The effects of global bank competition and presence on local business cycles: The Goldilocks principle may not apply to global banking in advanced economies

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Abstract

I investigate the effects of banking competition and global bank presence on the stability of advanced economies. I find that when global banks have a greater presence or they are less competitive in one of the economies than the other, the cross-country mobility of loanable funds is restrained by the asymmetric degree of diminishing returns that global banks face and the economies become less volatile. These results, unlike the usual unidirectional relationships in the literature, imply an inverted U-shaped relationship, i.e., the effects of global bank competition/presence on economic stability may depend on the initial levels of the two factors.

Keywords: Global banks, Cournot competition, real business cycles, advanced economies.

JEL Classification: E32, E44, F33, F44.

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1 Introduction

Economists have long grappled with identifying theoretical mechanisms that can explain the high degree of macroeconomic integration across advanced economies. Standard open economy models have failed along this dimension and various goods and capital market frictions have been proposed as remedies (c.f. Backus et al. 1992). More recently, a few number of studies have offered global banking as a solution (Kollmann et al., 2011; Kollmann, 2013, Alpanda and Aysun, 2014). Global banks provide a natural fit since they align international business cycles by transmitting the shocks that they face on the supply and demand side of credit markets similarly to all the countries that they lend in. This mechanism is consistent with the stylized fact that global banks use their internal capital markets effectively and shift assets across their overseas subsidiaries without incurring large costs. While the mobility of global banks' assets clearly forms a link between business cycles in open economy models, whether this mobility has a stabilizing or a destabilizing effect on economies is still up for debate. There is evidence for each side of this debate (see below for a discussion). A further confounding factor is that global banks face different degrees of competition and their loans are not evenly distributed across the world. Do global banks behave differently in markets where they face a lower/higher degree of competition? How does this behavior depend on the share of their loans in these markets? There is ample evidence, some of which I mention at the end of this section, that should convince the reader that finding the answers to these questions is crucial as they suggest that global banks are now a primary source of finance and the degree of banking competition and foreign bank presence varies widely across advanced economies.

In this paper, I attempt to answer these questions and assess the effects of global banking on economic stability by building, solving and simulating a dynamic two-country real business cycle model that includes local and global banks. Under the baseline scenario, the two countries are symmetric except for the number of their local banks and they are linked through trade as well as global banking activity. There are three aspects of this model that are at

the forefront. First, only global banks have the ability to allocate loanable funds across the two economies (hereafter, domestic and foreign economies) to equate marginal returns from lending. Second, both types of banks operate under a Cournot oligopoly so that each bank takes into account the behavior of the other banks when choosing how much to lend and the degree of competition is determined by the number of banks. Third, under different calibrations of the model, global banks are allowed to allocate an uneven share of their loans across two economies at steady state so that they can have a high or a low presence in the domestic economy. Throughout the paper, I put the spotlight on the interaction of these three features and I analyze how global banks react to domestic macroeconomic shocks and shift loanable funds across the two economies when they face different degrees of competition and when they have different degrees of presence in each economy. There are three types of shocks, in the model: a supply shock (a productivity shock), a demand shock (a credit default risk shock) and a trade shock (terms-of-trade shock). Although it is possible to broaden the set of shocks under each category, my methodology provides a reasonable representation of how supply, demand/financial and trade shocks propagate in large open economies.

The baseline results, based on a reasonable calibration to U.S. data, indicate that when global banks are more competitive in the domestic economy than they are in the foreign economy, the amplitudes of the domestic output responses to domestic macroeconomic shocks are higher. The reason is that when global banks are more competitive in the domestic economy, their lending behavior has a smaller impact on the overall returns to lending in this economy than it does in the foreign economy and their domestic lending response to domestic shocks are, therefore, larger. In response to a positive shock in the domestic economy (an increase in productivity, a decrease in credit default, and a real depreciation), for example, global banks not only increase their total global lending but also allocate a greater share of their loans to this economy to equate cross-country marginal returns. While this larger response of global banks is partially offset by the smaller lending response of less competitive local banks in the domestic economy, I find that the reallocation of global

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banks' loans to the domestic economy dominates and the output responses are larger in magnitude. These results imply that shocks are mostly absorbed by the economy where they originate if global banks are more competitive in this economy. These conclusions are reversed when global banks are less competitive.

In my model, global banks can have a greater presence in an economy not only in terms of numbers but also by allocating a larger share of their loans to this economy and capturing a larger share of its credit market. In a second set of simulations, I investigate how global banks and the domestic economy respond to macroeconomic shocks when global banking loans are unevenly distributed across the two economies at steady state. To keep the focus on this uneven distribution, I set the number of local and global banks in each economy equal to each other so that the share of loans that global banks allocate to the domestic economy also reflects their share in the credit market of this economy. Unlike earlier results, the relationship between the amplitude of output responses and global bank presence is not unidirectional for every shock. For productivity and credit default shocks this relationship is inverted U-shaped so that the domestic economy output responses have the highest amplitude when global banking loans are more evenly distributed across the two economies. The responses are smaller otherwise. The reason is that under an uneven distribution, global banks' cross country mobility of loanable funds is restrained as they face more rapid diminishing returns in the economy that they have a larger presence. If there is a positive productivity shock in this economy, for example, a small increase in global bank loans rapidly equates marginal returns across two economies and the large reallocation of global bank loans is not observed. I find that the cross-country mobility of loanable funds and the sensitivity to domestic shocks are at their peak when global banks' loans are evenly distributed.

To obtain the results discussed above, I assume that global banks do not face any frictions when allocating loanable funds across the two countries. In an alternative formulation, I relax this assumption such that if a global bank changes its share of loans in one country across time, it incurs portfolio

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adjustment costs. Under this more realistic scenario, the amplitude of output responses is nonlinearly related to not only the share of global bank loans that an economy receives but also to the number of global banks. The latter relationship is similarly inverted U-shaped, i.e., output responses are larger in magnitude when the number of global banks is not too large or small. While global banks' responses are similarly small when they are fewer, the substantial reallocation of global banking loans observed when the number of global banks is large is stymied by portfolio adjustment costs. These costs generate a wedge between the marginal returns that global banks receive from the two economies and as the number of global banks increase, the wedge becomes important enough to cause a drop in the degree of loan reallocation and the sensitivity to domestic shocks.

To conclude my analysis, I perform diagnostic tests to assess the empirical relevance of my results. Though the model lacks many features such as nominal and real frictions that are usually incorporated to approximate macroeconomic responses observed in standard Vector Auto Regressive (VAR) models, I find that the unconditional moments in my model come reasonably close to matching the moments computed by using data from two large advanced economies (the U.S. and the Euro Area).

While my analysis is not empirical, the construction of my model is informed by empirical findings and my results bring a unique perspective to the rapidly expanding empirical literature on global banking. While this expansion has become more noticeable after the 2007-09 financial crisis, the attention that global banks receive in the international business cycle literature has been steadily rising since the mid 90's. This is no coincidence as the degree of bank globalization has dramatically increased over this period and global banks have become a large source of private funding in most countries. The total foreign claims of Bank of International Settlements (BIS) reporting banks as a share of world GDP, for example, have increased from 25.9 to 43.9 percent from 1995 to 2011, constituting a large component of domestic credit in most advanced

economies.[1,2] Studies such as Cetorelli and Goldberg (2012), Bruno and Shin (2013) and Claessens and Van Horen (2014) make similar observations while also reporting a significant degree of heterogeneity in the presence of global banks across host nations.

There are two other major developments in global banking that characterize the past two decades. First, banks that are globally active have become larger and they are now operating in more concentrated banking markets; concentration ratios and other indicators of competition vary widely across countries.[3,4] Second, empirical studies such as Houston et al. (1997), Campello (2002), De Haas and Lelyveldb (2010) and Cetorelli and Goldberg (2012) reveal that global banks use their internal capital markets effectively and they often shift loanable funds across their overseas subsidiaries.

Overall, global banking assets have become a large part of world credit markets and these assets are held by a few banks that shift loanable funds across countries frequently. These developments make global banks and their decision making processes a necessary and a central piece in international macroeconomics.

While most economists would agree that global banking is crucial for international business cycles, the literature is divided on the effects global bank presence on the economic and financial stability of host nations. On the one hand, studies such as Hernandez and Rudolph (1995), Buch (2000), Dahl et al. (2002), Goldberg (2002), Jeanneau and Micu (2002) and Morgan and Strahan (2004), De Haas and Van Lelyveld (2006), De Haas and Van Horen (2013), find/predict that global banks, by shifting loanable funds from weak to strong

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[1] I used data from the BIS and the World Development Indicators databases in my computations.

[2] Aysun and Hepp (2014) show that BIS bank loans constitute approximately half of the total local credit in 15 advanced economies between 2000 and 2014.

[3] The Lerner index of bank competition has increased from 0.19 to 0.27 from 1996 to 2010 (data source: Federal Reserve Bank of St. Louis, FRED database).

[4] Aysun and Hepp (2014) find, for example that the average 3-bank concentration ratio across 15 advanced economies between 2000 and 2014 is 67.4 percent and the standard deviation of this ratio is 19 percent. A high level cross-country variance is also observed for the other indicators of market power and concentration in banking such as the Lerner and Boone indices and the 5-bank concentration ratio.

economies, can have a destabilizing effect.[5] On the other hand, studies such as Dages et al. (2000), Peek and Rosengren (2000), Crystal et al. (2002), Cetorelli and Goldberg (2012), De Haas and Van Lelyveld (2014) show that global banks can enhance stability by providing a robust source of funding during liquidity shortages. While it is not clear which of these two effects, i.e., the substitution and support effects, dominates, both sets of studies find a unidirectional, either a positive or a negative, relationship between global bank presence and economic stability. The results in my paper suggest that the relationship may not be unidirectional and may depend on the initial level of global bank presence in the economy.

The literature on banking competition and economic stability, though divided, suggests that the substitution and the support effects described above can be related to the degree of competition that global banks face in a host nation. While studies such as Marcus (1984), Keeley (1990), Boot and Thakor (1993) and Allen and Gale (2000, 2004) predict/find greater stability in economies with a more concentrated banking market, studies such as Boyd and De Nicolo (2005) and Johnson and Kwak (2010) find evidence that goes against this prediction.[6] A further confounding finding here is that the impact of competition on economic stability can be related to the presence of foreign banks. Anginer et al. (2012), for example, finds that economies with less competitive banks are less stable and that this relationship is stronger when foreign banks have a smaller presence. In this paper, I measure the effects of competition on economic stability independent of global bank presence and I find that these effects may not always be negative or positive and that they may depend on the initial level of banking competition.

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[5]Furthermore, studies investigating the behavior of banks during the 2007-09 financial crisis (e.g. Claessens and Van Horen, 2013) find that global banks, prompted by adverse funding shocks, have reduced credit by more than local banks.

[6]In this literature the negative effects of lower competition on economic stability is explained by the excessive risk taking behavior of the less competitive, too-big-to-fail banks that are under government safety nets. Conversely, the negative effects of higher competition on stability are explained by the excessive risk taking behavior and the smaller amount of monitoring that is caused by lower profit margins and the smaller risk-diversification capability of smaller more competitive banks (see also Hellman et. al, 2000).

To summarize, I uncover theoretical mechanisms that link economic stability in advanced economies to global banking competition and presence. I predict an inverted U-shaped relationship between economic stability and the two factors when global banks face portfolio adjustment costs. These relationships imply that countries that start with high (low) degree of competition and global bank presence within their borders would have to go over a hump (face higher economic volatility) if they want to decrease (increase) the degree of these features.

2   The Economy

The general equilibrium framework in this paper is a two-country real business cycle model that features, households, producers, entrepreneurs and a financial sector populated by local and global banks. In this section, I describe and solve the optimization problem of each agent, and I describe the general equilibrium in the economy. For brevity, I do this for only the domestic economy since the two economies are identical in every aspect except for the degree of banking competition and the presence of global banks.

2.1   Households and Producers

The households in the economy consume a final good, allocate their savings to a one-period bank deposit and supply labor. They are the owners of the banks in the model and they receive dividends in each period. The households have infinite lives and they maximize their life-time utility function in each period. This function for a representative household is given by,

$$U_t = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{1}{1-\sigma} \left[C_t \exp\left(-\xi \frac{L_t^{1+\sigma_l}}{1+\sigma_l} \right) \right]^{1-\sigma} \tag{1}$$

where C_t and L_t denote consumption and labor supply and σ, σ_l and β are the intertemporal elasticity of substitution, inverse elasticity of labor supply and the time discount parameter respectively. The parameter ξ is calibrated such

that labor supply is equal to 1 at steady state. In maximizing their utility function, households face the following budget constraint:

$$P_t C_t + D_t + T_t \leq W_t L_t + R_{t-1}^d D_{t-1} + DV_{h,t} + DV_{g,t}/2 \tag{2}$$

where D_t and T_t denote the household's bank deposits and lump-sum tax payments, respectively. Consumption is composed of domestic and foreign goods and the price of this composite consumption in terms of domestic goods is P_t. Throughout the model, prices of domestic goods are normalized at 1. The household's sources of income are the returns from bank deposit holdings (unit returns denoted by R_t^d), her wages, W_t, and dividends, $DV_{h,t}$ and $DV_{g,t}$, she receives from local and global banks. I assume that the households of the two countries have an equal equity share of the global banks, they own the local banks, and that they do not hold any shares of the local banks in the foreign country.

Maximizing the household's utility function with respect to consumption and domestic deposit holdings and combining the two optimality conditions produces the following intertemporal relationship:

$$C_t^{-\sigma} \exp\left(\xi \frac{(\sigma-1) L_t^{1+\sigma_l}}{1+\sigma_l}\right) = \beta E_t \left[C_{t+1}^{-\sigma} \exp\left(\xi \frac{(\sigma-1) L_{t+1}^{1+\sigma_l}}{1+\sigma_l}\right) \frac{P_t}{P_{t+1}} R_t^d\right] \tag{3}$$

where the household equates the marginal benefits from consuming today to the benefits of saving today and using the returns to consume tomorrow. The intratemporal tradeoff between leisure and labor is derived from the same problem as follows:

$$C_t \xi L_t^{\sigma_l} = W_t/P_t \tag{4}$$

The economy is populated by perfectly competitive producers that hire the household's labor services and rent capital from entrepreneurs to produce output according to the standard neoclassical function. For the representative producer this function is given by,

$$Y_t = \varepsilon_{a,t} K_t^\alpha L_t^{1-\alpha} \tag{5}$$

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where Y_t is the total amount of production, L_t is aggregate labor, K_t is the capital stock and $\varepsilon_{a,t}$ is a productivity shock that follows an AR(1) process given by $\varepsilon_{a,t} = \rho_a \varepsilon_{a,t-1} + \eta_{a,t}$, where ρ_a and $\eta_{a,t}$ are the persistence parameter and the shock innovation that is $i.i.d.$ (normal with mean 0 and standard deviation σ_a), respectively. The remaining shock processes in the model also follow an AR(1) process and their parameters have a similar notation. The rental rate of capital, R_t^k, and the real wage rate are derived from the maximization problem of the representative producer as,

$$R_t^k = \alpha \varepsilon_{a,t} K_t^{\alpha-1} L_t^{1-\alpha} \tag{6}$$

$$W_t/P_t = (1 - \alpha)\, \varepsilon_{a,t} K_t^{\alpha} L_t^{-a} \tag{7}$$

2.2 Financial Market

The financial market in each economy features entrepreneurs and two types of banks: local and global. While local banks accept deposits and lend solely in the country that charters them, global banks lend and accept deposits in each economy through their subsidiaries and they distribute dividends evenly across domestic and foreign households. Both types of banks lend and accept deposits in local currency. There are N_g global banks in the world, and N_l and N_l^* local banks in the domestic and the foreign economy, respectively, so that the total number of banks in the domestic and foreign economy are given by $N = N_g + N_l$ and $N^* = N_g + N_l^*$, respectively. Hereafter, the superscript "*" designates the foreign variables and parameters in the model. The banks operate under a Cournot oligopoly and they compete in the lending market. The number of banks in each economy is constant so that there is no exit or entry.

At the beginning of each period, banks lend to a continuum of perfectly competitive entrepreneurs (with mass equal to 1), indexed by i. Entrepreneurs convert these borrowed funds to capital, rent them out to producers and transfer the returns from capital to banks at the end of the period. To incorporate credit default shocks in my model, I assume that the conversion

from bank loans to capital is imperfect such that a unit of investment can be successfully converted to a unit of capital with probability $\theta_{s,t}$. If the conversion is not successful, the entrepreneur defaults and she is replaced by an identical entrepreneur. The probability of success is $i.i.d$ across entrepreneurs so that the capital supplied by entrepreneur i is given by, $K(i) = \varepsilon_{s,t}^i B(i)$, where $B(i)$ represents the amount borrowed by entrepreneur i and $\varepsilon_{s,t}^i$ is an $i.i.d.$ credit shock that has a binomial distribution with mean $\theta_{s,t}$ and variance $\theta_{s,t}(1 - \theta_{s,t})$.[7] The entrepreneurs are identical otherwise. The banks lend to a large number of entrepreneurs and diversify the idiosyncratic risk. I assume that the mean of the idiosyncratic shock follows an AR(1) process given by $\theta_{s,t} = (1 - \rho_s)\theta_s + \rho_s\theta_{s,t-1} + \eta_{s,t}$, where θ_s is the steady state value of the default probability. An increase in $\eta_{s,t}$ here implies a lower rate of default and therefore a decrease in credit risk.

The banks finance their loans with household deposits and the returns they receive from previous period's lending. The households are indifferent between global and local bank deposits and the banks, in each country and in each period, get an equal share of the deposits. Global banks pool the deposits that they collect in each region and then choose how much dividends to pay out, how much to lend, and the optimal allocation of their loans across the two countries to maximize the life-time dividend payments to their shareholders. They make these decisions simultaneously and in doing so, they take into account the lending behavior of the other banks, the expected rate of return from lending and their funding rates. Local banks, by contrast, only lend and accept deposits in the country that charters them and in each period they choose the amount of loans and dividend payments.

Let $dv_{g,t}^n$ denote the dividends paid by global bank n then the budget constraint of this bank can be represented as,

$$dv_{g,t}^n + \int_0^1 B_{g,t}^n(i)\,di + \varepsilon_{q,t}\int_0^1 B_{g,t}^{n^*}(i^*)\,di^* + R_{t-1}^d F_{g,t-1}^n + \varepsilon_{q,t}R_{t-1}^{d^*}F_{g,t-1}^{n^*} = \quad (8)$$

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[7]Cetorelli and Peretto (2012) use a similar imperfect transformation function to investigate the effects of relationship lending and banking competition on capital accumulation.

$$F_{g,t}^n + \varepsilon_{q,t} F_{g,t}^{n^*} + \int_0^1 \varepsilon_{s,t-1}^i R_{t-1}^k B_{g,t-1}^n (i)\, di + \varepsilon_{q,t} \int_0^1 \varepsilon_{s,t-1}^{i^*} R_{t-1}^{k^*} B_{g,t-1}^{n^*} (i^*)\, di^*$$

where $F_{g,t}^n$ and $B_{g,t}^n (i)$ are the deposits collected by global bank n and its loans to entrepreneur i in the domestic economy, respectively. The foreign economy counterparts of these variables are represented with a "*" superscript. I assume that the consumers' and the global banks' budget constraints are subject to a terms of trade shock, $\varepsilon_{q,t}$, that follows an AR(1) process. An increase in $\varepsilon_{q,t}$ here implies a real depreciation of the domestic currency. Given that the idiosyncratic credit default shock is independent of the amount of lending and since the entrepreneurs are identical prior to the realization of the shock, the budget constraint in equation (8) can be simplified as follows:

$$dv_{g,t}^n + B_{g,t}^n + \varepsilon_{q,t} B_{g,t}^{n^*} + R_{t-1}^d F_{g,t-1}^n + \varepsilon_{q,t} R_{t-1}^{d^*} F_{g,t-1}^{n^*} = \quad (9)$$
$$F_{g,t}^n + \varepsilon_{q,t} F_{g,t}^{n^*} + \theta_{s,t-1} R_{t-1}^k B_{g,t-1}^n + \varepsilon_{q,t} \theta_{s,t-1}^* R_{t-1}^{k^*} B_{g,t-1}^{n^*}$$

where $B_{g,t}^n = \int_0^1 B_{g,t}^n (i)\, di$ and $B_{g,t}^{n^*} = \int_0^1 B_{g,t}^{n^*} (i^*)\, di^*$ denote the aggregate amount of lending in each country and the aggregate returns from the previous period are given by $\theta_{s,t-1} R_{t-1}^k B_{g,t-1}^n + \varepsilon_{q,t} \theta_{s,t-1}^* R_{t-1}^{k^*} B_{g,t-1}^{n^*}$.

Facing this constraint, global banks make two simultaneous decisions: how much to lend, and how to allocate their loans across the two countries. By doing so, they also determine the amount of dividend payments. Let s_t^n and $B_{g,t}^{a,n} = B_{g,t}^n + \varepsilon_{q,t} B_{g,t}^{n^*}$ denote bank n's share of its loans in the domestic economy and its total amount of lending then its maximization problem can be represented as follows:

$$\max_{B_{g,t}^{a,n}, s_t^n} \int_{\tau=t}^{\infty} \beta^{\tau-t} dv_{g,t}^n \quad s.t.$$
$$dv_{g,t}^n + B_{g,t}^{a,n} + R_{t-1}^d F_{g,t-1}^n + \varepsilon_{q,t} R_{t-1}^{d^*} F_{g,t-1}^{n^*} = \quad (10)$$
$$F_{g,t}^n + \varepsilon_{q,t} F_{g,t}^{n^*} + \theta_{s,t-1} R_{t-1}^k s_{t-1}^n B_{g,t-1}^{a,n} + \varepsilon_{q,t} \theta_{s,t-1}^* R_{t-1}^{k^*} \left(1 - s_{t-1}^n\right) B_{g,t-1}^{a,n}$$

To solve the maximization problem (and also to solve the problem for the local banks below), I impose symmetry across local and global banks on both the

demand and the supply side of credit markets. On the demand side, I assume that the banks, local and global, receive an equal share of the deposits such that, $F^n_{g,t} = F^m_{h,t} = D_t / (N_g + N_l)$ and $F^{n*}_{g,t} = F^{m*}_{h,t} = D^*_t / (N_g + N_{l*})$. On the supply side, symmetry across global banks implies that these banks allocate loans similarly across countries so that $s^n_t = s_t$ for each n, and that they extend an equal amount of loans within each country so that $B^{a,n}_{g,t} = B^a_{g,t} / N_g$, $B^m_{h,t} = B_{h,t} / N_l$ and $B^{m*}_{h,t} = B^*_{h,t} / N_{l*}$, where $B_{h,t}$ and $B^a_{g,t}$ denote the total amount of loans extended by local and global banks, respectively. It is timely to note at this point that global banks, when solving their maximization problem, consider both the returns from a unit loan, R^k_{t-1}, and the effects of their lending on these returns that feed through the capital stock in the economy since bank loans that are successfully converted to capital supplement the existing stock of capital as follows:

$$K_t = (1 - \delta) K_{t-1} + \theta_{s,t} \left(B_{h,t} + s_t B^a_{g,t} \right), \tag{11}$$

where $\theta_{s,t} \left(B_{h,t} + s_t B^a_{g,t} \right)$ also represents the total amount of investment in the economy. Given this setup, solving the maximization problem of global bank n and imposing symmetry produces the following optimality conditions:

$$1 = \beta \left[\theta_{s,t} s_t \left(R^k_t + \frac{dR^k_t}{dB^a_{g,t}} \frac{B^a_{g,t}}{N_g} \right) + \varepsilon_{q,t+1} \theta^*_{s,t} (1 - s_t) \left(R^{k*}_t + \frac{dR^{k*}_t}{dB^a_{g,t}} \frac{B^a_{g,t}}{N_g} \right) \right] \tag{12}$$

$$\theta_{s,t} \left(R^k_t + \frac{dR^k_t}{ds_t} s_t \right) = \varepsilon_{q,t+1} \theta^*_{s,t} \left(R^{k*}_t - \frac{dR^{k*}_t}{ds_t} (1 - s_t) \right) \tag{13}$$

where $\frac{dR^k_t}{dB^a_{g,t}} = (\alpha - 1) s_t \theta_{s,t} R^k_t / K_t$ and $\frac{dR^k_t}{ds_t} = (\alpha - 1) \theta_{s,t} B^a_{g,t} R^k_t / (K_t N_g)$. The first equation describes the intertemporal choice between a unit of dividend today versus the return from a unit loan the next period. The second equation demonstrates how the global banks allocate a unit loan between the two economies to equate marginal returns. The partial derivatives in the two equations capture the impact of global banks' lending and allocation of loanable funds on their marginal returns.

The local banks' maximization problem is more straightforward since their loans are only extended in the country that they operate in. In each period, these banks choose the amount of loans and dividends to solve the following problem:

$$\max_{B_{h,t}^m} \int_{\tau=t}^{\infty} \beta^{\tau-t} dv_{h,t}^m \qquad (14)$$

$$s.t \quad dv_{h,t}^m + \int_0^1 B_{h,t}^m (i) \, di + R_{t-1}^d F_{h,t-1}^m = F_{h,t}^m + \int_0^1 \varepsilon_{s,t-1}^i R_{t-1}^k B_{h,t-1}^m (i) \, di$$

where $dv_{h,t}^m$ are the dividends paid by the local bank m, and $F_{h,t}^m$ and $B_{h,t}^m (i)$ are the deposits that it collects and its loans to entrepreneur i, respectively. Assuming symmetry amongst the local banks and entrepreneurs and given that the idiosyncratic shock is independent of the amount of lending, the maximization problem produces the following intertemporal condition:

$$1 = \beta \theta_{s,t} \left(R_t^k + \frac{B_{h,t}}{N_l} \frac{dR_t^k}{dB_{h,t}} \right) \qquad (15)$$

The local banks in the foreign country solve a similar problem and their lending decisions are governed by a similar intertemporal condition.

2.3 Monetary policy, Aggregators, and Market Clearing Conditions

I assume that both economies have central banks that intervene in their local funding markets to regulate local deposit rates as follows:

$$R_t^d = \left(R_{t-1}^d \right)^{\rho} \left[(P_t/P_{t-1})^{\pi_p} Y_t^{\pi_y} (Y_t/Y_{t-1})^{\pi_{\Delta y}} \right]^{1-\rho} \qquad (16)$$

where ρ is an interest rate smoothing parameter and π_p, π_y and $\pi_{\Delta y}$ measure the sensitivity of interest rates to inflation, output and output growth, respectively.

The economy includes perfectly competitive consumption good aggregators that produce final consumption goods as a CES aggregate over domestic and

foreign goods:

$$C_t = \left(\gamma_c^{1/\lambda_c} C_{h,t}^{(\lambda_c-1)/\lambda_c} + (1-\gamma_c)^{1/\lambda_c} C_{f,t}^{(\lambda_c-1)/\lambda_c} \right)^{\lambda_c/(\lambda_c-1)} \tag{17}$$

where the parameters γ_c and λ_c regulate the share of domestic goods and the elasticity of substitution between domestic and foreign goods, respectively. Given that the price of domestic goods is equal to 1, the corresponding relative price of consumption goods can be obtained as,

$$P_t = \left(\gamma_c + (1-\gamma_c)(\varepsilon_{q,t})^{1-\lambda_c} \right)^{1/(1-\lambda_c)} \tag{18}$$

In equilibrium, households maximize their utility, the entrepreneurs and consumption aggregators maximize their profits, the banks maximize dividend payments, and the optimal decisions of these agents clear the markets. The total amount of production in the domestic economy is used for household and government consumption, investment and exports so that,

$$Y_t = C_{h,t} + G_t + \theta_{s,t}(B_{h,t} + s_t B_{g,t}^a) + C_{f,t}^*, \tag{19}$$

where G_t represents exogenously determined government expenditures that

are financed with the local households' tax payments. In this equilibrium, the aggregate resource constraints for the global banks, domestic and foreign local banks are satisfied:

$$DV_{g,t} + B_{g,t}^a + \frac{N_g}{N_g + N_l} \left(R_{t-1}^d D_{t-1} - D_t \right) + \frac{N_g}{N_g + N_{l*}} \varepsilon_{q,t} \left(R_{t-1}^{d*} D_{t-1}^* - D_t^* \right) \tag{20}$$

$$= \theta_{s,t-1} R_{t-1}^k s_{t-1} B_{g,t-1}^a + \varepsilon_{q,t} \theta_{s,t-1}^* R_{t-1}^{k*} (1 - s_{t-1}) B_{g,t-1}^a$$

$$DV_{h,t} + B_{h,t} + \left(R_{t-1}^d D_{t-1} - D_t \right) N_l / \left(N_g + N_l \right) = \theta_{s,t-1} R_{t-1}^k B_{h,t-1} \tag{21}$$

$$DV_{h,t}^* + B_{h,t}^* + \left(R_{t-1}^{d*} D_{t-1}^* - D_t^* \right) N_{l*} / \left(N_g + N_{l*} \right) = \theta_{s,t-1}^* R_{t-1}^{k*} B_{h,t-1}^* \tag{22}$$

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where $DV_{g,t} = \sum_{n=1}^{N_g} dv_{g,t}^n$, $DV_{h,t} = \sum_{m=1}^{N_l} dv_{h,t}^m$ and $DV_{h,t}^* = \sum_{m^*=1}^{N_{l*}} dv_{h,t}^{m^*}$ represent the total amount of dividends paid out by global banks, domestic local banks, and foreign local banks, respectively.

3 Calibration

In calibrating the standard parts of my model, I set the parameter values equal to those commonly-used for large economies such as the U.S. economy (the parameter values are displayed in Table 1). These standard parts of the two economies are symmetric so that the parameter values that I mention below are used to describe the steady states of both the domestic and the foreign economy.

Consistent with common practice, β, is set equal to 0.99, implying an annualized 4% real interest rate. Similarly, the capital share parameter, α, is 0.3, the depreciation rate is 0.025, the intertemporal elasticity of substitution and labor elasticity parameters, σ and σ_l are 2 in the baseline calibration. The parameters regulating the share of domestic goods in consumption and the elasticity of substitution between domestic and foreign goods, γ_c and λ_c, are fixed to 0.90 (implying that imports are 10 percent of GDP) and to the commonly used value of 1, respectively. The Taylor rule parameters, ρ, π_p, π_y and $\pi_{\Delta y}$ are set equal to 0.9, 1.5, 0.75 and 0.25, respectively. These values fall within the range of values found in macro-econometric studies and those that form the distributions representing prior beliefs about the parameters (c.f. Smets and Wouters, 2007; Hofmann and Bogdanova, 2012). Fixing the steady state value of the credit shock parameter to 0.99 implies an annual default rate of 4% and an annualized credit spread $R^k - R^d$ of 2%. These values are consistent with empirical evidence and, together with a steady state government spending share of 20%, they imply a 63% and 17% share of consumption and investment in GDP, providing a reasonable representation of the historical composition of expenditures in the U.S. economy.[8]

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[8]The 4% failure rate is larger than the values used in studies investigating the period

Turning to the banking side, under the baseline calibration I assume that there are 50 local banks in each economy and 50 global banks that operate in both economies and that global banks allocate their loans evenly across the two economies. While the number of banks in large regions like the Euro Area and the U.S. are much larger (over 8000 in the U.S. for example), the banking markets in these economies are highly concentrated and the number of banks that have market power in lending are very few in number.[9] In my baseline calibration, I take a conservative approach and I assume that there are 50 local banks in each economy that have market power and face diminishing returns on the lending side of credit markets.[10] Under the baseline calibration this also implies that there are 50 global banks.[11] In alternative calibration exercises, I do, however, deviate from this baseline scenario and also investigate how the economies react to shocks when there are a smaller number of local and foreign banks. As mentioned in Section 2, there is no exit or entry in the Cournot competitive banking market so that the number of banks mentioned above stay the same when the economy deviates from its steady state. This assumption is consistent with empirical evidence. While the number of commercial banks and bank holding companies in the U.S. have decreased between the 80s and mid 90s, they've been relatively stable after this period (c.f. Alpanda and Aysun, 2012).

I follow the common practice in the literature and I assume that each shock in the model follows an AR(1) process with the persistence and standard devi-

before the 2007-2009 crisis (for example, Bernanke et al. (1999) use 3% and Aysun and Honig, (2011) use 2.3%. U.S. corporate bond spreads (Merrill Lynch US Corporate BBB, option adjusted spread) between 1997 and 2015 were on average 2.09 percent.

[9]Over the period 2000 to 2014, the 3 and 5 bank concentration ratios for the U.S., for example, were 27.6 and 36.6 percent, respectively. The ratios for countries in the Euro Area are much larger (see, Aysun and Hepp, 2014).

[10]Empirical evidence based on U.S. data indicates that while global banks are much larger than local banks, local banks are also considerably large in size. Aysun and Alpanda (2012), for example, use U.S. call report to data and find that the average assets of bank holding companies with a substantial amount of foreign loans are 25.1 billion between 1986 and 2009. This corresponding statistic for bank holding companies with more limited foreign lending is equal to 5.7 billion.

[11]The number of global banks in this calibration exercise is obtained by using the following steady state condition: $N_g = \theta_s \left(1 - \alpha\right) \left(\frac{B}{K} - \frac{B_h}{K}\right) / \left(1 - \frac{1}{\beta \theta_s R^k}\right)$

ation parameters governing these processes equal to 0.9 and 0.01, respectively.

4 Results

In this section, I examine the propagation of macroeconomic shocks and I assess the significance of global bank presence, both in terms of numbers and credit market share, for local business cycles. I then compare these inferences to those obtained by including portfolio adjustment costs. Finally, I compare model generated moments to those obtained from data. The simulations in this section are based on a linearized form of the model. The equations that describe this linearized form are listed in Appendix A.

4.1 Baseline responses to domestic shocks

I begin my investigation by simulating the model under the baseline calibration where the two economies are symmetric and they have an equal share of global and local bank lending. Since the economies are symmetric, they respond identically to their own shocks. For brevity, therefore, I only report the domestic economy responses to domestic shocks in this section. The responses (measured as percentage deviations from steady state values) to 3 types of shocks originating in the domestic economy are displayed in Figure 1. The shocks are all positive and represent a one standard deviation increase in productivity, a one standard deviation decrease in credit risk (corresponding to an increase in the mean value of the idiosyncratic risk variable) and a one standard deviation real depreciation of the domestic currency. Notice first that each shock has a positive impact on output and labor, and they each generate an increase in returns to capital, prompting local and global banks to increase their lending. The key difference between the two types of lending is that the local banks' responses are larger in magnitude. These responses also indicate, however, that while the aggregate global lending response of global banks are smaller, they allocate a larger share of their loans to the domestic economy. By so doing, the global banks equate the marginal returns from lending across the

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two economies. In contrast to the other shocks, a depreciation of the domestic currency causes global banks to shift their lending to the foreign economy since the shock generates a relatively larger positive response of the marginal returns (in terms of domestic currency) in the foreign economy. Finally, notice that the figure illustrates a larger response to a productivity shock since the other two shocks generate an increase in investment and exports and have a crowding out effect on the other components of demand.

4.2   Different numbers of global banks

The focal point of my paper is the impact of global bank competition and presence on local business cycles. In this section, I begin to steer the analysis in this direction by investigating how the domestic economy variables react to macroeconomic shocks when the number of global banks are larger and smaller than under the baseline calibration. This allows me to capture the behavior of business cycles in the local economy when global banks are less and more competitive, respectively.

To assess the effects of competition, I first calibrate the model economy so that the number of global banks, compared to their number under the baseline calibration (50 global banks), is 50% less and more (25 and 75 global banks, respectively). In doing so, I keep the total number of banks in the domestic economy the same (100 banks) and I calibrate the foreign economy asymmetrically so that the number of local banks in the foreign economy is still equal to the number of global banks. I should note here that the share of each global and local bank in the domestic economy's credit market remains the same so that the number of the banks and their relative competitiveness is the only factor that is different from the baseline calibration.

Figure 2 displays the results. For each shock, the response of output is larger when there are a larger number of global banks. The mechanism that generates this result can be explained as follows: The increase in returns to capital, produced by each shock, causes a similar increase in both global and local bank lending. When global banks are larger in number, their marginal

lending has a smaller negative impact on the returns to capital. These banks, therefore, increase their loans by more than they do under the baseline calibration in order to equate their marginal returns across the two economies. The magnitude of global banks' lending response also exceeds the response of local banks since the latter reach diminishing marginal returns more quickly. This mechanism is not observed in the foreign economy since the number of global banks is equal to the number of local banks and the global banks' increase their lending in the foreign economy by less as they face more rapidly diminishing returns. The increase in global bank lending in response to the positive shocks, therefore, are absorbed mostly by the domestic economy. The results are reversed when global banks are fewer in number, i.e., the local banks' response exceeds the global banks' response in the domestic economy since local banks have a smaller impact on marginal returns.

Under both scenarios, the deciding factor that determines the relative strength of the output responses is the global banks' international allocation of loans. While both types of banks increase the amount of lending in response to a positive shock in the domestic economy such that the discounted future returns from lending equals the dividend payments that can be made today, global banks, in addition, allocate a greater share of their loans to the domestic economy to equate the marginal returns across the two regions. This additional investment and therefore the domestic output response is larger (smaller) when global banks are relatively larger (smaller) in number in the domestic economy.

Figure 3 shows that a similar relationship between the amplitude of the output responses to macroeconomics shocks and the number of global banks can be obtained from simulations with alternative numbers of global banks (between 1 and 99). While this relationship, is positive for each shock, it is not linear since it becomes stronger when there are a larger number of global banks. Consistent with earlier results, I find that the total positive lending response of global banks (including the increase in the amount and the reallocation of loans) in the domestic economy exceeds the positive response of local banks when there are more global banks.

4.3 Different steady state allocation of global bank loans

I proceed by investigating how the domestic economy responds to shocks under different levels of global bank presence in this economy. To do so, I set the steady state share of global bank loans allocated to the domestic economy to values that span the range 0.28 to 0.99.[12] The different allocations within this range also represent the shares of global bank loans in the domestic economy (and one minus their share in the foreign economy) since I set the number of local and global banks equal to their baseline values of 50 throughout this section.

Figure 4 illustrates the maximum amplitudes of the output and the global bank responses to shocks that originate in the domestic economy. These amplitudes, displayed separately for each of the aforementioned allocations of global bank loans, demonstrate a nonlinear relationship between output responses and the steady state share of global bank loans in the domestic economy. Specifically, for productivity and credit shocks, the amplitudes of the output responses are at their highest when global banks have an equal share of lending in each economy at steady state. The responses are lower in magnitude, and negative for credit shocks, when the domestic share of global loans is set equal to lower and higher values. By contrast, the output responses to a depreciation shock that correspond to lower and higher steady state values of the share variable are larger than those obtained under the baseline calibration.

The common determinant of the nonlinear relationships observed is the lower sensitivity of the share variable to the three shocks when global banks' loans are asymmetrically allocated across the two economies. When global banks allocate a larger share of their loans to the domestic economy at steady state, for example, the foreign economy receives a smaller share. This also implies that global banks have larger and a smaller share of the credit market in the domestic and foreign economy, respectively, since their number remains the same in each economy. Given their large size in the domestic economy, global banks then have to reallocate only a small share of their loans to equate

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[12]Setting the parameter to values less than 0.28, while keeping the number of global and local banks equal to 50, caused indeterminacy.

marginal returns across the two economies since they reach diminishing returns quickly in the domestic economy. Similarly, if the domestic economy receives a small share of the global bank loans at steady state, a small change in the share of loans allocated to the foreign economy prompts a sharp returns to capital response in this economy and rapidly dissipates any wedge that may be generated between the marginal returns in the two economies. The sensitivity of the share variable and the response of output reach their highest values when there is an even cross-regional allocation of global loans at steady state.

In response to a depreciation shock, global banks allocate a larger share of their loans to the foreign economy since domestic currency returns are higher in this economy under the baseline calibration. When the steady state values of the share variables are low and high , however, this channel of transmission is weaker as explained above and there is, therefore, a stronger positive response of domestic output.

4.4 Portfolio adjustment costs and different number of banks

So far, I assumed that global banks can shift loanable funds across the two economies without incurring any costs. In this section, I relax this assumption by introducing portfolio adjustment costs. Next, I investigate how my results depend on the total number of banks in the two economies when I deviate from the baseline scenario (with 100 banks).

To incorporate this friction, I assume that global banks incur costs, given by $\tau \left(s_t^n - s_{t-1}^n \right)^2$ for bank n, if they deviate from the previous period's cross-country composition of loans. Adding these costs to the global banks' resource constraint alters the optimality condition in equation (13) as follows:

$$
\theta_{s,t} \left(R_t^k + \frac{dR_t^k}{ds_t} s_t \right) =
$$

$$
2\tau \left[(s_t - s_{t-1}) - \beta (s_{t+1} - s_t) \right] + \varepsilon_{q,t+1} \theta_{s,t}^* \left(R_t^{k*} - \frac{dR_t^{k*}}{ds_t} (1 - s_t) \right) \qquad (23)
$$

where τ is the adjustment cost parameter and it is set equal to 0.05 in my simulations. This value is commonly used to replicate the sluggish behavior of bank portfolios (e.g., Cooley and Quadrini, 2001; Guerrieri et al., 2012) and it implies that global banks lose 0.25 percent of the additional loans if they increase or decrease the baseline allocation of 0.5 by 10 percent.

Table 2 displays the amplitudes of the domestic output responses to domestic shocks when there are portfolio adjustments costs and compares these with the baseline results. The comparison is also made for the different steady state values for the number and the credit market share of global banks in the domestic economy. The results in the first two columns indicate that adding portfolio adjustment costs to the baseline formulation increases the amplitude of the responses to productivity and credit shocks. This relatively larger response of output is not caused by investment. While global banks increase their loans in each country in response to positive credit and productivity shocks, they reallocate a smaller share of their cross-country portfolio to the domestic economy when faced with portfolio adjustment costs. Although this prompts local banks to lend more than they do under the baseline calibration, the increase in the overall level of investment is smaller in magnitude. The reason behind the larger response is rather foreign demand. Specifically the positive domestic shocks cross-subsidize the foreign economy since global banks' loanable funds that do not flow into the domestic economy generate a higher level of economic activity and demand in the foreign economy, this in turn causes an increase in domestic exports that is larger than the increase in investment. In response to a depreciation shock, however, investment in the foreign economy increases relatively more than foreign demand and thus the trade effect described above is not enough to offset the smaller positive response of domestic investment and there is, therefore, a smaller increase in domestic output.

Unlike the conclusions drawn from the first two columns, the comparisons in the next two set of columns, corresponding to the models with relatively higher and lower number of global banks (75 and 25), demonstrate the negative effect that portfolio adjustment costs have on output responses. This negative

effect is at the same time much stronger compared to the positive output effects that portfolio adjustment costs have in the baseline economy. When the number of global banks in the domestic economy is large, local banks, that are smaller in number, do not respond as strongly to the positive shock and thus the relatively smaller response of investment (caused by the restraining effects of portfolio adjustment costs on the reallocation of global bank loans) is not dominated by the positive impact of foreign demand described above. The increase in domestic output with higher number of global banks that face portfolio adjustment costs is, therefore, smaller compared to the model with equal number of local and global banks. Similarly, when global banks are few in number they reach diminishing marginal returns more rapidly and their lending response is smaller. While portfolio adjustment costs have a similar negative effect on output responses under this scenario, the effect is not as strong since the share of global banks in total lending is smaller when they are fewer in number.

Compared to the results in the top panel, the pairwise comparisons in the bottom panel indicate that portfolio adjustment costs have a considerably smaller impact on output responses both when the domestic economy share of global bank lending is high and low (70 and 30 percent, respectively). Consistent with the results in Figure 4 and as described in the previous section, when global banks have an asymmetric position in the two economies, cross-country mobility of their loanable funds is restrained. With a lower degree of portfolio adjustment, therefore, adjustment costs have a smaller impact on output responses.

Panel A of Figure 5 demonstrates that the relationships discussed above are also observed when the number of global banks and global banks' share of lending in the domestic economy are fixed to a broader set of values. The graphs in panels A and B of the figure display the amplitudes of the domestic output responses to domestic productivity shocks only for brevity since the relationships obtained by using credit and depreciation shocks are similar. The first graph of Panel A shows that the relationship between the amplitude of the responses and the number of global banks becomes inverted U-shaped

when there are portfolio adjustment costs. Turning to the share of global banks' lending in the domestic economy, I similarly find, as displayed in the second graph of Panel A, that portfolio adjustment costs have a small impact on the amplitude of output responses.

As a second exercise, I investigate how the number and lending shares of global banks affect output responses by setting the total number of banks in both economies to 10, implying a steady state risk spread of 2.64 percent (on an annual basis) in both economies. The responses obtained from this alternative exercise are displayed in Panel B of Figure 5. The first graph of the panel compares how output responses are related to the number of global banks in the models with 10 and 100 banks. To make this comparison feasible, the horizontal axis values on the graph are set equal to the percentage of banks that are global in the domestic economy. The responses illustrated by the relatively flat dashed line suggest that when the total number of banks is equal to 10, an increase in the percentage of global banks has a smaller positive impact on the amplitude of output responses. This is consistent with the earlier finding that smaller number of global banks reach diminishing returns more quickly and lend less in response to a positive productivity shock. The second graph of the panel, similarly, demonstrates a decrease in the amplitude of responses (albeit smaller in magnitude) with a smaller number of banks and indicates that the inverted U-Shaped relationship remains intact under this alternative scenario.[13]

4.5 Model moments

The central focus of my paper is on identifying mechanisms that describe the relationship between global bank presence and local business cycles by using a relatively straightforward open economy real business cycle framework. While

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[13]When I set the total number of banks to smaller values, I find a larger drop in the amplitude of the output responses in the second graph of Panel B (the maximum response of output is 3.6 percent with 1 global and 1 local bank for example). I could not, however, obtain the responses corresponding to lower lending share values since setting both the number of banks and the share of lending in the domestic economy to low values caused indeterminacy.

determining if and how these mechanisms enhance open economy models' empirical relevance is not one of my goals, it would e informative at this point to compare the model generated output with data to identify and explain any potential shortcomings. To this end, I compare the moments generated from my model to those obtained by using U.S. and Euro Area data in this section. I choose to use these two regions since the economies are both large and they are highly integrated in terms of global banking activity. The first column of Table 3 displays several moments obtained by using data from these two regions and the moments displayed in the other columns correspond to the alternative calibrations of the model. Model generated domestic economy moments indicate higher level of investment and labor volatility and a much stronger positive relationship between labor and output. A common approach to aligning model and data moments along these dimensions is to include investment adjustment costs and wage stickiness that decreases labor supply elasticity (see, e.g. Smets and Wouters, 2007). The absence of these components in my model is the primary reason for the disparity between the model and data moments.

Turning to cross-regional correlations, I find that the model with portfolio adjustment costs performs fairly well in replicating U.S. – Euro Area macroeconomic correlation. A noticeable shortcoming here is the disparity between the cross-country correlation of labor obtained from the model and data. This is not an unusual result since the two economies are characterized by different degree of labor market frictions and this disparity is not modelled in my paper. When portfolio adjustment costs are removed, I find a considerable increase in all cross-country correlation coefficients. I reach a similar conclusion when I compare the results corresponding to a small and a large number of global banks. The implication of these results are that if a large number of global banks operate in both markets without facing any frictions in adjusting their cross-country share of loanable funds, the real economies of the countries become more integrated.

The results in the last two columns indicate that if global banks have asymmetric positions in the two economies, these economies become more

integrated. This finding is consistent with earlier results indicating that this asymmetry in loan allocation restrains global banks' ability to shift funds from one country to the other. Macroeconomic shocks, therefore, prompt global banks to cross-subsidize the economy that the shock does not originate in and cause a higher degree of cross-country symmetry in global bank lending.

5   Concluding remarks

This paper demonstrates that the degree of competition and global bank presence in an advanced economy's credit market is crucial for its business cycles by solving a two country real business cycle model. The amplitudes of the output responses to various shocks in this country are at their highest when the number of global banks is large and when their loans are evenly distributed across the two countries (the latter implying an inverted U-shaped relationship). These results are obtained under the assumption that global banks do not face frictions in shifting loanable funds from one country to the other. Under a more realistic scenario where global banks incur portfolio adjustment costs, both relationships become inverted U-shaped, implying that the amplitudes of business cycles are larger in economies where global banks are not too small or large in number and their presence (credit market share) is neither too low nor too high. These U-shaped relationships suggest that regulations that aim to change the degree of banking competition and global bank presence in a given country would not have a unidirectional effect on economic stability.

These predictions are different from those that can be made after surveying the empirical literature on global/foreign banking. While findings in this literature suggest that banking competition and global bank presence has a unidirectional (either positive or negative) effect on economic stability, I predict that the relationship is inverted U-shaped for advanced economies. It would be interesting to test this prediction by extending empirical models and methodologies to allow for nonlinear effects of competition and global bank presence on economic stability. Although this is beyond the scope of my paper, the predictions of my model are not inconsistent with statistics that de-

scribe foreign banking and economic stability in advanced economies. Figure 6 tabulates and graphs some of these statistics for 15 advanced economies.[14] While it would be imprecise to conclude from the figure that the relationship between output volatility and global bank presence is inverted U-shaped, it would be equally inaccurate to designate this relationship as linear.

The analysis in this paper can be extended in four natural directions. First, one could incorporate nominal rigidities into the model to determine how economies, characterized by different degrees of competition and global bank presence, respond to a broader set of shocks such as monetary policy and price shocks. Second, while following a Cournot setup allowed me to simplify the analysis considerably, the constant number of banks under this setup prevents the dynamics that feed through bank entry and exit. It would be informative to study the impact of bank entry and exit on business cycles in an open economy framework. Third, the degree of banking competition under a Cournot setting is exogenously modelled as it is directly related to the number of banks. This assumption could be relaxed and the degree of competition could be obtained endogenously as a product of the institutional arrangements in a given country that restrict or ease bank lending asymmetrically for small and large banks. Finally, it would be interesting to allow for competition on the production side of the economy and to determine how the demand and supply sides of the credit market interact when both banks and borrowers have market power. This analysis would also help in determining and comparing the whether the transmission of shocks to the economy mainly operates through the demand or supply side of credit markets.

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[14]The choice of countries are determined by data availability in the Bank of International Settlements (BIS) database. Output volatility and the foreign-bank-loans-to-GDP and foreign-bank-assets-to-domestic-bank-assets ratios are computed by using data from the Federal Reserve Bank of St. Louis, FRED database. The two ratios are computed by using annual data from 2000 to 2014. Output volatility is measured as the variance of using quarterly real GDP growth rates (growth over the previous quarter of Gross Domestic Product by expenditure in constant prices, seasonally adjusted) over the 2000Q1-2014Q4 sample period. BIS reporting banks' inflows are measured by using consolidated banking statistics (immediate borrower basis, claims by bank nationality) from the BIS database.

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(For online publication) Appendix A.The Log-linearized Model

In this appendix lower case letters denote deviations from steady state and capital letters without time subscripts denote steady state values.[15] The equations that describe the model are derived by log-linearizing all the variables in the equilibrium conditions around their steady state values. The variables with time subscripts thus represent deviations from steady state. For each equation, except the global banks' arbitrage condition, there is a corresponding equation for the foreign economy. For brevity, I only list the equations for the domestic economy. These equations and their description are as follows:

Consumption demand and labor supply:

$$c_t = E_t c_{t+1} + (\sigma - 1)\, \xi \, (l_t - E_t l_{t+1}) \,/\sigma - \left[r_t^d - (E_t p_{t+1} - p_t) \right] / \sigma \qquad \text{(A.1)}$$

$$c_t + \sigma_l l_t = w_t - p_t \qquad \text{(A.2)}$$

where $\xi = (1 - \alpha)\,/\,[C/Y\,(\sigma - 1)]$. Production function:

$$y_t = \varepsilon_{a,t} + \alpha k_t + (1 - \alpha)\, l_t \qquad \text{(A.3)}$$

Labor and capital demand, and the evolution of capital:

$$w_t - p_t = \varepsilon_{a,t} + \alpha \, (k_t - l_t) \qquad \text{(A.4)}$$

$$r_t^k = \varepsilon_{a,t} - (1 - \alpha)\, (k_t - l_t) \qquad \text{(A.5)}$$

$$k_t = (1 - \delta)\, k_{t-1} + \left[\theta_s B \theta_{s,t} + \theta_s B_h b_{h,t} + \theta_s s B_g^a \left(b_{g,t}^a + s_t \right) \right] / K \qquad \text{(A.6)}$$

Local banks' intertemporal condition (domestic banks):

$$\theta_{s,t} + \beta \theta_s R^k \left[r_t^k + (\alpha - 1)\, \theta_s B_h \left(b_{h,t} + \theta_{s,t} + r_t^k - k_t \right) / N_l K \right] = 0 \qquad \text{(A.7)}$$

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[15] The Greek letters with time subscripts also denote deviations from steady state.

Global banks' intertemporal condition:

$$-\frac{\theta_s s R^k}{\theta_s^* (1-s) R^{k*}} \left(\theta_{s,t} + s_t + r_t^k + (\alpha - 1) \theta_s s \frac{B_g}{N_g K} \left(b_{g,t}^a + 2 (s_t + \theta_{s,t}) + r_t^k - k_t \right) \right) =$$

(A.8)

$$\left(\varepsilon_{q,t+1} + \theta_{s,t}^* - s_t + r_t^{k*} + (\alpha - 1) \theta_s^* (1-s) \frac{B_g^a}{N_g K^*} \left(b_{g,t}^* + 2 \left(\theta_{s,t}^* - s_t \right) + r_t^{k*} - k_t^* \right) \right)$$

Global banks' cross-country loan allocation condition:

$$\theta_s R^k \left(\theta_{s,t} + r_t^k \right) + \theta_s s \left[\frac{(\alpha - 1) \theta_s B_g^a R^k}{N_g K} \left(b_{g,t}^a + 2\theta_{s,t} + s_t + r_t^k - k_t \right) \right] = \quad (A.9)$$

$$\theta_s^* R^{k*} \left(\varepsilon_{q,t+1} + \theta_{s,t}^* + r_t^{k*} \right) - \theta_s^* (1-s) \left[\frac{(\alpha - 1) \theta_s^* B_g^a}{N_g K^*} \left(b_{g,t}^a + 2\theta_{s,t}^* - s_t + r_t^{k*} - k_t^* \right) \right]$$

Deposit rates:

$$r_t^d = \rho r_{t-1}^d + (1 - \rho) \left[\pi_p \left(p_t - p_{t-1} \right) + \pi_y y_t + \pi_{\Delta y} \left(y_t - y_{t-1} \right) \right] \qquad (A.10)$$

Composition of consumption goods and the relative price of consumption:

$$c_t = \gamma_c c_{h,t} + (1 - \gamma_c) c_{f,t} \qquad (A.12)$$

$$p_t = (1 - \gamma_c) \varepsilon_{q,t} \qquad (A.13)$$

Relative demand for domestic consumption goods and imports:

$$c_{h,t} - c_{f,t} = \lambda_c \varepsilon_{q,t} \qquad (A.14)$$

Feasibility condition:

$$y_t = \frac{C}{Y} c_t + \frac{G}{Y} + \frac{B}{Y} \theta_{s,t} + \theta_s \left(\frac{B_h}{Y} b_{h,t} + \frac{s B_g^a}{Y} \left(b_{g,t}^a + s_t \right) \right) + (1 - \gamma_c^*) \frac{C^*}{Y} c_{f,t}^* \quad (A.15)$$

Table 1. Calibration

Parameters	Description	Value
β	time discount parameter	0.99
α	share of capital	0.3
δ	capital depreciation	0.025
σ	inverse intertemporal elasticity of substitution	2
σ_l	inverse labor supply elasticity	2
λ_c	share of domestic goods in the consumption aggregator	1
γ_c	elasticity of substitution between domestic and foreign goods	0.9
ρ	Taylor rule -- interest rate smoothing	0.75
r_π	Taylor rule -- inflation	1.5
r_y	Taylor rule -- output	0.75
$r_{\Delta y}$	Taylor rule -- output growth	0.25

Note: The table displays the parameter values used in calibrating the model. For each shock the persistence and standard deviation parameters are set equal to 0.9 and 0.01, respectively.

Table 2. Portfolio adjustment costs

Different number of local and global banks	Equal number of banks		High number of global banks		Low number of global banks	
	Baseline model	portfolio adjustment costs	Baseline model	portfolio adjustment costs	Baseline model	portfolio adjustment costs
Productivity shock	4.7694	5.0129	6.7586	0.1977	3.2508	0.8179
Credit shock	1.4337	1.5710	10.5358	-0.3476	0.4188	-0.2835
Depreciation shock	0.9566	0.6043	9.7727	-0.0197	-0.0918	-0.0090

| Different steady state portfolio shares	Equal share of domestic loans		Low share of domestic loans		High share of domestic loans	
	Baseline model	portfolio adjustment costs	Baseline model	portfolio adjustment costs	Baseline model	portfolio adjustment costs
Productivity shock	4.7694	5.0129	0.1219	0.0998	1.1981	1.1967
Credit shock	1.4337	1.5710	-0.3135	-0.3127	-0.2865	-0.2865
Depreciation shock	0.9566	0.6043	0.0133	0.0124	0.0597	0.0594

Notes: The table displays the amplitudes of domestic output responses (measured as percentage deviations from steady state values) to a one standard deviation domestic shock when global banks face portfolio adjustment costs. The values in the top panel are obtained by setting the number of global banks in the domestic economy equal to 25, 50 and 75. The values in the bottom panel are obtained by setting the share of global banks' loans in the domestic economy to 30, 50 and 70 percent.

Table 3. Business cycle moments

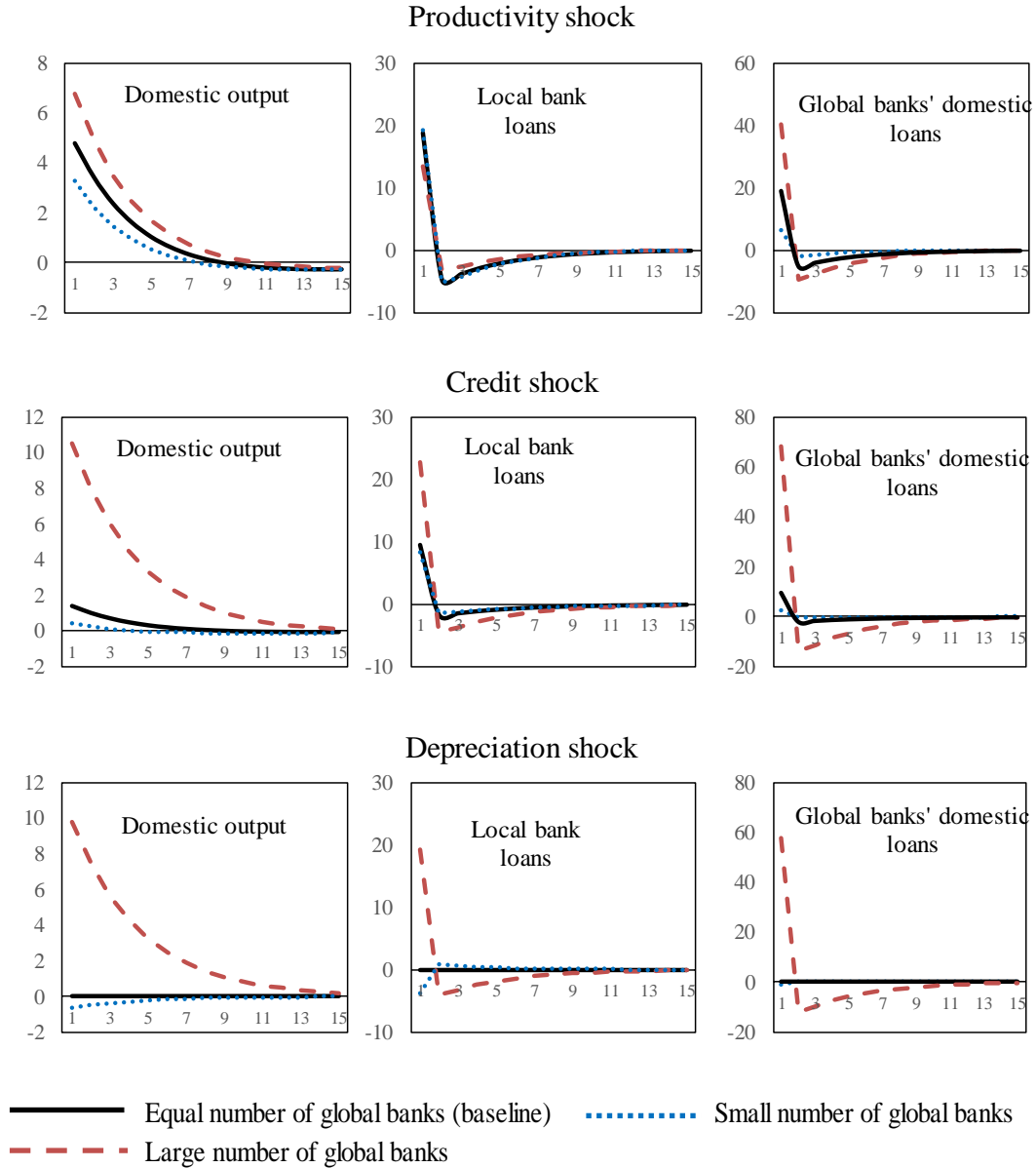|	Data	With portfolio adjustment costs	Without portfolio adjustment costs	Low number of global banks	High number of global banks	Low share of domestic loans	High share of domestic loans
Domestic economy							
$\rho(y,i)$	0.754	0.225	0.340	0.225	0.233	0.387	0.388
$\rho(y,l)$	0.471	0.999	0.999	0.985	0.994	1.000	1.000
$\sigma(c)/\sigma(y)$	0.812	0.809	0.705	0.731	0.711	0.703	0.703
$\sigma(i)/\sigma(y)$	3.230	5.603	5.864	5.850	5.614	5.879	5.878
$\sigma(l)/\sigma(y)$	0.736	1.043	1.003	1.010	1.006	1.002	1.002
Cross-regional correlation							
$\rho(y,y^*)$	0.573	0.652	0.952	0.495	0.899	0.994	0.994
$\rho(c,c^*)$	0.599	0.599	0.951	0.291	0.821	0.994	0.993
$\rho(i,i^*)$	0.613	0.760	0.995	0.686	0.995	1.000	1.000
$\rho(l,l^*)$	0.108	0.641	0.952	0.417	0.875	0.994	0.994

Notes: The table displays moments obtained from U.S. and Euro Area data and the unconditional model moments that are computed under different calibrations and by including portfolio adjustment costs.

Figure 1. Responses to domestic economy shocks, baseline model

Productivity shock

Credit shock
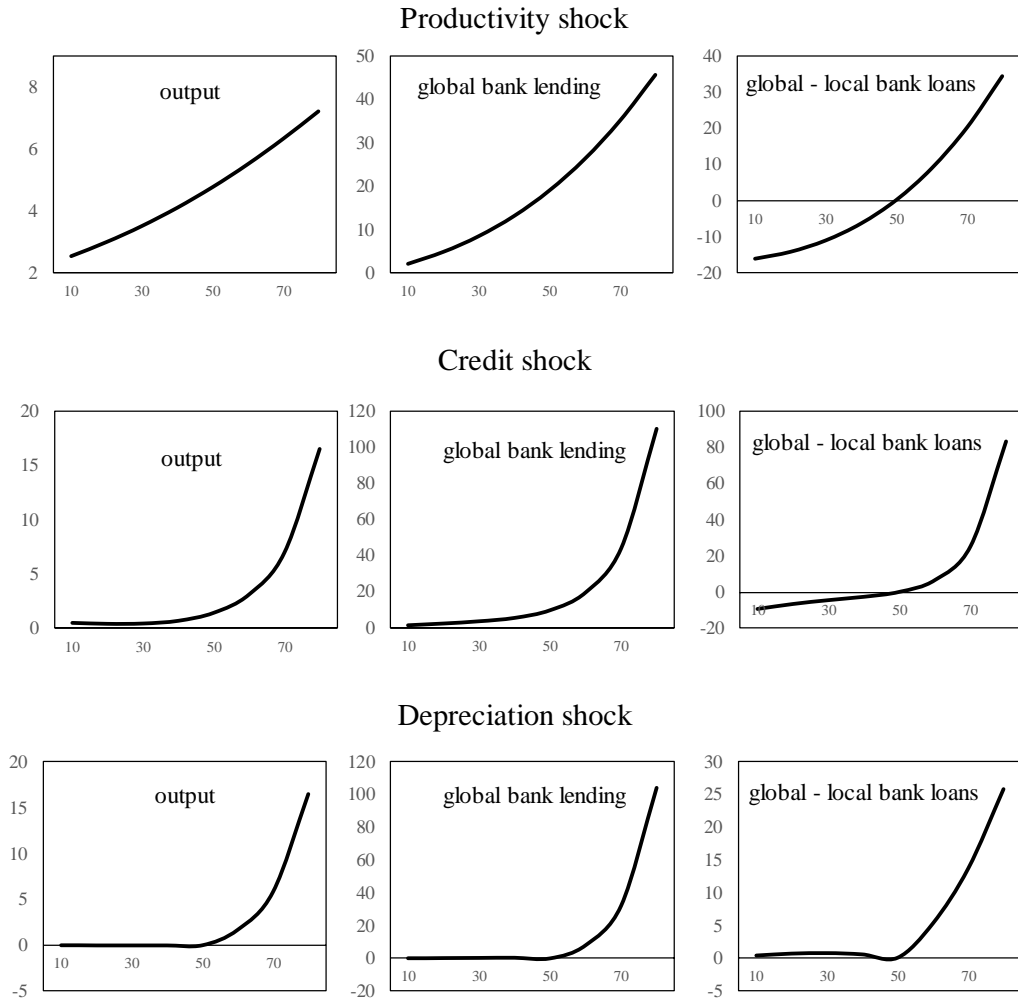

Depreciation shock
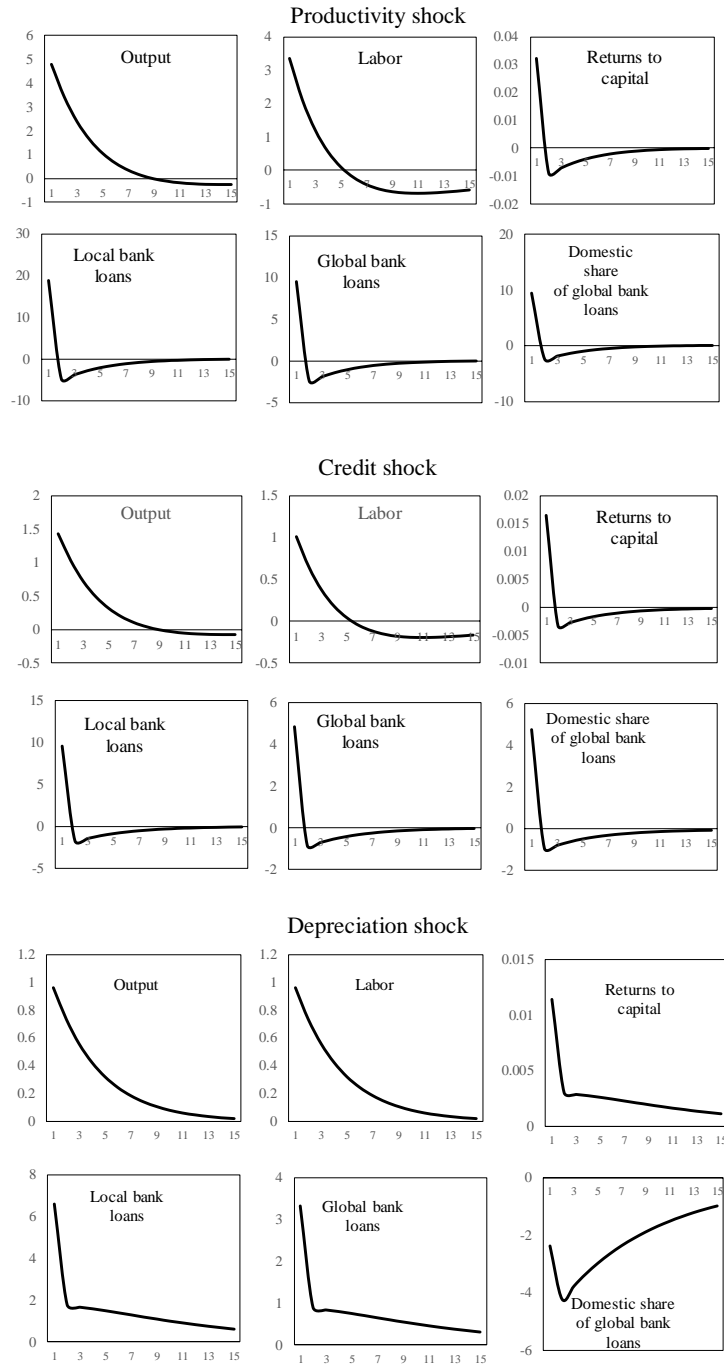
Note: The figure displays the responses (percentage deviations from steady state) of domestic economy variables to a one standard deviation domestic shock under the baseline calibration.

Figure 2. Number of global banks and responses to domestic shocks

Productivity shock

Credit shock

Depreciation shock

Legend:
— Equal number of global banks (baseline) ···· Small number of global banks
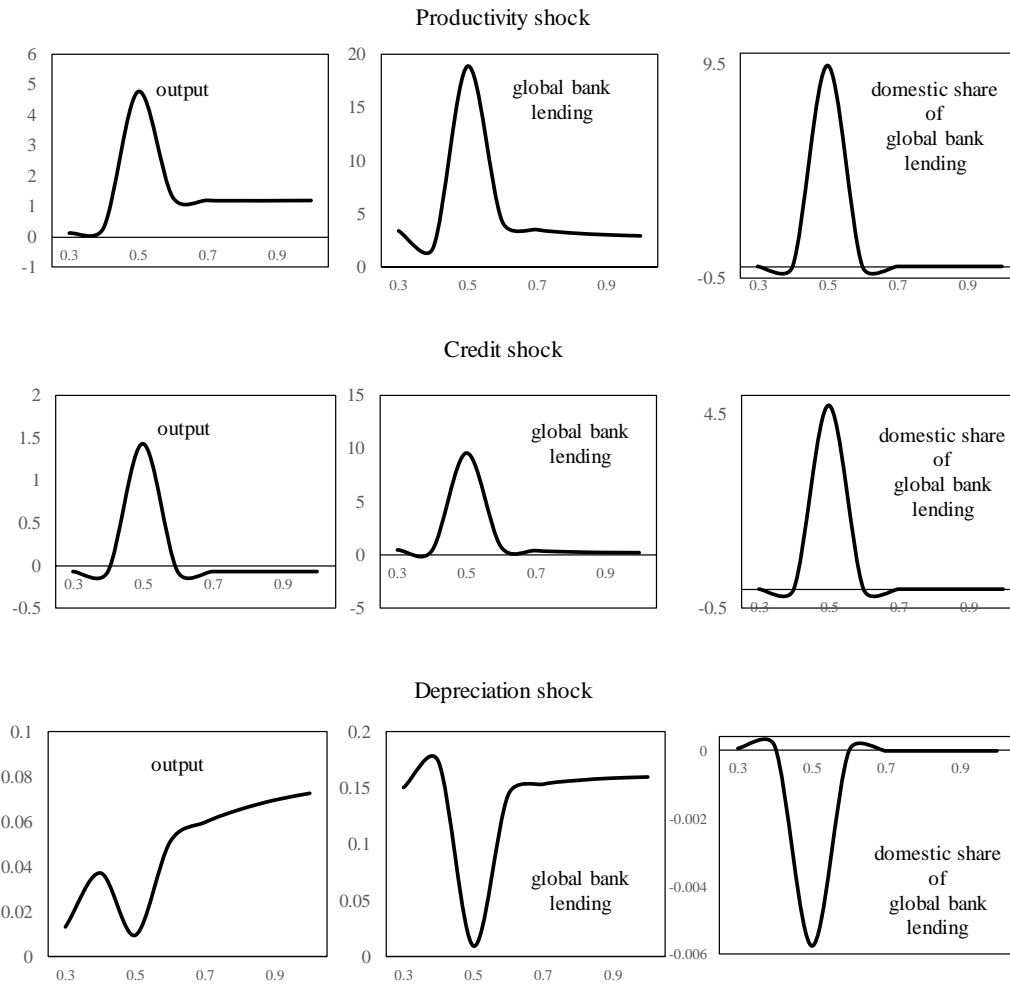– – – Large number of global banks

Notes: The figure displays the impulse responses (measured as percentage deviations from steady state values) of domestic economy variables to a one standard deviation domestic shock. The responses are obtained by setting the number of global banks in the domestic economy equal to 25, 50 and 75.

Figure 3. Number of global banks and the amplitude of output responses to domestic shocks

Productivity shock

Credit shock

Depreciation shock

Notes: The figure displays the amplitudes of domestic variable responses (measured as percentage deviations from steady state values) to a one standard deviation domestic shock. These amplitudes are measured by setting the steady state number of global banks to values between 1 and 99.

Figure 4. Global banks' loan allocation and the amplitude of the responses to domestic shocks


Notes: The figure displays the maximum amplitudes of domestic variable responses (measured as percentage deviations from steady state values) to a one standard deviation domestic shock. The responses are obtained by setting the share of global banks' loans in the domestic economy to values between 28 to 99 percent.
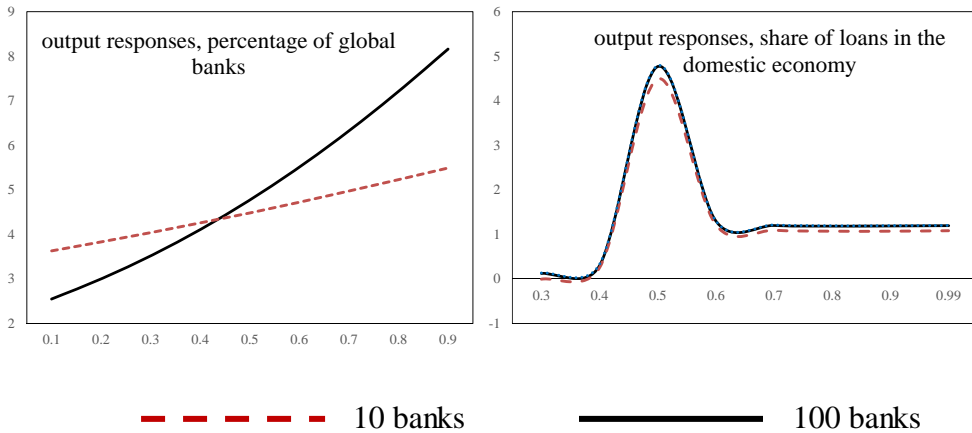
Figure 5. Portfolio adjustment costs and different number of banks, domestic output responses to domestic productivity shocks

*Panel A. Responses with and without portfolio adjustment costs*

- - - - - with portfolio adjustment costs ———— without portflio adjustment costs
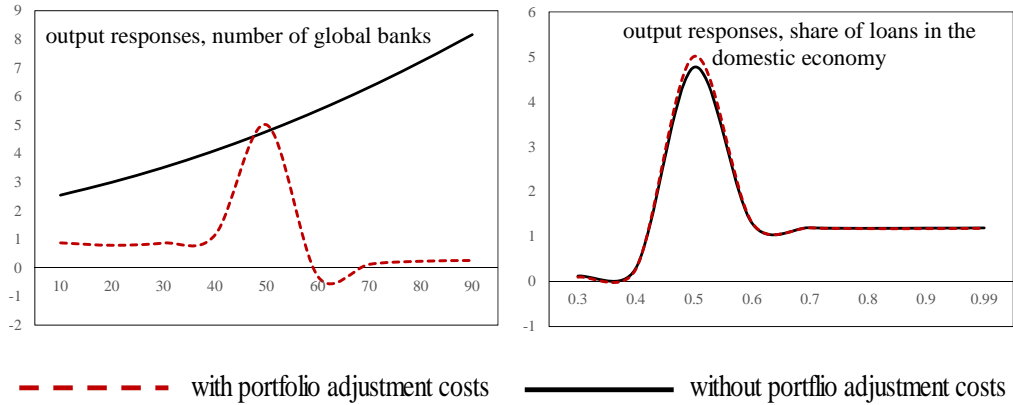
Panel B. Responses with different number of banks

- - - - - 10 banks ———— 100 banks

Notes: The horizontal axis on the first graph of Panel A and B represents the fraction of banks in the domestic economy that are global. The horizontal axis on the second graph of Panel A and B represents the steady state share of global bank lending in the domestic economy. The solid line in each graph represents the baseline responses. Output responses displayed with the dashed line in Panel A are obtained by setting the portfolio adjustment costs parameter to 0.005. Output responses displayed with the dashed line in Panel B are obtained by setting the total number of banks in the domestic economy to 10.

Figure 6. Descriptive statistics

	Output volatility	Foreign bank loans / GDP	Foreign Bank / Domestic Bank assets	BIS banks' inflows/ Domestic Credit
Austria	0.79	28.00	80.59	61.49
Belgium	0.33	79.35	113.83	111.23
Canada	0.37	16.63	32.37	15.57
Switzerland	0.34	128.79	137.74	30.80
Germany	0.84	30.06	55.76	33.26
Denmark	0.81	46.29	88.05	39.18
Spain	0.47	28.48	55.68	29.68
France	0.27	40.47	56.05	37.40
U.K.	0.44	127.92	131.48	64.47
Italy	0.55	22.08	53.03	45.28
Japan	1.28	12.95	17.47	11.31
Netherlands	0.48	84.26	124.65	55.31
Portugal	0.70	66.03	96.25	51.45
Sweden	1.03	39.44	57.90	39.43
U.S.	0.43	20.08	36.54	58.25
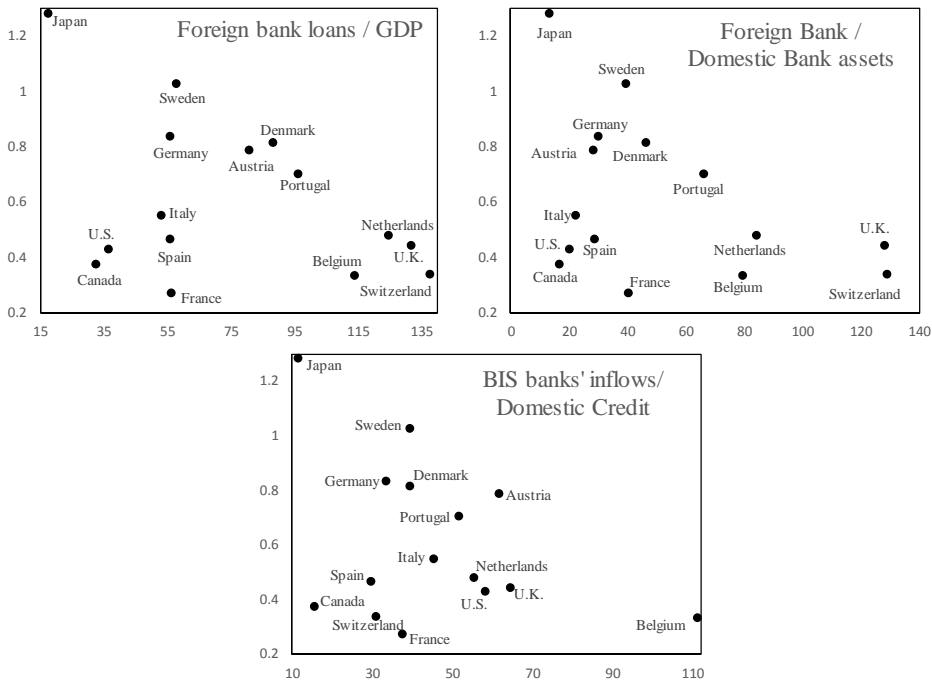
Note: The variables displayed in the first three columns and the last column are computed by using data from the Federal Reserve Bank of St. Louis, FRED and the Bank of International Settlements databases, respectively. The vertical axis values for each graph are the variances of quarterly GDP growth rates between 2000 and 2014. The horizontal axis values are the values displayed in columns 2 to 5 of the table.