Global Banks' Dynamics and the International Transmission of Shocks*

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Abstract

15% of the loans in the US are held by foreign banking institutions, headquartered in more than 50 countries. Using bank-level data, we present novel stylized facts describing characteristics of foreign institutions and compare them to the incumbent set of banks, distinguishing foreign banks by their mode of entry. We incorporate these facts into a structural model of entry in the banking sector where profit maximizing foreign banks decide whether and how to enter a foreign market. The model sheds light on the relationship between market access, capital flows, regulation, and entry, and has implications for the risk exposure that different organizational forms entail.

Keywords: banks, entry, multinational firms

JEL Classification: F12, F23, F36, G21

1 Introduction

"Spanish-based Santander (...) acquired Sovereign Bank in 2009 as the springboard for its US ambitions, [establishing] 700 branches and ATMs across nine northeastern

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states."

"Santander is the fourth-largest bank by deposits in Massachusetts and has 1.7 million US customers. Emilio Botin, chairman of the parent company, said last week during a visit to the United States that he hopes to see profits for the American business double in three years to $2 billion." (The Boston Globe, October 26th 2013)

15% of the outstanding loans in the U.S. are held by various types of foreign banking institutions, headquartered in more than 50 countries. Like Banco Santander SA in the quote above, these multinational banks have some ability of reallocating profits and losses in different markets, and they are often very large players in the countries in which they operate. As noted by Goldberg (2009), the sheer size of foreign banking institutions and their involvement with the real economy makes them important vehicles for the global transmission of shocks. Various empirical studies have explored the role of multinational banks in the transmission of shocks across countries.[1] To our knowledge however, previous work has overlooked the importance of banks' mode of entry for shock transmission. Moreover, most of the existent work has been conducted using exclusively reduced form analysis.[2]

This paper contributes to the literature in two ways. First, methodologically, we develop a micro-founded structural model of foreign entry in the banking sector. The model is designed to be consistent with a number of stylized facts from U.S. bank-level data while at the same time considers the institutional details of the banking industry. Second, the model explicitly distinguishes foreign banking institutions by their mode of entry, which is endogenous and responds to differences in cost structure and management efficiency. The model predicts selection along several dimensions of the entrants' characteristics. We use data on global international banks together with U.S. data on foreign branches and subsidiaries to confirm this prediction.

Despite the presence of a wide variety of organizational forms in the data, we focus our analysis on the two most prominent forms of foreign banking institutions in the US: branches and subsidiaries. The existing banking regulation treats branches and subsidiaries in different ways, so that the kind of activities that these firms are allowed to undertake differ: for example, while subsidiaries are separately capitalized, branches do not raise independent equity and can freely transfer funds to and from their parent.[3] We model carefully the institutional differences between

[1] See most notably Cetorelli and Goldberg (2011, 2012a,b).

[2] Notable exceptions are Bremus et al. (2013), de Blas and Russ (2013), Niepmann (2012), and Niepmann (2013).

[3] Section 2 illustrates the institutional features of the U.S. banking sector. Appendix A summarizes the U.S.

branches and subsidiaries, so that our framework is an accurate description of the global banking sector. Moreover, branches and subsidiaries display large differences in the extent of their common activities: subsidiaries appear to be larger than branches (in terms of deposits, loans, and overall assets), and the two types of institutions differ dramatically in their portfolio composition. The stylized facts we present help us discipline the parameterization of our model. The fact that the model is consistent with these stylized facts raises our confidence in effectively using it as a tool to study the response of the banking sector to various kinds of shocks.

Since modeling banks' behavior entails the study of several interconnected markets (loans, deposits, trading assets, equity) we first present an intratemporal version of the model whose scope is to present the trade-offs that banks face in the simplest possible way. Our toy model is a monopolistically competitive extension of the Monti-Klein model (see Klein, 1971, and Monti, 1972), augmented to include risky loans, deposits and investment.

We start with a static model where foreign banks decide to enter into a country and the form of entry (subsidiary or branch) without taking into account any dynamics. Banks are heterogeneous in their efficiency managing assets and liabilities, and there are sunk costs of entry into the new country. We find that there exists a threshold in efficiency which implies that more productive banks will open a subsidiary. We then extend the model to an infinite horizon with aggregate shocks using the investment under uncertainty framework initially proposed in Dixit (1989). In particular, we use the mechanism developed in Fillat and Garetto (2013), which applies investment under uncertainty to foreign direct investment. The dynamic model is better equipped to describe realistically the decisions of banks of how to react to shocks hitting loans supply or deposit demand at varying time horizons. The dynamic model also predicts that larger firms in terms of equity (and therefore assets, and liabilities) are more likely to enter in a foreign market.

The machinery also allows us to do conterfactual analysis of regulatory policies that target the expansion of foreign banks. We parameterize the model to match moments of the data and use it to simulate banks' optimal responses to various kinds of shocks and policies.

[HERE LITERATURE REVIEW TBA]

The remainder of the paper is organized as follows. Section 2 illustrates the data and documents a series of stylized facts about foreign banking institutions in the U.S. market. Section 3 develops a simple model that illustrates the decisions that multinational banks face. The model is extended

banking regulation and the changes it underwent in the past decades.

in Section 4 to a fully dynamic framework featuring frictions to banks' reallocation possibilities across different activities. The full model is calibrated and used to perform counterfactual exercises in Section 5. Section 6 concludes.

2 Foreign Banks in the US: Some Facts

The presence of foreign institutions in the U.S. banking market is substantial. Figure 1 shows data from foreign bank organizations operating in the U.S. About 20% of the aggregate assets held by banks operating in the U.S. belongs to banking offices that are ultimately owned by a foreign parent. Deposits and loans display a similar pattern over the last two decades, ranging from 15% of total deposits to 30% of the total commercial and industrial loans in hands of foreign owned banking offices.

A foreign bank may enter in the U.S. market under different organizational forms. The choice depends, in part, on the business line that the foreign bank wants to export. Foreign banks may open a *subsidiary bank*, which is subject to U.S. regulation and capital requirements. A subsidiary bank may accept both wholesale deposits and retail insured deposits and performs the same type of operations than a domestically owned bank does. Possible capital flows between the subsidiary and the parent must happen at arm's length. This means that if a parent wants to transfer funds to or from a subsidiary in the U.S., it must do so in the interbank market at market prices. Another established form of entry is via *branches and agencies*, which are subject to U.S. regulation, but not to capital requirements, as their balance sheet is consolidated with the one of the parent. A branch or agency may give loans, but accepts only non-insured deposits. Branches and agencies display large intrafirm capital flows with their foreign parents.

Subsidiaries and branches are the two most relevant forms in which foreign banks enter the U.S. banking system. Jointly, they represent more than 99% of the assets held by foreign-owned banking offices. In terms of business line, these two forms of entry also entail activities that are close to those of a traditional bank: in essence, accept deposits from savers, give loans to borrowers, and manage the maturity mismatch between savers and borrowers. In addition to branches and subsidiaries, the data display two more types of organizations. *Edge and Agreement Corporations* cannot engage in business in the U.S. with U.S.-based entities, including making any domestic loan or accept domestic deposits. Lastly, *Representative Offices and Non-depository Trusts* do not accept deposits or give loans, and their asset holdings are negligible, compared with the other

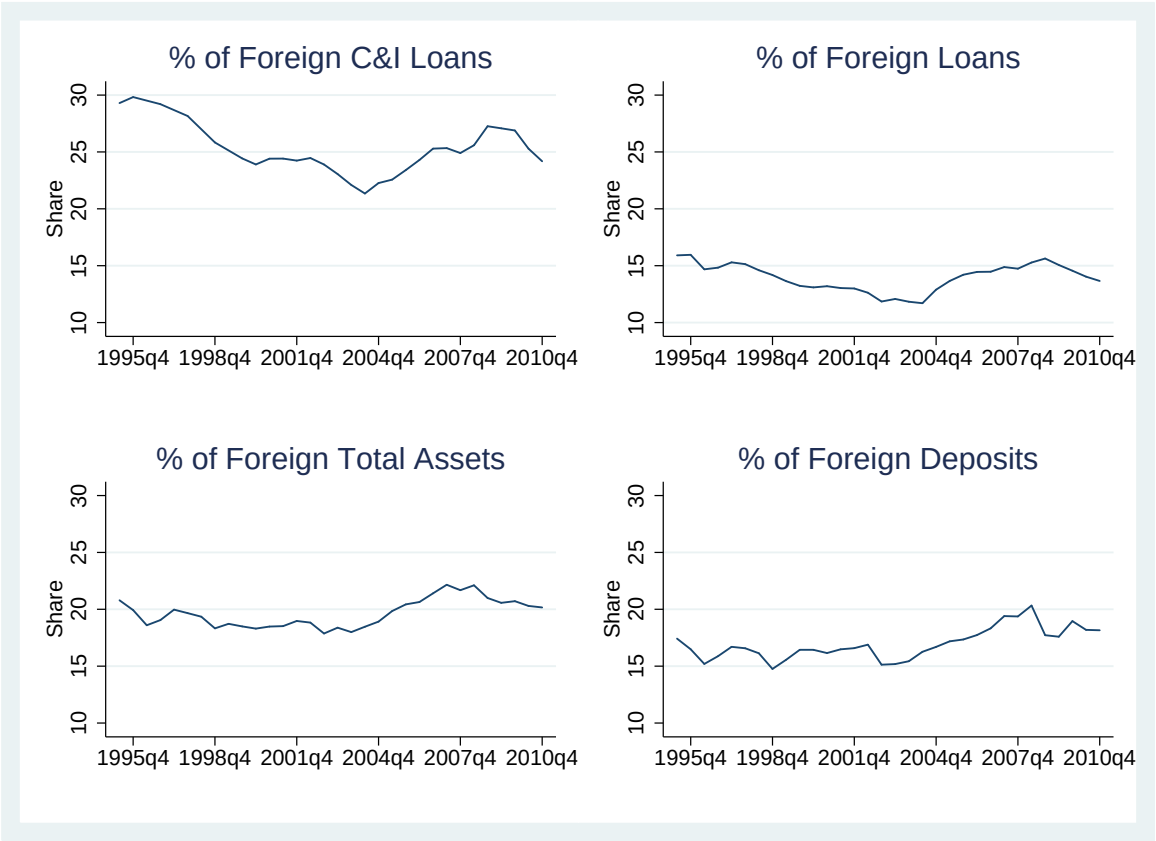

Figure 1: Percentage of assets, commercial and industrial loans, total loans, and deposits held in foreign owned banking institutions in the U.S. Data source: Share Data for U.S. Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign Owned U.S. Commercial Banks (state member, non-member and national) plus U.S. Branches and Agencies of Foreign Banks. Data are available on the Federal Reserve Board of Governors website, http://www.federalreserve.gov/releases/iba/fboshr.htm. The data covers the U.S. offices of foreign banking organizations that are located in the 50 states and the District of Columbia. Offices located in Puerto Rico, American Samoa, Guam, the Virgin Islands and other U.S.-affiliated insular areas are excluded. Foreign-owned institutions are those owned by a bank located outside of the United States and its affiliated insular areas.

types of foreign entities. Given their small weight in aggregate banking activities, we drop Edge and Agreement Corporations, Representative Offices and Non-depository trusts from our sample and focus the analysis on foreign branches and subsidiaries.

We use data from the "Quarterly Reports of Condition and Income" that every national bank, state member bank, insured state nonmember bank, and savings association chartered in the U.S. is required to file, regardless of the ultimate owner's headquarter location. These reports are better known as "Call Reports".[4] In addition to domestic banks, subsidiaries of foreign banks must fill out these reports as well. We also use the quarterly "Report of Assets and Liabilities of U.S. Branches and Agencies of Foreign Banks" that every branch and agency of a foreign bank is required to file.[5] This report is similar to the Call Reports but it also contains the balances due from and due to the head office (parent) and related depository institutions, wherever located, including unremitted profits, and any reserve accounts. The rest of items reported exclude any transaction with related depository institutions. The Riegle-Neal Interstate Banking and Branching Efficiency act of 1994 repealed interstate restrictions in the original Bank Holding Company act of 1956. We restrict the sample period from 1995 to 2010 to avoid capturing market dynamics stirred by the deregulation of interstate banking.[6]

Table 1 summarizes the average assets, loans, deposits, and number of establishments for the three types of banks that we consider: domestic depository institutions owned by a domestic company (which we refer as to domestic banks), subsidiaries owned by a foreign depository institution (foreign subsidiaries), and branches of a foreign depository institution (foreign branches). The average subsidiary of a foreign bank is substantially bigger than the average branch in terms of deposits, loans, and overall assets[7]. In addition, the average balance sheet of a foreign office (either branch or subsidiary) is substantially larger than the one of a domestic bank in terms of assets, loans, or deposits. Finally, foreign banking institutions are few compared to the number of domestic insti-

[4]FFIEC, which stands for "Federal Financial Institutions Examination Council", collects the Call Reports in two different reporting forms: FFIEC 031 and FFIEC 041. Banks with foreign offices must report the FFIEC 031 form and banks with only domestic offices must file the 041. A foreign office is defined as either (a) an international banking facility, (b) a branch or consolidated subsidiary in a foreign country, or (c) a majority-owned Edge or Agreement subsidiary. The information about domestic operations is identical across reports for all practical purposes.

[5]FFIEC 002.

[6]Appendix A summarizes the regulatory reforms that have been shaping the U.S. banking industry in recent years, with special focus on those regulations that had an impact on foreign banks operating in the U.S.

[7]The assets side of a bank's balance sheet includes many types of loans, wholesale (commercial and industrial loans, real estate loans, and loans to other financial institutions) and retail (mortgages, home equity, auto loans, and credit cards). In addition, other assets held by banks are securities (treasuries, residential and commercial mortgage-backed securities, other asset-backed securities, and a small amount of equity) and trading assets. The liabilities side includes deposits, short-term and long-term debt, and owners' equity.

Table 1: **Summary Statistics.** Assets, loans, and deposits of the U.S. offices of domestic and foreign banking organizations for 2010. Quantities are reported in billion dollars. Data source: U.S. Share Data for U.S. Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign Owned U.S. Commercial Banks (state member, non-member and national) plus U.S. Branches and Agencies of Foreign Banks, available on the Federal Reserve Board of Governors website, http://www.federalreserve.gov/releases/iba/fboshr.htm.

	Mean	Std. Dev.	Median	N. obs.
		Assets		
Domestic Banks	1,649.91	33,640.07	147.62	6934
Foreign Subsidiaries	15,270.86	35,613.84	1,314.64	64
Foreign Branches	8,892.19	19,548.42	803.33	215
		Deposits		
Domestic Banks	1,160.49	23,003.66	123.82	6934
Foreign Subsidiaries	11,006.95	26,373.87	985.61	64
Foreign Branches	5026.401	11990.65	299.34	215
		Loans		
Domestic Banks	940.6878	16038.81	93.389	6934
Foreign Subsidiaries	8092.347	17701.04	748.5415	64
Foreign Branches	2215.568	5411.098	345.288	215

tutions in the U.S.: only about 4% of banking institutions located in the U.S. are foreign-owned. Among foreign-owned banking institutions, branches are more pervasive than subsidiaries (at a ratio of one subsidiary to 3.3 branches).

Figures 2-4 plot the time series of assets, loans, and deposits for domestic banks, subsidiaries of foreign banks, and branches of foreign banks. The same size differences that are apparent in the summary statistics appear in the figures, and they have been growing over time. Domestic institutions appear much smaller on average than foreign institutions, suggesting selection of the largest banks into foreign markets.[8] This is consistent with a widespread tendency of large firms in all sectors to self-select into participation in foreign markets.[9] The figures suggest that a similar mechanism operates in the banking sector.

One of the reasons for branches to be large on average is the net amount due from their related institutions. Part of the differences in assets between branches and subsidiaries can be explained by international transfers within the boundaries of the multinational bank. Figure 4 shows the average asset holdings for the three type of offices. We plot the average assets in branches with and

[8] Domestic banks include all depository institutions in the U.S., including small regional and community banks.
[9] Bernard et al. (2009), among others, document selection by size of exporting and multinational firms.

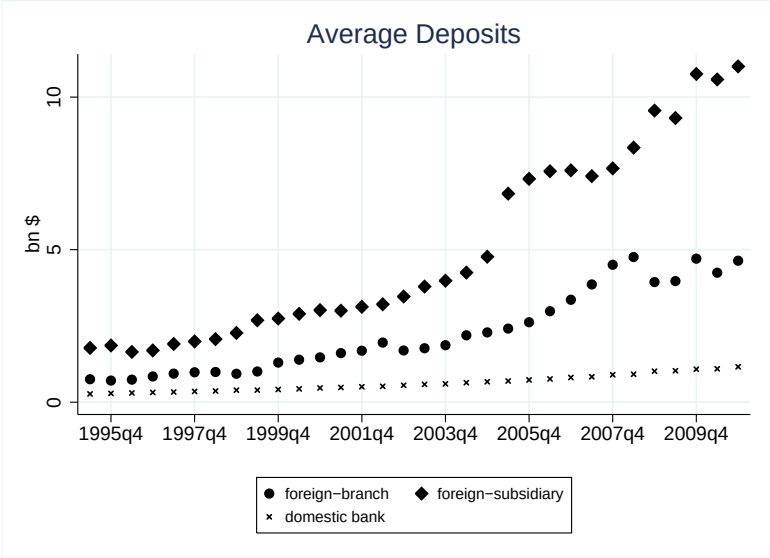

Figure 2: **Deposits**. Time series of average deposits per domestic bank, foreign subsidiary, and foreign branch. Data source: FFIEC 031, FFIEC 041, and FFIEC 002.

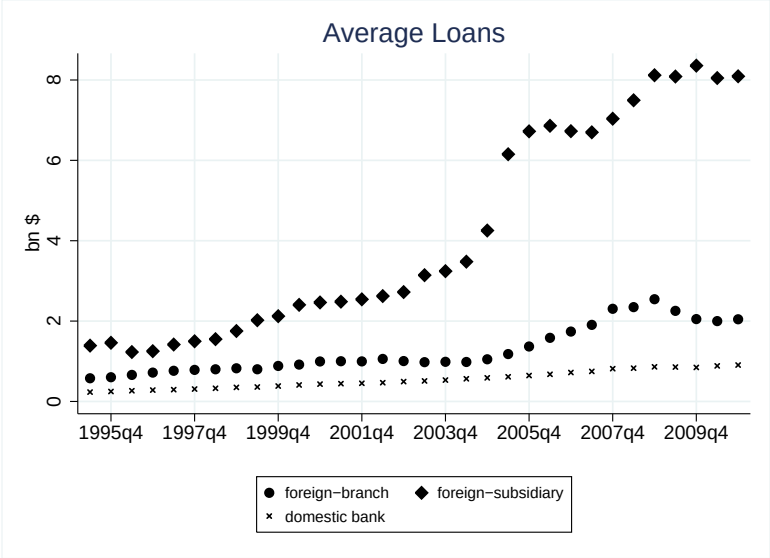

Figure 3: **Loans**. Time series of average loans per domestic bank, foreign subsidiary, and foreign branch. Data source: FFIEC 031, FFIEC 041, and FFIEC 002.

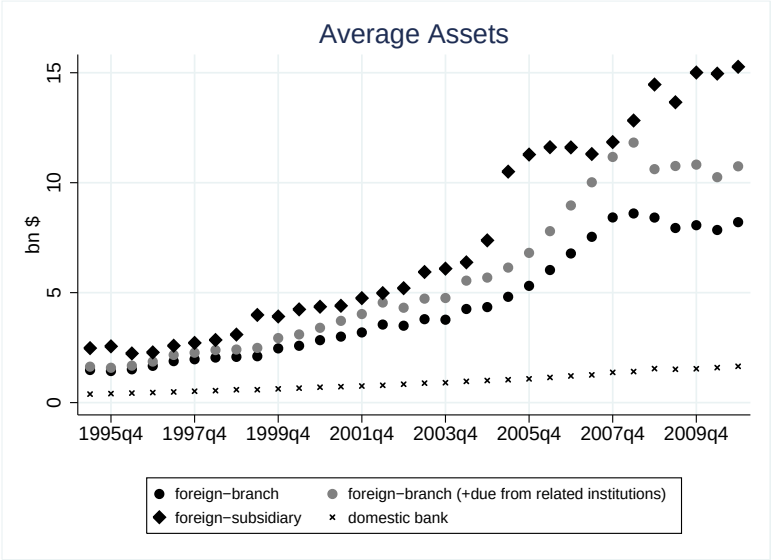

Figure 4: **Assets**. Time series of average assets per domestic bank, foreign subsidiary, and foreign branch (with and without net due from related institutions). Data source: FFIEC 031, FFIEC 041, and FFIEC 002.

without the net due from their related parties: these intrafirm flows account for about 25% of the average assets in foreign owned branches. Figure 5 shows the evolution of the aggregate net flows to and from related institutions, confirming that throughout the sample period the amounts that parent banks have been borrowing from their foreign branches are much larger than the amounts that foreign branches have been borrowing from their parent banks. This pattern is consistent with the evidence shown by Cetorelli and Goldberg (2012a,b) about foreign branches lending to U.S. parents.

The size differences that the time series plots display are not driven by a few firms holding extraordinarily large balance sheets. As we can observe in Figure 6, deposits, loans, and assets size distributions of foreign subsidiaries first-order stochastically dominate the analogous distributions of foreign branches.

The differences in assets between foreign subsidiaries and foreign branches are narrower than the differences in loans and deposits. Figure 7 shows the time series of loans as a share of total assets for domestic banks, foreign owned branches, and subsidiaries of foreign banks. The domestic banks have historically the highest ratio of loans to total assets. At first glance, subsidiaries are closer to domestic banks throughout the entire sample, as they are both subject to the same regulations. About 55% of their assets are loans for the time period considered. Branches, on the other hand,

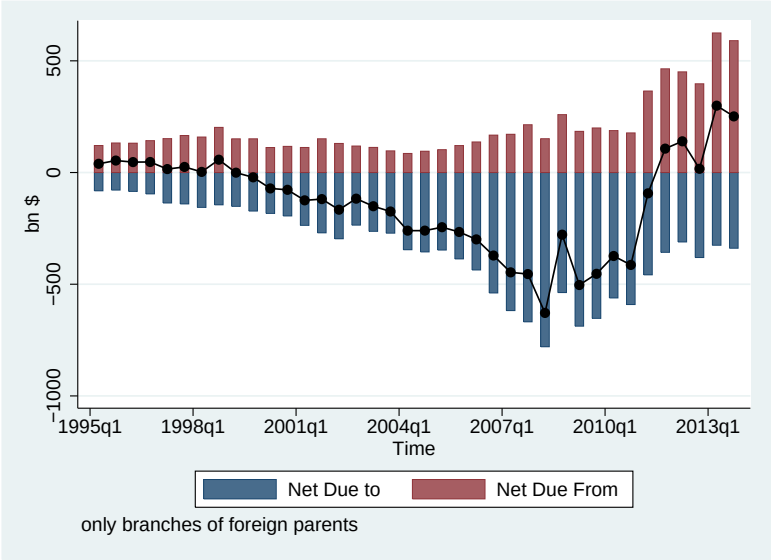

Figure 5: **Net intrafirm flows for foreign branches.** Net due from and net due to related parties. Data source: "Report of Assets and Liabilities of U.S. Branches and Agencies of Foreign Banks", or FFIEC 002. The items reported here are *Net due from related depository institutions* and *Net due to related depository institutions*, 2 and 5, respectively, from the "Schedule RAL–Assets and Liabilities". The solid line represents the net due from related parties if positive (item 2 minus 5).

display a different portfolio composition. The percentage of loans is much lower than those observed for domestic banks and subsidiaries, between 30 and 40%, more in line with what was observed in investment banks during the last decades. Taking a closer look at the portfolio composition, Figure 8 shows the loan portfolio of the three groups in broad terms. We observe that the loan portfolio of a branch is significantly different than the loan portfolio of a subsidiary and of a domestic bank. In particular, foreign branches do not participate in the real estate markets as actively as foreign subsidiaries and domestic banks. Branches have a 50% share of their assets invested in commercial and industrial loans, while that barely represents 20% of the assets in a domestic bank's or a subsidiary of a foreign bank's balance sheet. Anecdotal evidence and conversations with regulators support the claim that foreign branches behave more similarly to investment banks than to commercial banks.

Comparing the affiliates of foreign banks with domestic incumbents is instructive to think about competition in the host market, but in order to argue strongly about the fact that there is a selection mechanism driving the choices of foreign banks to enter the U.S., we need to compare the operations of these affiliates and of their foreign parents with the ones of foreign national banks that do not enter the country.

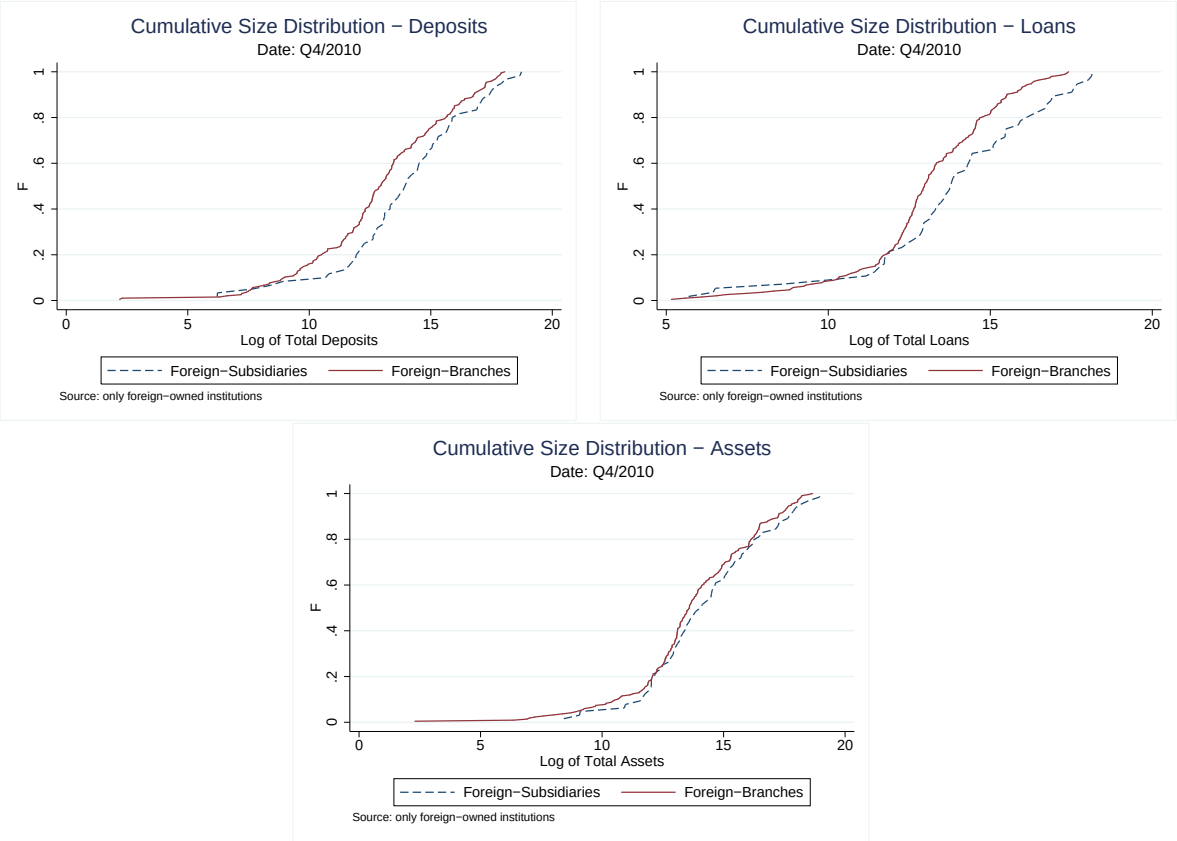

Figure 6: **Size Distributions.** Cumulative distribution functions for deposits, loans, and assets, respectively, held in foreign owned subsidiaries and branches in the fourth quarter of 2010. Data source: U.S. Share Data for U.S. Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign Owned U.S. Commercial Banks (state member, non-member and national) plus U.S. Branches and Agencies of Foreign Banks, available on the Federal Reserve Board of Governors website, http://www.federalreserve.gov/releases/iba/fboshr.htm.

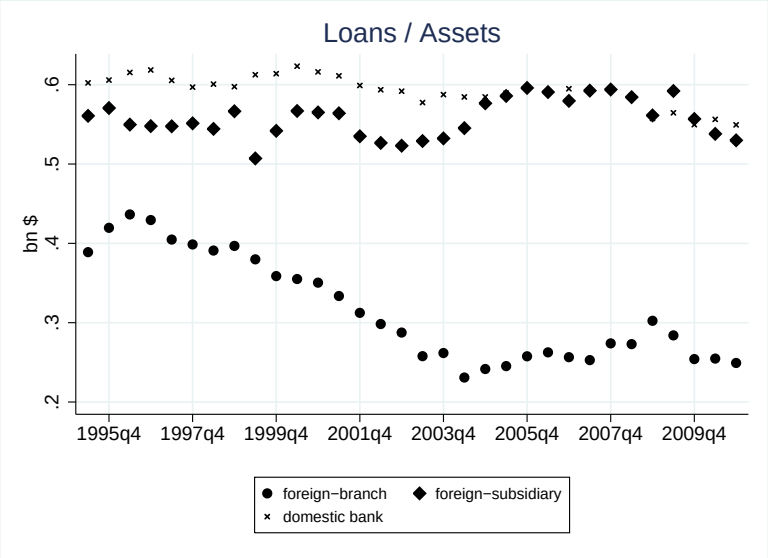

Figure 7: **Loans-to-assets ratio.** Time series of the percentage of loans in the asset side of the balance sheet of the three types of banking offices: domestic banks, foreign subsidiaries, and foreign branches. Data source: Call Reports and FFIEC 002.

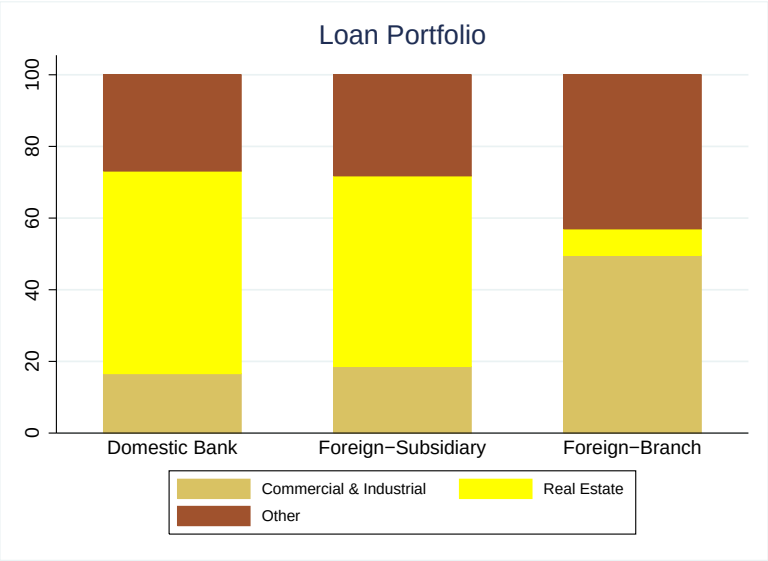

Figure 8: **Loan Portfolio.** Average loan portfolio for each of the three types of banking institutions considered in the paper: domestic bank, foreign-owned subsidiary, and foreign-owned branch. Loans are divided in commercial and industrial (C&I), commercial real estate (CRE), and other loans (fourth quarter of 2010).

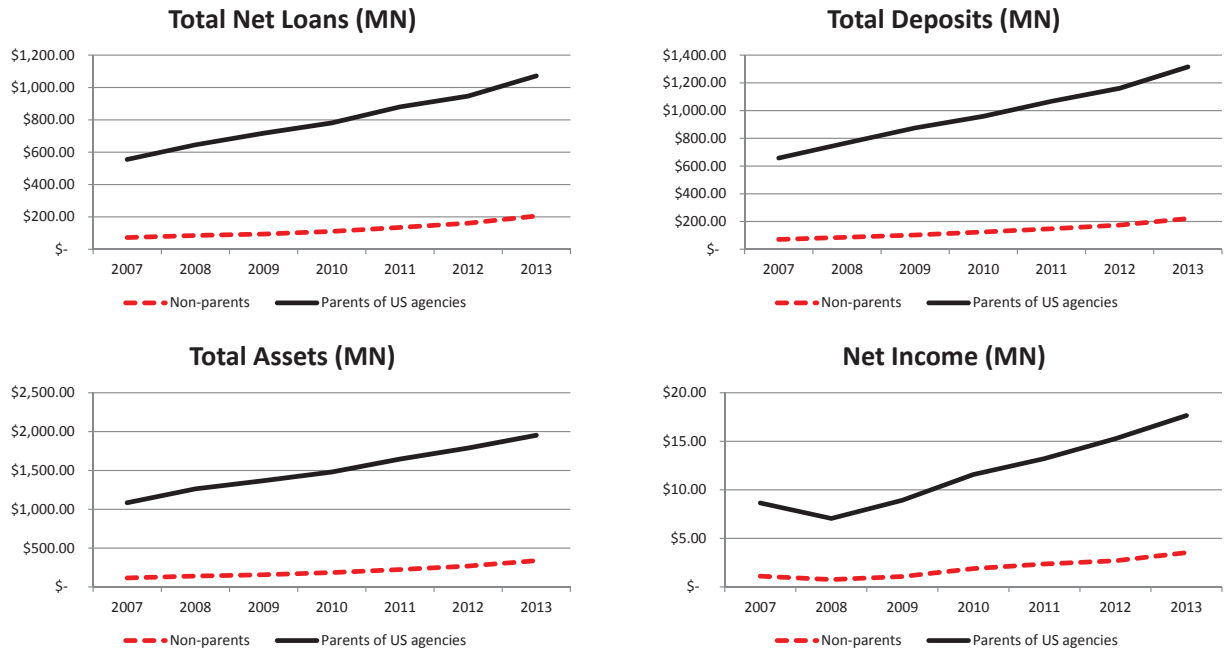

Figure 9: **Foreign Parents vs Foreign National Banks.** Comparison of loans size, deposits size, assets size, and net income of foreign national banks versus foreign parents of U.S.-based subsidiaries and branches. Source: SNL data for top tier parents of U.S. branches and subsidiaries from Canada, Europe, and Asia-Pacific. Sample period: 2007-2013.

This comparison is shown in Figure 9, which reports measures of size (loans, deposits, and overall assets) and profits for foreign national banks and for the foreign parents of U.S.-located branches and subsidiaries. It is evident that larger and more profitable banks enter the U.S. market through affiliates.

Lastly, in Figure 10 we show that the amount of assets banks hold in foreign countries is positively related to their domestic size. This is also evidence in support of selection if we believe that banks are able to "transfer" their managerial efficiency when going abroad.

In sum, we documented that the foreign presence in the U.S. banking system is a large phenomenon. We have highlighted several stylized facts: foreign banks are larger, on average, than domestic incumbents. Foreign banks can enter as a subsidiary or as a branch of the parent institution. Subsidiaries are, on average, larger and more similar to the domestic incumbents in their activities compared to branches. Finally, there is selection of the largest and most profitable banks in the U.S. markets, and the largest entrants have also the largest operations in the U.S.

In the next section we introduce a structural model of foreign banking that is consistent with

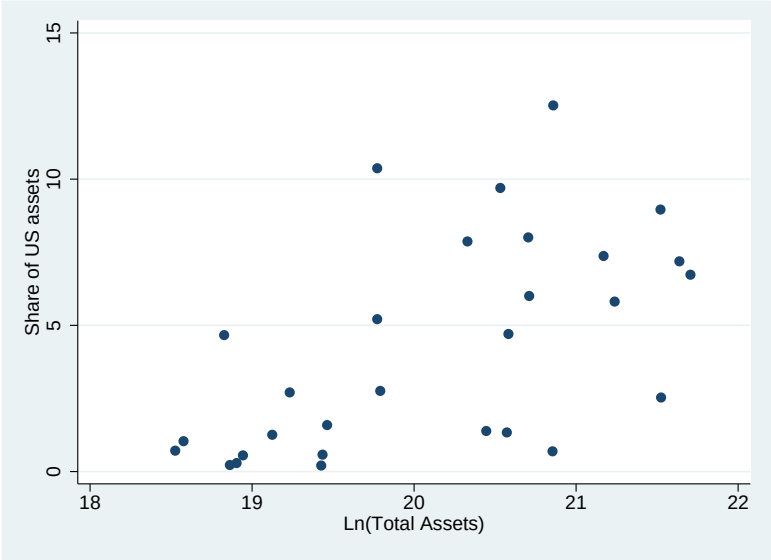

Figure 10: **Size of Domestic versus Foreign Assets.** Relathionship between the share of U.S. assets (in a parent's total assets) versus the parent's size. Source: SNL data for top tier parents of U.S. branches and subsidiaries from Europe, 2013.

the institutional details of the sector and with the evidence presented above.

3 A Simple Model of Foreign Banking

We introduce here a simple model that sets the ground for the quantitative analysis developed in the next sections. The model is useful to introduce the main trade-offs that a bank faces when deciding whether and how to sell in a foreign country. Banks in the model operate in several interconnected markets, each subject to different extents of uncertainty. Once the problem of an individual bank is well understood, we will incorporate in a dynamic and stochastic model of the banking sector in Section 4. The industry equilibrium of the full model will be able to depict banks' state-contingent decisions as responses to various shocks and their consequences for the banking sector on aggregate.

3.1 Setup

The model economy is composed by two countries, Home and Foreign. Variables referring to the Foreign country are denoted by an asterisk ($*$). The Home and Foreign countries are each populated by a large mass of banks operating there. In addition, each bank may open an affiliate abroad,

either as a branch or as a subsidiary, so becoming the parent of a multinational bank.

We assume that each bank has market power in the loans market, originating from some kind of differentiation (spatial or product). This differentiation, together with customers' love for variety for a set of banking products (to be specified later) is the rational for the coexistence of many banks in the economy. Banks are heterogeneous in the efficiency with which they manage their activities, and operate under monopolistic competition in the loans market. For simplicity, the other markets in which a bank operates are assumed to be perfectly competitive. We do not model domestic entry: all banks operate and (due to monopoly power) make non-negative profits in their Home market. In addition, each bank may also enter the Foreign country if it can make non-negative profits there as well.

We describe here the intra-temporal problem of a bank. The inter-temporal problem and industry equilibrium will be the subject of Section 4. Every period, each bank is endowed with a fixed amount of equity $\bar{E}$. On the liabilities side, it also raises interbank debt M (which can be negative), and accepts deposits D. On the assets side, it issues loans L and makes risky investments I. We use the term investments to refer generically to the trading books activities and to the banking books activities other than loans. With a certain probability of default $(1-p)$ the loans may be delinquent and not repay the principal. The bank collects the interest and payments of the loans (if they are not delinquent) and investments, and at the end of the period the bank is liquidated: the profits, loan repayments (if not delinquent), and investment gross returns minus deposit and debt repayments are returned to the equity holders.

During each period, banks need to pay a cost to manage deposits, loans, and investments, described by the convex cost function $a \cdot C(D, L, I)$. The bank-specific efficiency parameter a is the source of heterogeneity across banks, and it affects the management cost function multiplicatively, so that "low a" banks are more efficient than "high a" banks.

Banks that accept deposits have to pay a deposit insurance premium every period. The FDIC determines the deposit insurance premium (or "assessment") on a risk basis. A bank's assessment is calculated by multiplying its assessment rate f_p by its assessment base, where a bank's assessment base is equal to its average consolidated total assets minus its average tangible equity (definition from the Dodd-Frank Act). Hence the total premium IP is given by:

$$IP = f_p \cdot (L + I - \mathbb{1}_{M<0} M - E) \approx f_p \cdot D$$

where the last term comes from the bank's resource constraint (see below) and the assessment rates f_p used are reported in Table 2.

	I	II	III	IV	Total
Assessment Rate (pct. points)	5 to 9	14	23	35	5 to 35

Table 2: FDIC assessment rates by risk categories, in basis points. Assessment rates range from 0.025% to 0.45% of total assets.

Finally, banks are subject to capital requirements every period, *i.e.* there is a lower bound on the capital ratio that they are allowed to sustain:

$$\frac{E}{\omega_L L + \omega_I I} \geq k$$

where $k = 0.04$ under Basel II regulation in the U.S., and $k = 0.06$ under Basel III, for example. The parameters ω_L and ω_I are appropriate weights that reflect the riskiness of loans and investment. These weights are usually determined by the appropriate regulator (in the U.S. case, by the Federal Deposit Insurance Corporation, or FDIC).[10]

When a bank enters the Foreign market, it transfers his efficiency a to his affiliate. Entering the Foreign market involves a sunk cost, that is higher if the bank enters with a subsidiary compared to when it enters with a branch: $F_s > F_b > 0$. If a bank enters as a subsidiary, the Foreign subsidiary performs exactly the same operations as the parent: it accepts deposits, issues loans, makes investments, borrows/lends on the interbank market, and holds independent equity. The operating costs are also modeled in the same way. Conversely, if a bank enters as a branch, the activities of the affiliate differ from the ones of the parent. While the parent bank can accept all kinds of deposits (both wholesale and retail), branches only accept wholesale deposits and they are not subject to deposit insurance. Branches do not raise independent equity and they are not subject to capital requirements. Finally, there exist an intrafirm channel linking the assets and liabilities of the parent and the ones of the branch: parents of offshore branches can borrow from or lend to their branches at no cost. This intrafirm transfer characterizes the activities of parent-branch pairs, but is not allowed between parents and subsidiaries, who can trade only at arm's length via the interbank market.[11]

[10] Uncertainty is essential to model the banks' optimal decisions. In a model without uncertainty, where loans are always repayed and there are no runs on deposits, there would be no need of capital requirements or of deposit insurance. For this reason, parent banks, branches and subsidiaries would all be solving the same problem. Zero arbitrage would make the equilibrium rates equal across markets.

[11] In the no-uncertainty case, the presence of the intrafirm transfer and the lower fixed cost of entry make branches

3.2 The Parent-Subsidiary Pair

Since there are no internal transfers between parent and subsidiary, we can solve their problems separately. A parent bank chooses the optimal amounts of loans, deposits, and investment to maximize its expected profits, subject to resource constraints and capital requirements.

The maximization problem of a bank is:

$$\begin{aligned} \max_{L,I,D,M} \quad & pr_L(L) \cdot L - (1-p)L + \bar{r}^I I - r^D D - r^M M - aC(D,L,I) - f_p \cdot D \\ s.t. \quad & M + D + \bar{E} = L + I \quad \text{(resource constraint)} \\ & \frac{\bar{E}}{\omega_L L + \omega_I I} \geq k \quad \text{(capital requirement).} \end{aligned} \tag{1}$$

The term $r_L(L)$ denotes a downward sloping demand for loans. In each period, investment gives an average return $\bar{r}_I$. r_D and r_M denote the interest rates paid on deposits D and on interbank borrowing M, respectively. Each bank optimally sets his interest rate on loans and takes the other rates $\bar{r}_I$, r_D and r_M as given. We will use r_D as a numeraire, while r_M will be pinned down by equilibrium conditions on the interbank market. The rate on investments $\bar{r}_I$ will be treated as exogenous and will be a source of shocks in our quantitative analysis.

We assume that in equilibrium the capital requirement is always binding, so that there is a trade-off between loans and investments: $I = \frac{\bar{E}}{k\omega_I} - \frac{\omega_L}{\omega_I} L$, and the amount of interbank borrowing can be written as: $M = \left(1 - \frac{\omega_L}{\omega_I}\right) L + \left(\frac{1}{k\omega_I} - 1\right) \bar{E} - D$. The first order conditions with respect to L and D are:

$$[L] \quad p\left[\frac{\partial r_L(L)}{\partial L} L + r_L(L)\right] = a\left(\frac{\partial C}{\partial L} - \frac{\omega_L}{\omega_I} \cdot \frac{\partial C}{\partial I}\right) + (1-p) + \frac{\omega_L}{\omega_I} \cdot \bar{r}_I + \left(1 - \frac{\omega_L}{\omega_I}\right) \cdot r_M \tag{2}$$

$$[D] \quad r_M = r_D + a\frac{\partial C}{\partial D} + f_p \tag{3}$$

The first order conditions are intuitive. A bank chooses the optimal amount of loans such that the marginal revenue from loans is equal to the marginal cost of loans management plus the expected marginal loss from delinquent loans plus the opportunity cost of alternatives forgone, namely investments and loans to other financial institutions in the interbank market.

weakly cheaper than subsidiaries, implying an equilibrium with pervasive branching and no subsidiaries.

Deposits are set such that the sum of interest, deposit insurance premium and marginal cost of deposit management is equal to the reduction in the marginal cost of external borrowing that the bank incurs by financing loans and investments via deposits.

Since we don't observe entry and exit of national banks and of parents of multinational banks, we will parameterize the model such that every bank makes positive profits in its Home market. When establishing a subsidiary abroad, a bank must solve an identical profit maximization problem to solve for the optimal size of loans L^*, investments I^*, deposits D^*, and external borrowing M^* that the subsidiary will undertake in the host country. Moreover, entering a Foreign market with a subsidiary entails a fixed cost F_s. As a result, a bank will consider entering the Foreign market with a subsidiary if and only if the said subsidiary is solvent in the Foreign market, once the fixed entry cost is accounted for.

3.3 The Parent-Branch Pair

When a parent bank enters the Foreign market with a branch, the possibility of intrafirm transfers links the decisions of the parent and of the branch. A parent-branch pair solves:

$$\begin{aligned}
\max_{\substack{L,I,D,M \\ L^*,I^*,D^*,M^*,T}} \quad & pr_L(L) \cdot L - (1-p)L + \bar{r}_I I - r_D D - r_M M - aC(D,L,I) - f_p \cdot D + ... \\
& pr_L^*(L^*) \cdot L^* - (1-p)L^* + \bar{r}_I^* I^* - r^{*w}_D D^* - r_M^* M^* - aC(D^*,L^*,I^*) - F_b \\
s.t. \quad & M + D + \bar{E} + T = L + I \quad \text{(parent's resource constraint)} \\
& \frac{\bar{E}}{\omega_L L + \omega_I I} \geq k \quad \text{(parent's capital requirement)} \\
& M^* + D^* = L^* + I^* + T \quad \text{(branch's resource constraint)} \qquad (4)
\end{aligned}$$

where T denotes the intrafirm transfer between the parent and the branch ($T > 0$ when the branch is lending to the parent).

The profit function reflects the institutional restrictions that make branches differ from banks and subsidiaries. Branches do not raise independent equity and can only accept uninsured wholesale deposits. As a consequence, the interest rate they pay on deposits is different from the one paid by banks and subsidiaries. We assume $r^{*w}_D > r^*_D + f_p$: since branches are not insured, deposits are riskier and command a higher interest rate. We consider all markets to be national, so that the rates in the Foreign country may potentially differ from the ones in the Home country. The term

F_b indicates the fixed cost that a parent must bear to open a branch abroad.

The first order conditions for the parent bank are identical to (2)-(3). The first order conditions for the branch are given by:

$$[L^*] \quad p\left[\frac{\partial r_L^*(L^*)}{\partial L^*}L^* + r_L^*(L^*)\right] = a\frac{\partial C}{\partial L^*} + (1-p) + r_M^* \tag{5}$$

$$[D^*] \quad r_M = r_D^w + a\frac{\partial C}{\partial D^*} \tag{6}$$

The economic intuition associated with conditions (5)-(6) is identical to the one of the first order conditions of the parent. The intrafirm transfer is a costless funding option that the parent-branch pair has in the scenario in which either the parent or the branch need to borrow in the interbank market. The two linked entities clear as much as possible of their imbalances internally, and go to the interbank market for the remaining funding needs. The intrafirm transfer may also be used to transfer funds between parent and branch to invest or lend in the most profitable market.

Notice that the absence of capital requirements for branches does not allow to pin down I^* separately. Since the problem of the parent-branch pair is linear in M, M^*, and I^*, the optimal amounts of these variables are determined by corner solutions depending only on the net asset positions of the parent and of the branch and on the relative magnitudes of the respective interest rates.

Finally, a parent bank will consider entering the Foreign market with a branch if and only if the said branch is solvent in the foreign market, once the fixed costs of entry are accounted for.

3.4 Comparative Statics

The simple model developed in this section is a useful tool to understand the trade-offs that banks face when entering foreign markets.

In order to show some comparative statics properties, we choose convenient functional forms for the loan demand function and for the cost management function. We assume that the loan demand function has a constant elasticity $\eta > 1$ and that the cost management function is linear

in loans and investment, and quadratic in deposits:

$$C(D, L, I) \equiv c_L L + c_I I + \frac{c_D D^2}{2}. \tag{7}$$

We also assume that the risk weight on investment is higher than the risk weight on loans: $\omega_I > \omega_L$ and that $\omega_I c_L > \omega_L c_I$.

Under these assumption, it is immediate to show[12] that the profit functions of the parent/subsidiary pair and of the parent/branch pair are increasing in bank efficiency $1/a$, with the parent/subsidiary pair having a lower intercept due to higher fixed entry costs but a possibly higher slope given parameters restrictions. As a result the model delivers selection of the most efficient banks into global banks, and among global banks the most (least) efficient ones operate in the foreign market through subsidiaries (branches).

The first-order conditions imply that more efficient banks issues more loans, accept more deposits, have overall more assets and higher loans-to-assets ratios than less efficient banks. Coupled with selection by efficiency into different modes of entry, the model is consistent with the stylized facts we observe in the data: foreign subsidiaries are larger than foreign branches in terms of loans, deposits, and overall assets, and have higher loans-to-assets ratios.

Finally, the model generates intrafirm transfers between parent banks and branches. The sign of the intrafirm transfer depends on the sign of the net assets of the parent/branch pair, and on the relationship between interbank rates and interest rates on investment in the two countries. The intrafirm transfer is a mechanism to improve the solvency of the separate parts of the multinational banks, allowing the parent to manage liquidity shocks, but at the same time facilitating the transmission of shocks across countries.

The calibration that we report in Section 4 illustrates that the model can replicate these facts not only qualitatively but also quantitatively.

3.5 A Numerical Example

We are currently in the process of computing the full model, but we can start by providing some intuition about the channels at work with a simple, partial equilibrium numerical example. We can parameterize the simple intra-temporal problem described above and study what are the effects of

[12] See Appendix B

a funding shock in the model.

For this purpose, we calibrate part of the parameters of the model like in Table 3 below, and choose some reasonable numbers to assign to the remaining parameters in order to obtain a positive mass of banks in each group, some ordering in the size measures across three groups, and a positive value for the intrabank transfer (like in the data from 2000 to 2010, when branches of foreign banks in the U.S. were overwhelmingly lending to their foreign parents).[13]

This parameterization implies that, in equilibrium, branches are about 6 times more frequent than subsidiaries, they have loans on average 2% higher, and deposits on average 2.55 times higher. All banking organizations need to borrow in the interbank market, and – since it is more convenient to do so in the host market – foreign branches borrow and transfer funds to their parents. The average intrabank transfer is about half of the average assets of a parent.

Starting from this configuration of the equilibrium, we examine the effects on the economy of a funding shock in the Home market. Since we assume that deposits supply is perfectly elastic at the interest rate r_D, we model a funding shock as an increase in the interest rate from $r_D = 0.0025$ (like in Table 3) to $r'_D = 0.008$. As a result of this increase, the overall cost of funding increases, the marginal cost of loans increases, profits decrease, and no bank in the economy finds profitable to enter the foreign market as a subsidiary. The equilibrium is one with pervasive branching. The amounts banks need to borrow increase, and so does the intrabank transfer from foreign branches to their foreign parents, which increases of about 30%. So funds are borrowed in the host market (the U.S. in our data) and channeled to the foreign parents, decreasing the availability of funds for loans in the U.S.

This is just an example of how the activities of global banks, mostly through international, intrabank flows between parents and branches, can be vehicles of transmission of shocks across countries.

[13]The list of the parameter values used for this example follows: $\eta = 4$, $c_L = 0.001$, $c_I = 0.0035$, $c_D = 0.0001$, $k = 0.05$, $\omega_L = 0.2$, $\omega_I = 0.8$, $F_s = 195$, $F_b = 140$, $\mathcal{L} = \mathcal{L}^* = .1$, $E = E_S = 300$, $f_p = 0.02$. For now we also take the rates in the interbank market as given to $r_M = 0.011$ and $r^*_M = 0.01$ to induce a preference for borrowing in the host market.

4 Foreign Banking Dynamics: A Quantitative Framework

In this section we nest the problem of an individual bank that we just described into a dynamic model of the banking industry.

Let $\mathcal{L}$ ($\mathcal{L}^*$) denote aggregate loans demand in the Home (Foreign) market. We assume aggregate loans demand to be exogenous, and to evolve over time according to the following geometric Brownian motions:

$$\frac{d\mathcal{L}}{\mathcal{L}} = \mu dt + \sigma dz \tag{8}$$

$$\frac{d\mathcal{L}^*}{\mathcal{L}^*} = \mu^* dt + \sigma^* dz^* \tag{9}$$

where $\mu, \mu^* \geq 0$, $\sigma, \sigma^* > 0$ and dz, dz^* are the increments of two standard Wiener processes with correlation $\rho \in [-1, 1]$. The idea behind a stochastic process for aggregate loans is the following: we can construct an economy where agents maximize consumption over time and income fluctuates according to some stochastic process. If we assume that agents need banks to smooth consumption over time, loans demand will also follow a stochastic process. The problem then is simply to construct an income process such the the resulting loans processes are described by (8) and (9). For now we abstract from this and we simply impose loans demand to be exogenous. We also assume that international loans markets are incomplete: consumers in the Home (Foreign) country can only borrow from firms that are located in their own country. Foreign banking will weaken this restriction by allowing consumers to borrow from foreign banks once they choose to locate in their home country.

There are many possible kinds of loans in the economy: personal loans, credit cards, car loans, mortgages and so on. We assume that each bank in a country specializes in a distinct kind of loan and is the sole provider of it. Loans are perceived as imperfect substitutes, and aggregate to total loan demand through a CES aggregator:

$$\mathcal{L} = \left(\int L^{1-1/\eta} dL \right)^{\eta/(\eta-1)}$$

where $\eta > 1$.

Each country is populated by a continuum of banks of total mass n (n^*), which operate under a monopolistically competitive market structure. Each bank offers a differentiated loan variety L

taking the aggregate loan demand as given. Each bank's technology is as described in Section 3, where the only feature differentiating banks is the bank-specific efficiency a, which scales up or down the bank's management cost function. a is a random draw from a distribution $G(a)$ ($G^*(a)$ for the foreign market).[14] These assumptions ensure that interest rates on loans are independent of aggregate loans demand, and that each bank's profits in a country are a linear affine function of aggregate loans $\mathcal{L}$.[15]

Rates in the interbank market are such that net borrowing at the industry level in each country is equal to zero:

$$\int M(r_M, a)dG(a) = 0 \tag{10}$$

$$\int M^*(r_M^*, a)dG^*(a) = 0. \tag{11}$$

There are two dynamic aspects in the problem of the banks. First, we assume that per-period profits are re-invested, so that bank equity is equal to previous period profits:

$$\bar{E}'(a) = \pi(a). \tag{12}$$

Second, the interaction of aggregate shocks and sunk entry costs induces hysteresis in foreign markets, so banks consider the evolution of their profits over time when deciding whether and how to enter the foreign market. Without sunk costs, this decision would be made period-by-period.

We start by considering an economy where the only shocks are aggregate shocks to loans demand as described by (8)-(9). We will then extend the model to consider funding shocks on deposit supply (like in Cetorelli and Goldberg, 2011), shocks to the probability of loans repayment p and to the interest rate on investment $\bar{r}^I$.

Let $\mathcal{V}_i(a, \mathcal{L}, \mathcal{L}^*)$ denote the value of a bank with efficiency a, when aggregate loan demand in the two markets is described by $(\mathcal{L}, \mathcal{L}^*)$. The index i denotes the international status of the bank: $i \in \{N, B, S\}$ where N denotes a national bank who only operates in its Home market, B denotes a multinational bank that operates in the foreign market through branches, and S denotes

[14] For quantitative purposes, we can also extend the model to consider a bank specific efficiency parameter evolving over time: this will be useful to simulate the effect of bank-specific shocks to the economy.

[15] CES aggregation over loan types implies that the bank-specific residual demand for loans is given by: $L(a) = r_L(L;a)^{-\eta} R_L^{\eta} \mathcal{L}$, where R_L is an average interest rate on loans: $R_L = \left[\int r_L(L;a)^{1-\eta} dG(a)\right]^{1/(1-\eta)}$. Consequently, equilibrium interest rates on loans are given by: $r_L(a) = \frac{\eta}{p(\eta-1)} MC_L(a)$, where $MC_L(a)$ is the marginal cost of a loan for a bank with efficiency a, and is equal to the right-hand side of equation (2) .

a multinational bank that operates in the foreign market through subsidiaries.[16]

We solve the model along the lines of Dixit (1989). We choose a parameterization such that all banks are active in their domestic market and make positive profits there. Domestic activities are not directly affected by the realization of foreign loan demand $\mathcal{L}^*$. Similarly, the decision of whether to enter the foreign market is not directly affected by the realization of domestic loan demand $\mathcal{L}$. For this reason, we can express the value function as:

$$\mathcal{V}_i(a, \mathcal{L}, \mathcal{L}^*) = \mathcal{S}(a, \mathcal{L}) + V_i(a, \mathcal{L}^*) \tag{13}$$

where $\mathcal{S}(a, \mathcal{L})$ is the expected present discounted value of profits from domestic activities, which is independent on the bank's international status, and $V_i(a, \mathcal{L}^*)$ is the expected present discounted value of profits from foreign activities for a bank in status i.

Over a generic time interval Δt, the two components of the value function for a bank that is currently operating only in its domestic market can be expressed as:

$$\mathcal{S}(a, \mathcal{L}) = \pi_N(a, \mathcal{L}) + E[\mathcal{S}(a, \mathcal{L}')|\mathcal{L}] \tag{14}$$

$$V_N(a, \mathcal{L}^*) = \max\left\{E[V_N(a, \mathcal{L}^{*\prime})|a, \mathcal{L}^*]\ ;\ V_B(a, \mathcal{L}^*) - F_B\ ;\ V_S(a, \mathcal{L}^*) - F_S\right\} \tag{15}$$

where $\pi_N(a, \mathcal{L})$ denotes the maximal domestic profits of the bank, solution of problem (1).

While (14) simply tracks the evolution of domestic activities, the right hand side of (15) expresses the bank's possible choices. If it remains a national bank, it gets the continuation value from not changing status. If it decides to enter the foreign market with a branch (subsidiary) it gets the value of the corresponding foreign activity V_B (V_S) minus the sunk cost of entry F_B (F_S). Similarly, the present discounted value of profits from foreign activities of a multinational bank is:

$$V_B(a, \mathcal{L}^*) = \max\left\{\pi_B(a, \mathcal{L}^*) + E[V_B(a, \mathcal{L}^{*\prime})|\mathcal{L}^*]\ ;\ V_N(a, \mathcal{L}^*)\right\} \tag{16}$$

in case of branching, and:

$$V_S(a, \mathcal{L}^*) = \max\left\{\pi_S(a, \mathcal{L}^*) + E[\cdot V_S(a, \mathcal{L}^{*\prime})|\mathcal{L}^*]\ ;\ V_N(a, \mathcal{L}^*)\right\} \tag{17}$$

[16]Notice that the cost structure and the nature of uncertainty imply that if a bank decides to enter the foreign market, it will do so either with branches or with subsidiaries, but it will never adopt the two strategies at the same time.

in case of subsidiarization.

Notice that the continuation values of multinational banks also include the profit flows $\pi_B(a, \mathcal{L}^*)$, $\pi_S(a, \mathcal{L}^*)$ from foreign market activities. There are no costs of exiting the foreign market: if a bank decides to exit, its value is simply that of a national bank.

In Appendix B we show that the value functions $\mathcal{S}(a, \mathcal{L})$, $V_i(a, \mathcal{L}^*)$ for $i \in \{N, B, S\}$ take the form:

$$\mathcal{S}(a, \mathcal{L}) = \frac{\pi_N(a, \mathcal{L})}{r_M} \tag{18}$$

$$V_N(a, \mathcal{L}^*) = A_N(a)\mathcal{L}^{*\alpha} + B_N(a)\mathcal{L}^{*\beta} \tag{19}$$

$$V_B(a, \mathcal{L}^*) = A_B(a)\mathcal{L}^{*\alpha} + B_B(a)\mathcal{L}^{*\beta} + \frac{\pi_B}{r_M^*} \tag{20}$$

$$V_S(a, \mathcal{L}^*) = A_S(a)\mathcal{L}^{*\alpha} + B_S(a)\mathcal{L}^{*\beta} + \frac{\pi_S}{r_M^*} \tag{21}$$

where α and β are the roots of:[17]

$$\frac{1}{2}\sigma^{*2}\xi^2 + (\mu^* - \frac{1}{2}\sigma^{*2})\xi - r_M = 0.$$

$A_i(a)$ and $B_i(a)$ ($i \in \{N, B, S\}$) are firm-specific, time-varying parameters to be determined, depending on the empirical patterns of entry and exit that we observe in the data.

The value functions in (18)-(21) preserve some intuition. First of all, since all banks operate in the domestic market, $\mathcal{S}(a, \mathcal{L})$ is simply the present discounted value of profits from domestic operations. The last term of (20) and (21) carry the same intuition, as they capture the stream of profits should the bank remain in the current status permanently. The exponential terms capture the option value component. We impose $A_N(a) = 0$ since for low realizations of loan demand, the value of entering in the foreign country should be near zero. Similarly, we impose $B_B(a) = B_S(a) = 0$, since for high realizations of loan demand, the value of exiting the foreign country should be near zero. In (19), as loan demand grows in the foreign country, it becomes more and more attractive to enter (via a branch or via a subsidiary, depending on the bank's productivity), hence B_N should be positive. Conversely, in (20) and (21), if loan demand shrinks in the foreign country, the option value of exiting increases, hence A_B and A_S should be positive.

We impose value matching and smooth pasting conditions to obtain the coefficients of the value

[17] $\alpha < 0$, $\beta > 1$.

functions and the thresholds in aggregate loan demand that trigger the foreign expansion of a bank using either a branch or a subsidiary. Given the discrete nature of the problem, these thresholds represent the policy function for the banks. We solve numerically for the coefficients and the thresholds.

Once we have solved for the parameters of the value functions in the continuation region, our objective is to simulate an economy with a large number of domestic banks and simulate the stochastic process describing aggregate loan demand in each country. Every period, the model delivers the banks' endogenous decision of foreign entry and exit by type and the flows of deposits, loans, investments, interbank borrowing and intrafirm transfers. Since banks' extensive and intensive margins decisions are endogenous, the model can be used as a laboratory for policy analysis.

4.1 Calibration

We parameterize the model and generate an economy with a large number of domestic banks.[18] Then we simulate the stochastic process describing aggregate loan demand in each country.

Every period, the solution of the model delivers: banks' endogenous decisions of foreign entry (by type), banks' endogenous decisions of exit from the foreign market (by type), banks' domestic and foreign flows of deposits, loans, investment, interbank borrowing, and intrafirm transfers, and banks' domestic and foreign profits depending on the mode of entry.

In order to parameterize the model, we choose some parameter values directly from empirical observations, and we calibrate the remaining parameters through a simulated method of moments procedure. More precisely, we calibrate directly the parameters p, k, f_p, r_I, r_D, r_D^w, ϑ, b, μ, μ^*, σ, σ^*, ρ.

The remaining 10 parameters (η, c_L, c_I, c_D, ω_L, ω_I, F_S, F_B, $\mathcal{L}_0$, $\mathcal{L}_0^*$) are calibrated jointly to match the following moments from the data: the average interest rates on loans, the relative size of deposits and loans in branches compared to subsidiaries, the relative loans-to-assets ratios in branches compared to subsidiaries, the percentages of branches and subsidiaries in the total number of banks in the U.S., and entry and exit dynamics: average share of national banks that become branches (subsidiaries) each year, and average share of branches (subsidiaries) exiting each

[18] To simplify the computation of the model, we assume that banks' management efficiency $x \equiv 1/a$ is distributed according to a Pareto distribution $H(x) = 1 - b^{\vartheta} x^{-\vartheta}$. We estimate the magnitude of ϑ by fitting the empirical loan size distribution with a Pareto distribution.

Parameter	Definition	Value	Source
Revenue and cost parameters			
p	prob. of loan repayment	0.96	World Bank
η	elasticity of loan demand		
c_L, c_I, c_D	param. of cost function		
k	capital requirement	(0.04, 0.08)	Basel II/III
ω_L, ω_I	weights for RWA		
f_p	insurance premium	(0.005, 0.035)	FDIC
F_S, F_B	sunk entry costs		
Rates			
r_I	av. return on investment	0.009	treasuries
r_D	int. rate on retail deposits	0.0025	one-year CD
r_D^w	int. rate on whol. deposits	0.006	LIBOR
Banks efficiency distribution			
ϑ	shape parameter	$.5\eta$	emp. loans size distrib.
b	location parameters	1	normalization
Brownian motions			
μ, μ^*	drift	0	no growth
σ, σ^*	st.dev.	0.06	st. dev. of loans
ρ	correlation	(-1,1)	corr. of loans
$\mathcal{L}_0$, $\mathcal{L}_0^*$	initialization		

Table 3: Calibration

year. Table 3 summarizes the calibration.

5 Numerical Results (in progress)

In this section we exploit the theoretical model to answer counterfactual questions. The solution the model consists of value functions and policy functions that determine the behavior of bank holding companies in the presence of loan demand shocks. Since we take quantity demanded as given, the changes in equilibrium will be captured through the effect of the extensive margin and endogenous market structure on prices, i.e., interest rates for different type of loans, on the variety of loans, and on the interbank market equilibrium and its effects on the intrafirm transfers between parents and branches.

In a nutshell, the model predicts that more efficient bank holding companies expand via subsidiaries after a series of positive shocks to foreign demand, while less efficient bank holding com-

panies expand via subsidiaries. The resulting endogenous market structure and number of players affect the prices of the retail and wholesale deposits, prices of heterogeneous loans and prices and quantities of interbank loans. We use the equilibrium prices for loans to identify the effects of the changes in industry structure on credit markets.

With this mechanism in mind and the model calibrated to market structure dynamics, we are able to evaluate the effects of changes in policies regarding foreign banks on the equilibrium of credit markets, holding demand constant. The policies that we evaluate are changes in deposit insurance rules for foreign branches, changes in capital requirements for foreign subsidiaries, and elimination of the possibility of opening either branches or subsidiaries altogether.

Use the model to evaluate the following counterfactual scenarios:

- changes in deposit insurance and capital requirements rules;
- extending interbank transfers to subsidiaries;
- elimination of the possibility of opening branches or subsidiaries.

Extensions:

- stochastic rates of return on investments;
- shocks to deposits supply.

Numerical results *TBA*

6 Conclusions

TBA

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Appendix

A The Regulatory Framework: History and Current Status

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B Derivation of the Solution of the Model

TBA