is limited in its setting of the markup by the second internationally best bank.

In order to derive loan volumes in general and volumes of cross-border lending in particular, the steady state of the model has to be solved for. Solving for the equilibrium prices and quantities works in analogy to the autarky case. However, the consumer budget constraints are extended by profits banks make abroad and amount to

$$\begin{aligned} q_h &= w_h h_h + \Omega_h + \Pi_h^h + d_h \bar{r}_h + \Pi_h^f - \Pi_f^h \\ q_f &= w_f h_f + \Omega_f + \Pi_f^f + d_f \bar{r}_f + \Pi_f^h - \Pi_h^f \end{aligned}$$

where  $\Pi_f^h$  are profits made by foreign banks in  $H$  while  $\Pi_h^f$  are profits made by home banks in  $F$ . The balance of payments can be written as

$$nx_h = q_h^f - q_f = \Pi_f^h - \Pi_h^f$$

and goods market clearing in the open economy is given by

$$y_i = q_i + nx_i$$

for country  $i = H, F$ . Hence, an export surplus in  $H$  is financed by positive net profits of foreign banks operating in  $H$ . If banks' profits are different in  $H$  and in  $F$ , then trade does not have to be balanced.

The equilibrium allocation in the open economy can be determined by proceeding in three steps.

*Step 1.* Firms' labor demand is determined as in the autarky case since labor is assumed to be immobile across countries. Hence, take equation (7) for  $h_h$  and analogously for the foreign country for  $h_f$ .

Deposits in each niche are determined by

$$d_i(j) = l_i(j) c_{1i}(j) = \left( \frac{r_i(j)}{r_i} \right)^{-\epsilon} w_i h_i c_{1i}(j)$$

for  $i = H, F$ .

*Step 2.* Aggregate firms' profits are then given by

$$\Pi_i^F = A_i h_i^{1-\alpha} - w_i(1+r_i)h_i$$

while banks' profits have to be aggregated over all niches and we distinguish between domestic and foreign profits.

$$\begin{aligned}\Pi_h^h(j) &= r_h(j) \left( \frac{r_h(j)}{r_h} \right)^{-\epsilon} w_h h_h - \bar{r}_h d_h(j) \\ \Pi_f^h(j) &= r_f(j) \left( \frac{r_f(j)}{r_f} \right)^{-\epsilon} w_f h_f - \bar{r}_f d_f(j)\end{aligned}$$

and analogously for  $\Pi_f^h(j)$  and  $\Pi_h^f(j)$ . Note that since the best bank in niche  $j$  - either from  $H$  or from  $F$  - may supply credit in *both* countries, deposits for credit supply in niche  $j$  are supplied locally as they are entirely determined by credit demand and the cost of the best bank. If there are no additional costs from lending abroad, i.e. if  $\delta_h = \delta_f = 1$ ,  $c_1^{LL}(j)$  is the same in both  $H$  and  $F$ . Consequently, deposits are determined by local credit demand so that  $d(j) = l(j)c_1^{LL}(j)$  and  $d^*(j) = l^*(j)c_1^{LL}(j)$ .

*Step 3.* Next, bank profits as well as deposits are aggregated over all niches  $j$ . Hours worked, output and firm profits do not have to be aggregated any further as we assume firms to be identical and can hence consider one representative firm only.

Finally, take the consumer budget constraints and substitute equation (6) for  $q$

$$\left( w_h h_h^{-1/\gamma} \right)^{\frac{1}{\rho}} = w_h h_h + d_h \bar{r}_h + \Omega_h + \Pi_h^h + \Pi_h^f - \Pi_f^h \quad (23)$$

$$\left( w_f h_f^{-1/\gamma} \right)^{\frac{1}{\rho}} = w_f h_f + d_f \bar{r}_f + \Omega_f + \Pi_f^f + \Pi_f^h - \Pi_h^f \quad (24)$$

so that we end up with a system of two equations in the two unknown wage rates  $w_h$  and  $w_f$ . The system is solved using a non-linear equation solver.

### 3.1.2 Simulation results

Figure 5 plots the distribution of the variables of interest for the loan liberalization scenario against the benchmark of a closed economy. A look at the CDFs reveals that the autarky-case stochastically dominates the loan liberalization scenario for costs, markups, and lending rates. That is, the probability of observing high realizations of these three variables is higher in autarky than in the open economy with direct cross-border lending. Hence, both costs and lending rates decline under loan liberalization. This can also be seen from the PDFs where the probability mass shifts to left, i.e. towards lower cost-realizations. The simulation results show that approximately 50

percent of the 1000 average markups are lower after opening up the economy for international lending. All 1000 average lending rates are lower under liberalization in both  $H$  and  $F$ , so that firms are better off under internationally integrated loan markets.

Concerning the lending volumes, the PDF in Figure 5 illustrates that they do not change by much after liberalization. The distribution is somewhat more tilted towards its mean: middle realizations are observed somewhat more frequently while the very large realizations get a little less frequent. Interpreting loan volumes as a proxy for banks' size, we obtain that opening up the economy to international lending yields a somewhat more equal distribution of bank sizes and hence less concentration. This is similar to what we observed for the closed economy when increasing contestability in the banking sector. The small change in lending volumes results from the fact that both, sectoral lending rates,  $r(j)$ , and aggregate the lending rate  $r$  fall after liberalization while the total demand for loans by the representative firm, i.e. the wage bill, is not significantly altered after liberalization. As a consequence, we do not see much of a change in the distribution of sectoral loan demand  $l(j)$ . Overall, aggregate credit slightly increases after loan liberalization in all of the 1000 simulated economies with a rise of 1% on average.

Concentration marginally decreases after opening up the economy to foreign lending, as in the simulation for intensified competition in the closed economy. Consequently, the aggregate volatility of total lending in both countries is reduced if international lending is allowed for.

[Figure 5 about here.]

When it comes to cross-border lending, the model implies that half of the niches in each country are supplied by foreign banks if countries are symmetric and if banks do not incur any additional costs when lending abroad. At the same time, the share of cross-border lending in total lending is smaller with approximately 44 percent, meaning that foreign banks supplying market niches abroad are smaller (have smaller lending volumes in the foreign market) than domestic banks, on average. Finally, having a look at the stability of aggregate cross-border lending, I find that the latter is significantly more volatile than total lending. This is due to the fact that concentration is higher in the sample of banks that are internationally active than for the whole sample of banks.

If it is costly for banks to lend abroad, e.g. due to transaction or information costs related to international lending, and hence the distance factor is larger than one, the share of niches as well as the share of cross-border lending in total lending decreases in the two countries. For example, if both countries face distance costs of 10 percent, the fraction of niches supplied by foreign banks drops from 50 percent down to 40

percent while the share of cross-border credit flows in total credit even drops to about 30 percent.

Moreover, if transaction costs increase and the volume of cross-border lending falls, the volatility of cross-border lending rises, thus making international capital flows less stable. Consequently, in order to stabilize cross-border lending flows, regulatory policies should be harmonized across countries such that distance costs are reduced: The smaller the cost of lending abroad, the higher are competitive pressures from financial liberalization and thus the more stable are cross-border credit flows.

An increase in contestability, i.e. in the number of rivals in each country, has qualitatively the same effects as under financial autarky. It reduces lending rates, concentration and hence volatility and raises aggregate lending volumes. Regulatory policy should thus reduce the barriers to entry in the banking sector in order to foster competition and hence stability.

### 3.2 FDI in the banking sector

In contrast to the scenario with direct cross-border lending, the following setup looks at a world where banks in each niche can merge with foreign banks which are active in the same market niche  $j$  abroad. Hence, multinational banks extend credit via local subsidiaries and branches in the foreign country. This scenario mirrors the dominating form of financial integration in Europe.

Vander Vennet (2003) presents empirical evidence for Europe that the best, i.e. the most productive foreign banks tend to takeover the best domestic banks in each market segment. Empirical findings by Bonin, Hasan, and Wachtel (2005a,b) point into the same direction: Foreign-owned banks in European transition economies are found to be more cost-efficient than domestic ones. Based on these findings, foreign takeovers are modeled as follows. Having drawn their efficiency parameters from the Pareto-distribution as before, the best international bank in niche  $j$  takes over the best bank in niche  $j$  abroad by paying a takeover fee which is sufficiently high to make the target bank at least as well off as without the merger. The merged bank then serves the foreign market under a new, mixed cost  $c_1^M(j) = c_{1f}(j)^{1/\delta_{FDI}} c_{1h}(j)^{1-(1/\delta_{FDI})}$  given that it cannot entirely establish its production technology abroad. The domestic market of the parent bank is served under the same cost as before, namely at  $c_1$ . As it is only meaningful that active banks merge, i.e. the lowest-cost ones, the cost structure of the second-best banks remain the same as under autarky. Overall, costs decrease when opening up the economy to foreign mergers and acquisitions, because costs either remain at  $c_1(j)$  or drop down to  $c_1^M(j)$ .



### 3.2.1 Model setup and equilibrium under FDI liberalization

The open economy equilibrium under FDI liberalization can be solved for very similarly to the loan liberalization case. The only difference concerns takeover fees which are paid to the target bank by the lowest cost bank in niche  $j$ , i.e. the parent bank of the merger.

Following De Blas and Russ (2010), the buyout price offered to the target has to be at least as big as the profit the target bank would earn without merging in the open economy. Both the parent and the target take interest rates under FDI liberalization in all other niches as given. The resulting buyout fee in niche  $J$  is then given by

$$\begin{aligned} V(j) &= wh \max \left\{ r^{aut}(j) \left( \frac{r^{aut}}{r_{fdi}} \right)^{-\epsilon} - \bar{r} C_1(j) \left( \frac{r^{aut}}{r_{fdi}} \right)^{-\epsilon}, 0 \right\} \\ &= \max \{ [r^{aut}(j) - \bar{r} C_1(j)] l^d(j), 0 \} \end{aligned}$$

where  $r^{aut}(j)$  is the autarky-lending rate that the home bank would charge if there were no takeovers at all while  $r_{fdi}$  is the aggregate lending rate that the market participants take as given under FDI-liberalization where takeovers take place whenever  $C_{1i}(j) < C_{1k}(j)$ , where  $i, k = F, H$  and  $i \neq k$ .

Moreover, the consumers' budget constraints now include profits net of the aggregated takeover fees  $V_h$  and  $V_f$ :

$$\begin{aligned} q_h &= w_h h_h + \Omega_h + \Pi_h^h + d_h \bar{r}_h + \Pi_h^f - \Pi_h^h + V_h - V_f \\ q_f &= w_f h_f + \Omega_f + \Pi_f^f + d_f \bar{r}_f + \Pi_f^h - \Pi_f^f + V_f - V_h \end{aligned}$$

and hence net exports can be expressed as

$$\begin{aligned} nx_h &= (\Pi_f - V_h) - (\Pi_h^f - V_f) \\ nx_f &= (\Pi_h^f - V_f) - (\Pi_f^h - V_h) \end{aligned}$$

The aggregate resource constraint,  $y + y^*$ , is fulfilled if

$$y_h + y_f - (w_h h_h + w_f h_f + \Omega_h + \Pi_h^h + \bar{r}_h d_h + nx_h + \Omega_f + \Pi_f^f + \bar{r}_f d_f + nx_f) = 0.$$

Since  $V_h$  and  $V_f$  appear in both the consumers' budget constraints  $q_h, q_f$  and the expression for net exports  $nx_h, nx_f$ , they cancel out in the aggregate resource constraints. Thus, the resource constraints are the same in the loan liberalization and in the FDI scenario.

### 3.2.2 Simulation results

Figure 6 compares the distribution of costs, markups, lending rates and lending volumes under FDI liberalization to the case of financial autarky. It shows that, for the lowest costs, the closed economy case stochastically dominates the CDF under FDI liberalization, whereas for the markup, the CDF under FDI dominates the CDF under autarky. Intuitively, this means that markups increase under liberalization towards FDI in the financial sector. This is explained as follows. In those niches where the markup in the closed economy is maximal, i.e.  $m(j)^{AUT} = \bar{m}$ , it will remain the same when FDI is allowed for. This is because the spread between the lowest and the second lowest cost stays at least equal or gets bigger under FDI, and  $m(j)$  is already at the optimal Dixit-Stiglitz level which only depends on the constant elasticity of substitution between varieties,  $\epsilon$ . In those niches where the markup in the closed economy is smaller than the Dixit-Stiglitz markup  $\bar{m}$ , it stays the same or increases after FDI liberalization, since the cost of the merged bank is smaller than the cost under autarky ( $c_1^M(j) < c_1(j)$ ), so that the spread between  $c_2(j)$  and the lowest cost grows. Hence,  $m(j)^{FDI}$  is either the same as  $m(j)^{AUT}$  or it is larger, implying that average markups must increase. In fact, all of the 1000 average markups are higher under FDI liberalization.

[Figure 6 about here.]

For the lending rate, however, the CDFs for the FDI and the autarky-case are nearly identical. There is no single average lending rate which is higher after allowing for FDI in the banking sector. Thus, firms do not incur higher financing costs even though markups increase. For those niches where the maximum markup has been charged under autarky already, lending rates are given by  $r(j) = c_1(j)\bar{m}\bar{r}$  which implies that borrowing in those niches may get cheaper as  $c_1^M(j) < c_1(j)$ . In the other niches where markups have been less than the maximum, FDI liberalization has no effect on lending rates, given that lending rates are determined by  $r(j) = c_2(j)\bar{r}$  and  $c_2(j)$  stays the same. Hence, the overall lending rate  $r$  will fall a little after FDI liberalization due to the niches where  $\bar{m} = m^{AUT}(j)$ , but it cannot increase, since in the remaining niches, it stays the same as in the closed economy given that  $c_2$  is the same as before.

Figure 7 contrasts the distributions under FDI liberalization with those under loan liberalization and under financial autarky. The distributions of costs point to the fact that banks are least efficient under autarky. As the economy is opened up to international lending, active banks in each niche get more efficient. If banks do not incur additional costs when lending abroad, costs are lowest under loan liberalization, while under FDI, costs are reduced compared with autarky, but less than under direct

foreign lending since merged banks supply under the mixed cost  $c_1^M(j) > c_1^{LL}(j)$ .

Concerning markups, Figure 7 illustrates that the distribution under FDI stochastically dominates the ones under autarky and under direct cross-border lending. Hence, markups are highest under FDI. However, the increased markups after foreign takeovers have no negative implications for the lending costs of firms. Lending rates under FDI are even a little lower than under autarky. Lending rates either decrease under FDI liberalization (if  $m(j) = \bar{m}$ ) or stay the same and thus reduce firm's financing costs. Why can markups be higher under FDI at the same lending rate as under autarky? The increase in markups is due to the fact that efficiency of the best banks in each niche picks up while the second best rival's cost stays the same. Consequently, the gap between the best and the second best bank in niche  $j$  grows which automatically allows for higher markups.

[Figure 7 about here.]

Let us now have a look at the effects of FDI liberalization on macroeconomic stability. Setting the distance factor under FDI,  $\delta_{FDI}$ , equal to 2 for both countries  $H$  and  $F$ , the simulation results show that the volatility of aggregate credit decreases after opening up the economy to foreign takeovers. This is driven by the fact that the Herfindahl-index drops by roughly 10 percent when opening up. However, concentration drops less than under the loan liberalization scenario, because lending rates drop by less under FDI liberalization.

However, the patterns of cross-border lending are different under loan liberalization and FDI. Even if we set the parameter values such that the share of niches supplied by foreign banks is one half in both scenarios (if  $\delta_h = \delta_f = 1$ ), the share of cross-border lending in total lending is significantly smaller under FDI with 20 percent compared to 40 percent under loan liberalization. Hence, foreign banks are smaller under FDI, meaning that their loan volumes are smaller than the loan volumes of foreign banks under direct cross-border lending. This is due to the fact that lending rates drop by more under loan liberalization and hence credit demand is higher than under direct cross-border lending than under FDI.

Another point that can be made when comparing financial stability under loan versus FDI liberalization concerns the different evolution of markups. Following the "concentration-stability hypothesis" (see e.g. Beck, Demirguc-Kunt, and Levine (2006)), the increase in markups under FDI liberalization increases the resistibility of banks against adverse shocks: Higher markups increase banks' profits and thus provide a buffer against adverse shocks. Furthermore, higher markups increase the bank's charter value which reduces its incentives to take excessive risks. This in turn reduces

the probability of systemic banking crisis and thus supports stability in the financial system. In addition to this, in the model used here, an increase in markups does *not* correspond to an increase in concentration and increased lending rates. Following the argument by Boyd and De Nicolò (2005), as lending rates do not rise, there are no incentives for firms to assume greater risk. The model above thus establishes a negative link between concentration and stability. As concentration decreases, the volatility of lending decreases so that stability is enhanced. Overall, increased markups may be an additional argument for higher stability under FDI liberalization compared to direct cross-border lending. Increasing contestability in the FDI scenario has qualitatively the same effects as in the benchmark case of financial autarky. Lending rates, concentration and hence the aggregate volatility of credit decreases in the degree of contestability,  $n$  while loan volumes increase. Markups do not significantly change as shown by the theoretical distribution of markups which is independent of the level of contestability.

Compared to the scenario with direct cross-border lending and no distance costs ( $\delta_f = \delta_h = 1$ ), the volatility of total loans is the same under FDI, while the volatility of cross-border lending is a little higher under loan liberalization (even though the share of cross-border in total lending is higher under loan liberalization). Once distance costs of 10 percent are introduced in the loan liberalization scenario ( $\delta_f = \delta_h = 1.1$ ), this pattern is reinforced: With foreign mergers and acquisitions, the volatility of cross-border lending is just one third the volatility under arms-length international lending, depending on the degree of contestability. Moreover, the share of cross-border lending under FDI is up to five times the share under loan liberalization with 10-percent distance costs. The more intense competition, the larger the difference between the shares of cross-border lending under FDI versus loan liberalization.

Thus, foreign lending via local subsidiaries is more stable than arms-length cross-border lending in the model. This pattern is in line with the empirical evidence from the financial crisis. Parent banks from Western Europe engaged in Eastern Europe stucked to their foreign affiliates and did not reduce cross-border lending by as much as banks handing out cross-border loans directly<sup>9</sup>.

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<sup>9</sup>Even though the financial crisis was triggered by a common shock to the financial sector, individual banks were differently affected due to different exposures to the US-subprime market (see Buch, Eickmeier, and Prieto (2010)). Hence, the common shock affected banks differently at the idiosyncratic level.

## 4 Conclusion

The aim of this paper is to analyze the role that large banks play for the stability of aggregate total and cross-border lending. In order to understand the microeconomic background for macroeconomic stability in the context of banking sector integration, I employ a general equilibrium model with heterogeneous banks which lend to firms under imperfect competition. The model by De Blas and Russ (2010) is extended to account for the concept of granularity which links volatility at the bank-level to aggregate outcomes.

The simulation results point to the fact that banking sector integration involving a fat-tailed bank size distribution *lowers* the volatility of aggregate lending. Hence, considering the channel of granularity at the level of loan volumes only, financial integration seems to foster macroeconomic stability. Comparing direct cross-border lending to FDI in the banking sector, the model implies more stable cross-border lending flows under the latter form of integration. This model outcome is in line with the empirical evidence on the stability implications of different forms of banking sector integration: Liberalization towards FDI in the banking leads to more stable lending than cross-border lending at arms-length does.

The model may thus inform the current debate on changes in the international regulation of the banking sector. Looking at the effects of shocks to large banks on the stability of cross-border lending only, the theoretical results suggest that banking sector integration and the associated international capital flows reduce concentration and support aggregate stability. Hence, in the model setup presented above, the introduction of capital controls by emerging market economies would not be welfare-enhancing. More generally, financial protectionism which reduces overall cross-border activity would lead to less contestability in the above presented framework and would thus have a negative effect on the aggregate stability of lending. However, it has to be kept in mind that there are other important mechanisms which affect the stability of cross-border lending. For instance, adverse shocks to one region may spill-over to other regions via asset price effects, interbank markets or changes in risk perceptions. These additional channels of contagion are not modeled here.

There are several tasks that could be addressed in future research. In the model above, I only study how shocks to changes in loan volumes - i.e. variations at the intensive margin - affect the aggregate stability of credit. However, the exit and entry of banks may be important for macroeconomic stability. It may thus be an interesting avenue for future research to follow the lines of Di Giovanni, Levchenko, and Méjean (2011) who study the role of individual firms in generating aggregate fluctuations: The

authors combine a strand of the literature which addresses the link between the extensive margin and aggregate fluctuations (see for example Ghironi and Melitz (2005) and Bilbiie, Ghironi, and Melitz (2007)) with the granularity literature. It may be instructive to investigate how both variation at the intensive and at the extensive margin of lending impact on the aggregate stability of credit. Moreover, including the extensive margin in the model above may be a promising starting point to study the internationalization patterns of banks by allowing for different fixed costs of entry for domestic and foreign markets as in Helpman, Melitz, and Yeaple (2004) for heterogeneous firms.

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## A Appendix

### A.1 Derivation of the Dixit-Stiglitz aggregate interest rate

Knowing that aggregate loan demand is given by  $\ell^d = \left[ \sum_1^J l^d(j)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$ , take (9) to the power of  $-(\epsilon-1)$  to get  $l^d(j)^{\frac{\epsilon-1}{\epsilon}}$ :

$$r(j)^{-(\epsilon-1)} = r^{-(\epsilon-1)} (\ell^d)^{\frac{-\epsilon-1}{\epsilon}} l^d(j)^{\frac{\epsilon-1}{\epsilon}} . \quad (25)$$

Now, take the sum from 1 to  $J$  over (25) to get

$$\sum_1^J r(j)^{-(\epsilon-1)} = r^{-(\epsilon-1)} (\ell^d)^{\frac{-\epsilon-1}{\epsilon}} \sum_1^J l^d(j)^{\frac{\epsilon-1}{\epsilon}} \quad (26)$$

and isolate  $r$  by taking the above equation to the power of  $-\frac{1}{\epsilon-1}$ :

$$\left[ \sum_1^J r(j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} = r (\ell^d)^{\frac{1}{\epsilon}} \underbrace{\left[ \sum_1^J l^d(j)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{1}{1-\epsilon}}}_{(\ell^d)^{-1/\epsilon}} \quad (27)$$

$$\Leftrightarrow \left[ \sum_1^J r(j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} = r \underbrace{(\ell^d)^{1/\epsilon} (\ell^d)^{-1/\epsilon}}_{=1} \quad (28)$$

$$\Leftrightarrow r = \left[ \sum_1^J r(j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \quad (29)$$

### A.2 Steady State in the closed economy

As a first step, compute labor supply  $h^s$  as a function of the wage rate  $w$ . For this goal, substitute  $q$  from the labor supply equation (14) and  $y$  from the production function in the aggregate resource constraint  $y = q$  and solve for  $h(w)$ :

$$y \equiv q \quad (30)$$

$$Ah^{1-\alpha} = w^{1/\rho} h^{-\frac{1}{\gamma\rho}} \quad (31)$$

$$h^{\frac{(1-\alpha)\gamma\rho+1}{\gamma\rho}} = w^{1/\rho} A^{-1} \quad (32)$$

$$h^s = w^{\frac{\gamma}{(1-\alpha)\gamma\rho+1}} A^{-\frac{\gamma\rho}{(1-\alpha)\gamma\rho+1}} \quad (33)$$

set  $1 + (1 - \alpha)\gamma\rho = x$  and substitute to get

$$h^s(w) = w^{\frac{\gamma}{x}} A^{-\frac{\gamma\rho}{x}} . \quad (34)$$

As a second step, compute the wage  $w$  as a function of the aggregate lending rate  $r$ :

$$h^d(w) \equiv h^s(w) \quad (35)$$

$$\left[ \frac{(1-\alpha)A}{(1+r)w} \right]^{1/\alpha} = w^{\frac{\gamma}{x}} A^{-\frac{\gamma\rho}{x}} \quad (36)$$

$$w^{\frac{x+\alpha\gamma}{\alpha x}} = A^{\frac{x+\alpha\gamma\rho}{\alpha x}} \left[ \frac{1-\alpha}{1+r} \right]^{1/\alpha} \quad \text{take } (\dots)^{\frac{\alpha x}{x+\alpha\gamma}} \quad (37)$$

$$w = w(r) = A^{\frac{x+\alpha\gamma\rho}{\alpha\gamma+x}} \left[ \frac{1-\alpha}{1+r} \right]^{\frac{x}{\alpha\gamma+x}} \quad (38)$$

$$\Leftrightarrow w(r) = A^{\frac{1+\gamma\rho}{\alpha\gamma+x}} \left[ \frac{1-\alpha}{1+r} \right]^{\frac{x}{\alpha\gamma+x}}. \quad (39)$$

Step three consists in substituting  $w$  into labor supply (34) to get employment as a function of  $r$ .

$$h = \left[ A^{\frac{1+\gamma\rho}{\alpha\gamma+x}} \left[ \frac{1-\alpha}{1+r} \right]^{\frac{x}{\alpha\gamma+x}} \right]^{\frac{\gamma}{x}} A^{-\frac{\gamma\rho}{x}} \quad (40)$$

$$\Leftrightarrow h(r) = \left[ \frac{1-\alpha}{1+r} \right]^{\frac{\gamma}{\alpha\gamma+x}} A^{\frac{(1+\gamma\rho)\gamma}{(x+\alpha\gamma)x} - \frac{\gamma\rho}{x}} \quad (41)$$

Further simplify the exponent of  $A$ :

$$\frac{(1+\gamma\rho)\gamma - \gamma\rho(x+\alpha\gamma)}{(x+\alpha\gamma)x} = \frac{\gamma[(1+\gamma\rho) - \rho(x+\alpha\gamma)]}{x(x+\alpha\gamma)} \quad (42)$$

and rewrite the nominator as

$$\gamma [1 + \gamma\rho - \rho - (1-\alpha)\gamma\rho^2 - \rho\alpha\gamma] \quad (43)$$

$$= \gamma \left[ \underbrace{1 + \gamma\rho(1-\alpha)}_x - \rho \underbrace{(1 + (1-\alpha)\gamma\rho)}_x \right] \quad (44)$$

$$= \gamma [(1-\rho)x]. \quad (45)$$

Hence, the employment equation (41) simplifies to

$$h = \left[ \frac{1-\alpha}{1+r} \right]^{\frac{\gamma}{\alpha\gamma+x}} A^{\frac{\gamma(1-\rho)}{x+\alpha\gamma}}. \quad (46)$$

Finally, plug  $h(r)$  into production  $y$  to get  $y = q$  as a function of  $r$ :

$$y = Ah^{1-\alpha} = A \left( \left[ \frac{1-\alpha}{1+r} \right]^{\frac{\gamma}{\alpha\gamma+x}} A^{\frac{\gamma(1-\rho)}{x+\alpha\gamma}} \right)^{1-\alpha} \quad (47)$$

$$\Leftrightarrow y(r) = \left[ \frac{1-\alpha}{1+r} \right]^{\frac{\gamma(1-\alpha)}{\alpha\gamma+x}} A^{1+\frac{\gamma(1-\rho)(1-\alpha)}{x+\alpha\gamma}} = q(r) \quad (48)$$

The lending rate  $r$  is determined above in the duopolistic competition problem from each niche  $j$  (see equation (11)).

### A.3 Distributions of model variables

Each bank draws its  $c_k(j)$  from an i.i.d. bounded Pareto function of the form

$$F(z) = \frac{1 - b^\theta z^{-\theta}}{1 - \left(\frac{b}{B}\right)^\theta} \quad (49)$$

with support  $(0, 1]$  as the minimum of  $z$  equals  $b = 0.1$  and the maximum is fixed at  $B = 1$ . It implies that the marginal cost of loaning out 1 *EUR*,  $c = 1/z$ , is greater than the deposit rate  $\bar{r}$ , i.e. that  $c > 1$ . Hence, the probability that  $c < 1$ ,  $F(z > 1) = 0$ .

How to draw cost-parameters from the Pareto function

$$F(1/c) = Pr(1/c \leq y) = 1 - \left(\frac{b}{y}\right)^\theta = 1 - (bc)^\theta \quad (50)$$

$$(bc)^\theta = 1 - F(1/c) \quad (51)$$

$$c = \frac{1}{b} \left[ \underbrace{1 - F(1/c)}_{=y \in [0,1]} \right]^{1/\theta} \quad (52)$$

Parameter values:  $b = 0.1$  as in Di Giovanni and Levchenko (2009),  $\theta = 4.3$ ,  $\epsilon = 4.3$ .

How to draw cost-parameters from the *bounded* Pareto function

Since the cost parameter  $c$  needs to be greater or equal to 1, the support of the efficiency parameter  $z = 1/c$  is limited to  $z \in (0, 1]$ . Hence, the Pareto distribution needs to be limited with the lower bound  $b = 0.1$  as above and an upper bound  $B = 1$ . The corresponding bounded Pareto function is given by

$$F(1/c) = Pr(1/c \leq y) = \frac{1 - b^\theta y^{-\theta}}{1 - \left(\frac{b}{B}\right)^\theta} \quad (53)$$

$$= \frac{1 - b^\theta c^\theta}{1 - \left(\frac{b}{B}\right)^\theta} \quad (54)$$

$$c = \frac{1}{b} \left\{ 1 - \left[ 1 - \left(\frac{b}{B}\right)^\theta \right] F(1/c) \right\}^{1/\theta} \quad (55)$$

Parameter values:  $b = 0.1$ ,  $B = 1$ ,  $\theta = 4.3$ ,  $\epsilon = 4.3$ .

Distribution of the cost parameter  $c$

We have that efficiency  $z = 1/c \sim \text{Pareto}(b, B, \theta) = F(z; b, B, \theta) = Pr(Z \leq z)$ . To obtain the distribution of  $c$ , write down the complementary distribution  $G^c(c)$  to start with:

$$G^c(c) = Pr(C > c) = Pr(1/Z > c) = Pr(Z \leq 1/c) = F(c^{-1}, b, B, \theta)$$

Hence, the distribution of  $c$  is given by

$$G(c) = 1 - G^c(c) = 1 - F(c^{-1}, b, B, \theta) = 1 - \frac{1 - (bc)^\theta}{1 - (b/B)^\theta} \quad (56)$$

$$= \frac{(bc)^\theta - (b/B)^\theta}{1 - (b/B)^\theta} \quad (57)$$

Draw  $c$  from  $G(c)$ :

$$\begin{aligned} [1 - (b/B)^\theta] G(c) &= (bc)^\theta - (b/B)^\theta \\ (bc)^\theta &= [1 - (b/B)^\theta] G(c) + (b/B)^\theta \\ c &= \frac{1}{b} \left\{ \left[ 1 - \left( \frac{b}{B} \right)^\theta \right] G(c) + \left( \frac{b}{B} \right)^\theta \right\}^{1/\theta} \end{aligned}$$

Derive the distribution of the markup: unbounded Pareto distribution

Following Malik and Trudel (1982), the quotient of two order statistics that are independently drawn from a Pareto distribution can be derived as follows.

Given that efficiency  $\mathbf{Z} \sim \mathbf{Pareto}$  with support  $[\mathbf{0}, \infty]$ , i.e.  $\mathbf{C} \in [\mathbf{0}, \infty]$ , the first step consists in deriving the *PDF* of the ratio  $Q = \frac{Z_i}{Z_j}$  where  $i < j$  and  $Z_1 < Z_2 < \dots < Z_n$ . According to Malik and Trudel (1982), the *PDF* of  $Q$  is given by

$$h(q) = \frac{\theta q^{\theta - \theta n - \theta j - 1}}{\beta(j - i, n - j + 1)} (1 - q^\theta)^{j - i - 1}, \quad (58)$$

where  $\beta(a, b)$  is the Beta-function  $\beta(a, b) = \frac{(a-1)!(b-1)!}{(a+b-1)!}$ . As I want to compute  $h(q)$  for the highest and the second-highest efficiency level, I set  $i = n - 1$  and  $j = n$ , so that (58) can be rewritten as

$$h_{n-1, n}(q) = \frac{\theta q^{\theta - \theta n - \theta n - 1}}{\beta(1, 1)} (1 - q^\theta)^0 \quad (59)$$

$$= \theta q^{\theta - 1}. \quad (60)$$

To compute the *CDF* of  $0 < Q < 1$ , integrate  $h(q)$ , such that

$$H(q) = \theta \int_0^q x^{\theta - 1} dx = \theta \left[ \frac{1}{\theta} x^\theta \right]_0^q \quad (61)$$

$$= q^\theta. \quad (62)$$

Let us now turn to the ratio  $\tilde{M} = \frac{C_2}{C_1} = 1/Q$ . The complementary distribution of  $\tilde{M}$  is given by

$$\begin{aligned} F^c(\tilde{m}) &= Pr(\tilde{M} \geq \tilde{m}) \\ &= Pr(1/Q \geq \tilde{m}) = Pr(Q \leq 1/\tilde{m}) \\ &= H(\tilde{m}^{-1}). \end{aligned}$$

Hence, I have that

$$F(\tilde{m}) = 1 - F^c(\tilde{m}) = 1 - H(\tilde{m}^{-1}) = 1 - \left(\frac{1}{\tilde{m}}\right)^\theta$$

which shows that the cost-ratio  $\tilde{M} = C_2/C_1$  follows a Pareto-distribution with minimum  $b = 1$ . The distribution of the markup  $M$  thus also follows a Pareto-distribution. However, it is truncated at the Dixit-Stiglitz markup  $\bar{m}$ , such that

$$F(m) = Pr(M \leq m) \begin{cases} 1 - \left(\frac{1}{m}\right)^\theta & \text{if } 1 \leq m < \bar{m} \\ 1 & \text{if } m \geq \bar{m} \end{cases} \quad (63)$$

This is the same result as in Bernard et al. (2003). The probability of observing the maximum markup is independent of the number of rivals  $n$ . As dispersion increases ( $\theta$  falls), the probability of observing the maximum markup,  $Pr[M(j) \geq \bar{m}] = 1 - Pr[M(j) \leq \bar{m}] = \bar{m}^{-\theta}$  increases. Thus, the higher the dispersion of cost parameters (the more fat-tailed the distribution of cost parameters), the more likely is granularity to hold since banks can pass cost shocks on to firms only if charging  $\bar{m}$ .

#### Lending rates

As in De Blas and Russ (2011b), the distribution of markups is independent of  $C_1(j)$  and  $C_2(j)$ , so that the expected lending rate can be written as

$$E[r(j)] = Pr[M(j) \geq \bar{m}]\bar{m}E[C_1(j)] + Pr[M(j) \leq \bar{m}]E[C_2(j)].$$

The CDF and PDF of the cost parameters are given by  $G_C(c) = (bc)^\theta$  and  $g_C(c) = \theta b^\theta c^{\theta-1}$ , respectively.

The aggregate lending rate  $r$  can be expressed as

$$r^{1-\epsilon} = \sum_{j=1}^J r(j)^{1-\epsilon} = E[r(j)^{1-\epsilon}] \quad (64)$$

so that

$$E[r(j)^{1-\epsilon}] = Pr[M(j) \geq \bar{m}]\bar{m}^{1-\epsilon}E[C_1(j)^{1-\epsilon}] + Pr[M(j) \leq \bar{m}]E[C_2(j)^{1-\epsilon}] \quad (65)$$

$$= \bar{m}^{1-\epsilon-\theta}E[C_1(j)^{1-\epsilon}] + (1 - \bar{m}^{-\theta})E[C_2(j)^{1-\epsilon}] \quad (66)$$

$$= r^{1-\epsilon} \quad (67)$$

#### Distribution of loan volumes (bank size)

Banks' loan volume is given by  $l(j) = \left[\frac{r(j)}{r}\right]^{-\epsilon} \ell$  so that

$$l(j)^{\frac{\epsilon-1}{\epsilon}} = \left[\frac{r(j)}{r}\right]^{1-\epsilon} \ell^{\frac{\epsilon-1}{\epsilon}} \quad (68)$$

$$= \frac{r(j)^{1-\epsilon}}{E[r(j)^{1-\epsilon}]} \cdot \ell^{\frac{\epsilon-1}{\epsilon}} \quad (69)$$

$$(70)$$

where  $\ell = wh$ . For granularity to hold, the loan volume must follow a power law

$$\Pr(l(j) > s) = Cs^{-\zeta} \tag{71}$$

with  $\zeta$  close to one.



**Table 1: Asset Concentration in the EU**

Year	Number of banks	Average size	Percent of assets held by...		Mean/median $\sqrt{HHI}$	
			largest 1% of banks	largest 10% of banks		
2000	1511	2.5	58.3	76.7	5.2	.25
2001	1511	2.5	58.5	77.0	5.2	.25
2002	1511	2.8	54.1	74.8	4.7	.21
2003	1511	3.4	53.6	74.7	4.7	.20
2004	1511	3.9	54.4	75.2	4.8	.21
2005	1511	3.7	55.1	75.8	4.9	.20
2006	1511	4.7	57.4	77.4	5.3	.21
2007	1511	5.6	57.5	77.7	5.4	.21

Table 1 shows how asset concentration has evolved over time for a balanced panel including the same banks for the pre-crisis period 2000-2007. The higher the share of assets held by the largest x % of banks, the higher concentration. The mean-to-median ratio equals one for a symmetric distribution. The higher the mean-to-median ratio, the more skewed to the right is the distribution of bank sizes. The Hirschman-Herfindahl index (HHI) measures concentration. It equals one for monopolistic markets and zero in case of perfect competition. The higher the HHI, the more concentrated the banking sector.

**Table 2: Parameter values**

Parameter	Value	Description
$\theta$	4.3	Shape parameter of the distribution of efficiency levels
$\epsilon$	4.3	Elasticity of substitution between credit varieties
n	[2,100]	Number of rivals per niche
J	100	Number of niches
$\bar{\sigma}_i$	0.12	Sectoral shock variance
$\gamma$	1	Elasticity of labor supply
$\rho$	2	Coefficient of relative risk aversion
$\beta$	0.96	Subjective discount factor
$1 - \alpha$	0.64	Labor share of income

**Table 3: Idiosyncratic Volatility in the EU**

year	Balanced Panel	Unbalanced Panel
2000		.13
2001	.12	.14
2002	.11	.10
2003	.11	.09
2004	.10	
2005	.13	.09
2006	.12	.07
2007	.13	.09
Average	0.12	0.1

Idiosyncratic volatility is defined here as the cross-sectional standard deviation of loan growth per year as in Gabaix (2011). The table compares values for the balanced panel of banks (see Table 1) to the unbalanced panel.

**Table 4: Values of aggregate variables for different levels of contestability**

<b>n</b>	m	r	$\ell$	$\sqrt{HHI}$
<b>2</b>	1.154	0.075	0.525	0.027
<b>10</b>	1.154	0.053	0.539	0.017
<b>100</b>	1.154	0.032	0.552	0.005

Table 4 shows simulated average outcomes for markups  $m$ , lending rates  $r$ , loan volumes  $\ell$ , and the squareroot of the Herfindahl-index.  $n$  denotes the number of rivals per niche, i.e. contestability.

Figure 1: Empirical Histograms of Bank Sizes in the EU

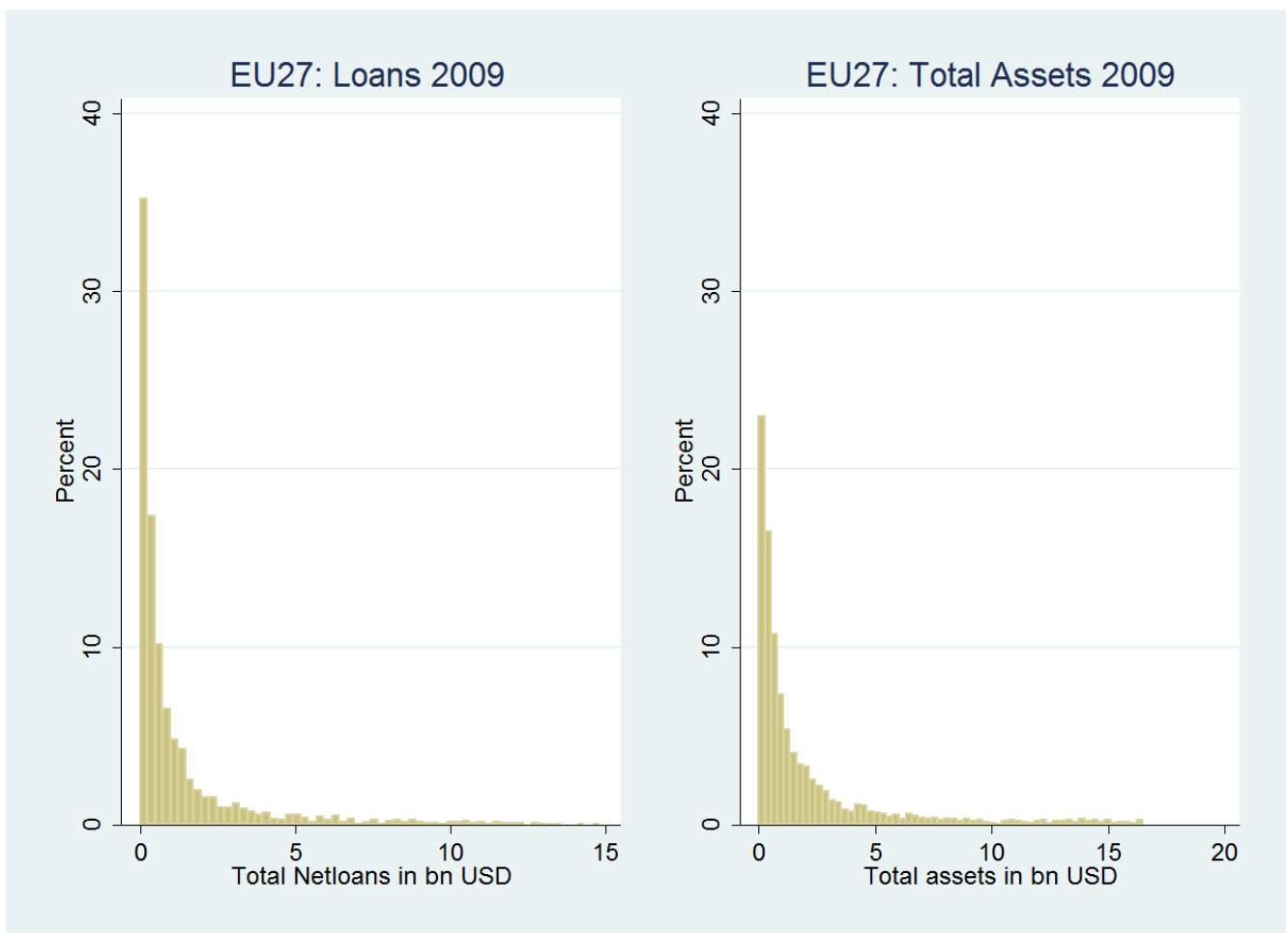


Figure 2: Bank size distributions: Empirical histograms and fitted Pareto distributions

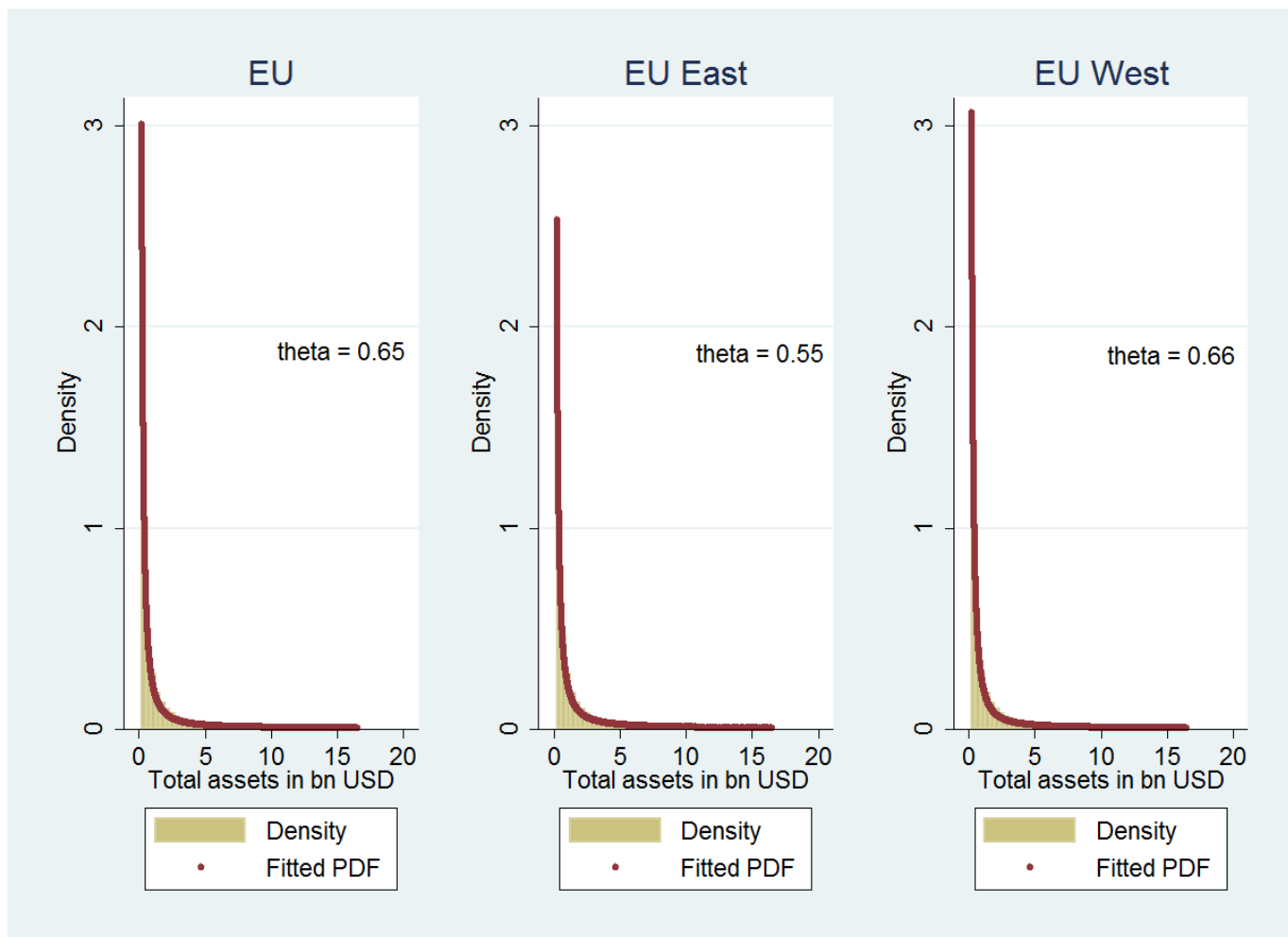


Figure 3: CDFs and PDFs under autarky

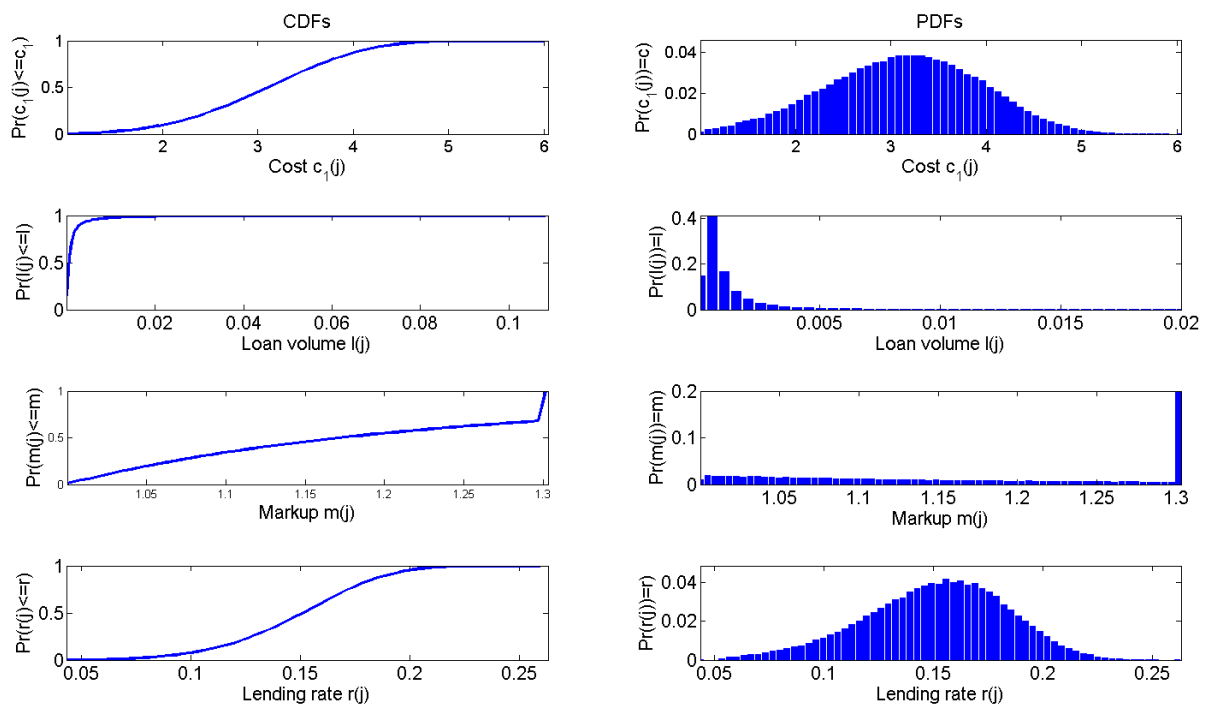


Figure 4: Structure of the Two-Country Model: Loan Liberalization

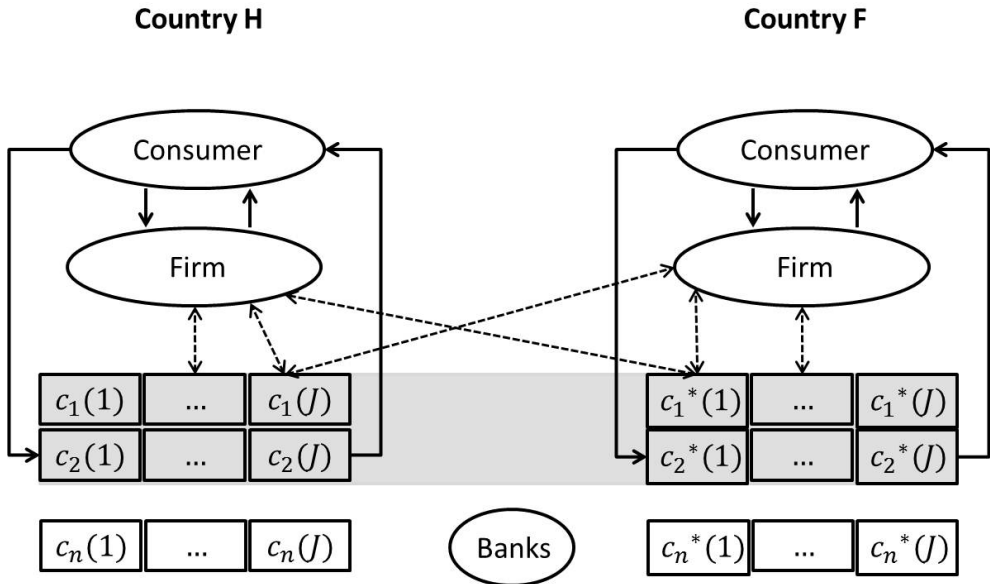




Figure 5: CDFs and PDFs for the closed and open economy, with and without distance factor

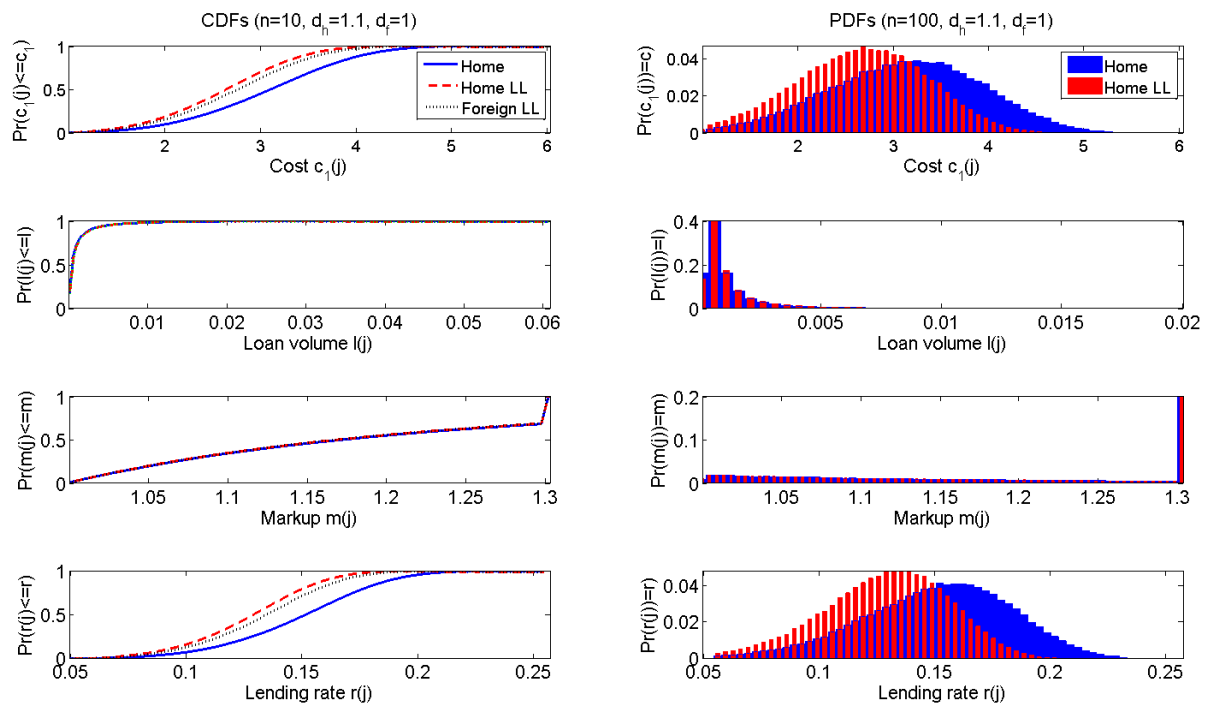


Figure 6: CDFs and PDFs: Closed economy vs. FDI liberalization

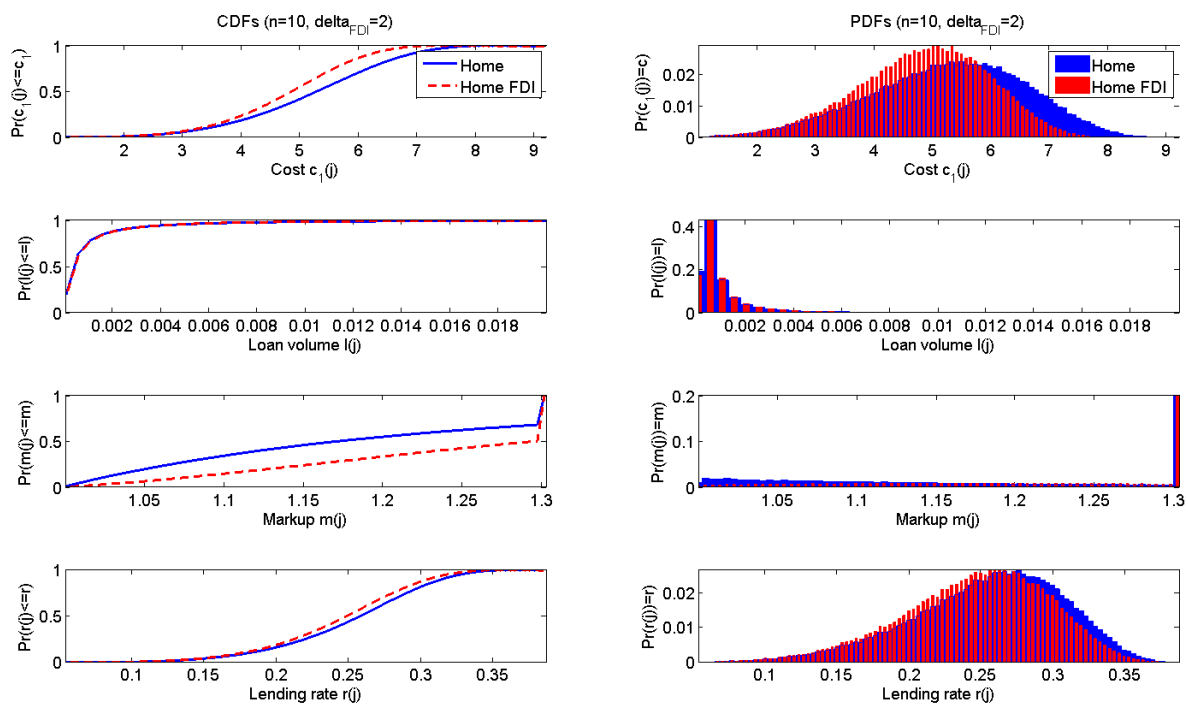


Figure 7: CDFs for autarky, loan liberalization, and FDI

