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Global banking and the international transmission of shocks: A quantitative analysis☆

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ABSTRACT

Regulatory reforms typically follow financial crises. We propose a model of global banking that can be used proactively to study alternative regulatory policies. The model mimics the US regulatory framework and highlights the organizational choices that banks face when entering a foreign market: branching versus subsidiarization. The model is able to replicate the response of the US banking sector to the European sovereign debt crisis. Counterfactual analysis suggests that pervasive subsidiarization, higher capital requirements, or an ad hoc monetary policy intervention would have avoided entirely the negative effects of the sovereign debt crisis on US lending. However, the same measures would have had limited effects in more severe scenarios.

1. Introduction

Recent financial crises have spurred debates among academics and policymakers about the regulation of large, systemically important banks. Most of the institutions under scrutiny are multinational banks, with operations in multiple countries, raising concerns about contagion and shock transmission. Arguably, regulatory reforms should be not only reactive to crises, but also designed ex-ante to reduce the likelihood and limit the severity of such crises.

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In this paper, we inform the design of multinational banking regulation by developing a quantitative structural model of global banking and by using it to evaluate the effects of counterfactual policies. We focus our analysis on global banks because they are often the largest players in the countries where they operate: as noted by Goldberg (2009), the size of foreign banking institutions and their involvement with the real economy makes them important vehicles for the global transmission of shocks. For example, the Japanese banking crisis in the early 1990s had a substantial effect on credit supply in the United States, and subsequent consequences in the real economy, as many US branches and subsidiaries of Japanese banks shrank or closed down their US operations following a shock in their home country. Our empirical analysis shows that the European sovereign debt crisis also had rippling effects in the US credit markets, mostly due to the fragility of foreign branches' funding. Several empirical studies have explored the role of multinational banks in the transmission of shocks across countries.[1] Our paper contributes to this literature in two ways. First, while prior theoretical contributions have overlooked the importance of a bank's mode of operations, our model provides a microfoundation for the bank's decision of whether and how to enter a foreign market—through branches or subsidiaries. We find that this differentiation is of first-order importance to understanding the effects of financial crises. Second, while most of the existing work has been conducted using reduced-form analysis, our quantitative model enables us to study the consequences of potential regulatory changes via counterfactual analysis.

The model we develop is designed to describe the institutional details of the banking industry and to be consistent with stylized facts from US bank-level data. For this reason, our analysis focuses on the two most prominent forms of foreign banking institutions in the United States: branches and subsidiaries. Current US bank regulations treat foreign-owned branches and subsidiaries differently, so the activities that a branch and a subsidiary are allowed to undertake differ: for example, while subsidiaries are separately capitalized, branches do not raise independent equity and are subject to capital requirements only at the parent bank level. While subsidiaries can accept all types of deposits, branches can accept only uninsured wholesale deposits. Finally, unlike subsidiaries, branches can freely transfer funds to and from their parent.[2]

The distinction between branches and subsidiaries is important, both for the selection of different banks into these two organizational modes, and for their different responses to shocks. We show that the European parents of global banks with affiliates in the United States tend to be larger than European banks without operations in the United States. Moreover, the parent banking organizations of foreign subsidiaries are systematically larger than the parent banks of foreign branches. At the affiliate level, subsidiaries also are larger than branches. These size rankings hold when evaluated in terms of both loans and deposits. To study the extent of shock transmission, we analyze the response of US-based affiliates of European banks to the European sovereign debt crisis. We find that, in the wake of the crisis, US branches of exposed European banks experienced a flight in their uninsured deposits, while deposits at subsidiaries (both insured and uninsured) grew. Because the shortage of funding that branches experienced was only partially compensated by intrafirm transfers of funds from their parents, US branches of exposed European banks experienced a decrease in their loans. At the same time, loans issued by exposed US subsidiaries increased. These facts inform the construction of the model.

We model the bank's problem as a monopolistically competitive extension of the Monti-Klein model (see Klein, 1971, and Monti, 1972), augmented to include institutional features like capital requirements and deposit insurance. The model explicitly distinguishes among foreign banking institutions by their mode of operations, which is endogenous and responds to differences in the regulatory environment and in bank management efficiency. This feature allows us to assess whether the mode of operations matters for the severity of shocks' transmission across countries. The model features the channels of adjustment that we document in the data, and its simple structure is amenable to quantification. We calibrate the model to match a set of cross-sectional moments of the US foreign banking sector and show that our calibrated economy generates responses to shocks that are consistent with the actual responses of multinational banks to the European sovereign debt crisis. We then use the model to perform counterfactual exercises that shed light on the quantitative implications of current and counterfactual banking regulations for the transmission of shocks across countries.

Our baseline quantitative exercise consists of an analysis of the European sovereign debt crisis, which started with Greek sovereign debt repayment problems in 2010. We take this event as a shock that is exogenous to the US banking system. We model the crisis as a sudden decline in the probability of loan repayment in Europe. This decline reduces European banks' profits and equity accumulation, lowers their equity to risk-weighted assets ratio, and tightens the banks' buffer on capital requirements. To examine the effect of this change in the balance sheets of European banks on the operations of their US-based affiliates, we model deposit supply following the empirical evidence reported in Egan et al. (2017): on the one hand, a tightening in global banks' capital reduces the supply of wholesale deposits, which represents a funding shock for US branches. On the other hand, tighter bank capital doesn't affect the supply of retail deposits. Faced with solvency problems in their foreign branches, European parents use their internal capital market to support profitable lending in their US branches. Nonetheless, US branches decrease their total loans. Quantitatively, in the model, a default shock that causes European parents to lose, on average, 10% of their equity results in a 3% decline in aggregate lending in the US. In addition, European parents increase funding for their US branches by 19%, after these branches experience a 10% drop in their wholesale funding. Conversely, foreign subsidiaries'

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

[2] In the remainder of this paper, as an analogy to the literature on multinational corporations, we refer to a parent bank, or just parent, as the home-based banking organization. Branches are owned by a bank, while subsidiaries may be owned by a bank or directly by a bank holding company.

balance sheets are isolated from the shock that affects their parents. As a result, there is no direct effect on their loans and deposits.

We use the model to simulate banks' responses to the crisis under counterfactual policy scenarios. The results of our exercises suggest that increased capital requirements, the elimination of branching, or an ad hoc monetary policy intervention would have avoided entirely the negative effects of the crisis on US aggregate lending. Conversely, the elimination of subsidiarization would have caused a decline in banking activity in the United States twice as large as the baseline case.

We take our model further to study the effect of other shocks on the activities of foreign banking organizations (henceforth, FBOs). First, we show that our model is consistent with the data in replicating the effect of a *positive* shock to parent banks. To this end, we examine the effect of Mario Draghi's "*Whatever it Takes*" speech on deposits and loans of US-based branches and subsidiaries of European banks. Consistent with the predictions of the model, we find that Draghi's speech had the effect of slowing down the wholesale deposit flight that started at the onset of the sovereign debt crisis. Second, we examine our model's implications about the possible responses of FBOs to *large* shocks to their parents. More precisely, frictions to the internal capital market between parents and subsidiaries imply that, following a large negative shock, a parent bank may decide to repatriate funds by shutting down its foreign subsidiaries. The parents of branches do not have the same incentives, as they can freely repatriate funds through their internal capital market. As an external validation of this mechanism, we show that subsidiaries are more likely than branches to exit a foreign market, and that exits are more common in periods when the parents' equity positions are declining. The possibility of subsidiaries' exit also implies that the conclusions of our policy counterfactuals depend on the size of the shock that banks face. On the one hand, subsidiaries' independent capitalization isolates them from shocks abroad, as long as those shocks don't hinder the solvency of their parent, in which case subsidiaries may be shut down to repatriate funds. For this reason, the size of the shock matters when examining subsidiaries' responses. On the other hand, branches' ability to exchange funds with their parents has the effect of transmitting both small and large shocks across countries, but makes banks that operate through branches more flexible and resilient to large shocks. Taken together, the results illustrate the consequences that different organizational forms have for the transmission of financial shocks across countries. Subsidiarization isolates a global bank's balance sheets by location; hence, it minimizes cross-country contagion. However, by not having access to a fluid internal capital market within the bank, subsidiaries do not provide an effective instrument to dampen the global effect of shocks, resulting in possible reorganizations and exits.[3] Conversely, parent-branch organizations can more easily take advantage of their internal capital market, smooth the intensity of shocks across countries, and reduce their global impact. These results highlight the conflicting objective functions of national and supranational regulatory bodies.

This paper aims to contribute to the growing literature that uses tools from international trade theory to study the operations of multinational banks. In his seminal paper, Eaton (1994) sets directions for structural research on this topic. Eaton (1994) proposes to model the banking sector as a simple economy where firms compete and enter foreign countries:

> "*One type of international competition is the entry of foreign banks into domestic banking. In its pure form such competition is between foreign banks and domestic banks in accepting domestic deposits and making loans domestically on the domestic banks' home turf. Foreign-owned banks are subject to the same reserve requirements and other regulatory constraints as domestically-owned banks (…). At issue here, then is the relative productivity of individual banks, all operating in the same regulatory environment.*"
>
> [Jonathan Eaton, "Cross-Border Banking", 1994]

Our approach is inspired by these ideas, with the caveat that – after the time of Eaton's writing – the US regulatory system underwent important changes that affected differently branches and subsidiaries of foreign banks. This differential regulation forms the basis of our identification strategy and is reflected in the assumptions of our model.

The use of international trade techniques to model the banking sector was pioneered by Niepmann (2015, 2018). Our framework shares with Niepmann (2018) the emphasis on within-country bank heterogeneity and on the role of endogenous selection to understand aggregate outcomes in the global banking sector. The role of bank heterogeneity is also prominent in de Blas and Russ (2013) and Bremus et al. (2018), which both show evidence of granularity in the banking sector. Finally, this paper shares with Corbae and D'Erasmo (2021) the emphasis on using quantitative analysis to understand features of the banking data.

This paper is related to a large empirical literature that studies the role of global banks as vehicles of shock transmission across countries. In an early contribution, Peek and Rosengren (2000) have shown the role that US-based branches of Japanese banks played in transmitting the effect of the Japanese banking crisis to the United States. In a similar spirit, Cetorelli and Goldberg (2011) document a decline in lending by foreign affiliates of global banks in emerging economies in the wake of the 2007–2009 financial crisis. Cetorelli and Goldberg (2012a, 2012b) point to the internal capital markets between parents and branches of global banks as a channel that strongly contributed to spreading financial shocks during the 2007–2009 crisis. The possibility that parents and branches transfer funds across borders but within the boundaries of the bank holding company is a feature of primary importance in the framework that we present in this paper. Heterogeneous bank responses to the 2007–2009 financial crisis are also the object of study in De Haas and Van Horen (2013), who document higher resilience of cross-border lending for banks lending to nearby countries where they had longer experience, a larger network of lending

[3] Internal capital markets are not fluid in that capital transfers from subsidiaries to their parents are limited by capital requirements set by the subsidiary's host-country regulator.

relationships, and local subsidiaries. Our paper focuses on the responses to crisis of US-based subsidiaries versus branches. While the geographic scope of our analysis is narrower than in De Haas and Van Horen (2013), the peculiarities of the US regulatory system allow us to disentangle the mechanisms behind banks' heterogeneous responses to shocks which are driven by organizational, rather than geographic, differences. Like Ivashina et al. (2015), our paper puts emphasis on the consequences of funding shocks for the lending behavior of global banks. While Ivashina et al. (2015) examine the effect of the European sovereign debt crisis on US lending compared to Euro lending within global banks, our analysis focuses on the effects on US lending across different types of global banks.

By presenting stylized facts about the features distinguishing multinational from nonmultinational banks, our analysis is also closely related to Claessens et al. (2001), Buch et al. (2011), and Niepmann (2018). Our structural model focuses on two alternative forms of foreign banking: branching and subsidiarization. In this dimension, our work is related to Cerutti et al. (2007), Dell'Ariccia and Marquez (2010), Fiechter et al. (2011), Luciano and Wihlborg (2013) and Danisewicz et al. (2017). Some of the facts that we report, related to changes in foreign branches' balance sheets in the wake of the European sovereign debt crisis, are present also in Correa et al. (2021). We explicitly compare changes in branches' balance sheets to changes in the balance sheets of subsidiaries.

There has been an increasing concern about the unintended cross-border effects of policy actions, and global banks play an important role in the international transmission of shocks. In an empirical analysis of the spillovers of national banking regulations across borders, Berrospide et al. (2017) find that tighter banking regulations shift lending away from countries where the tightening occurs. In particular, subsidiaries and branches of banks domiciled in the tightening country play an important role in the transmission mechanism. A similar argument is made in Ongena et al. (2018), who study the transmission of US monetary policy across borders through the foreign lending operations of multinational banks headquartered in the United States. We contribute to this literature by examining the potential effects of alternative banking regulations in our quantitative analysis.

2. Foreign banks in the United States: stylized facts

2.1. Data

This analysis relies on bank-level data from three sources. Our main source is the Quarterly Report of Condition and Income that every US bank is required to file (also known as "Call Reports"). In addition to domestic banks, US-based subsidiaries of foreign banks must fill out these reports as well. We also use the quarterly "Report of Assets and Liabilities of US Branches and Agencies of Foreign Banks" that every branch and agency of a foreign bank is required to file. Call Reports data include detailed information about a foreign bank's US operations, and the ultimate owner's identity, which allows us to distinguish US-based entities belonging to foreign-owned global banks from US-owned banks.[4]

In order to have a full picture of global banks' operations at home and abroad, we merge the Call Reports data with two additional data sources. First, we obtain regulatory reporting data and accounting data filed by the foreign parents of US-based subsidiaries and branches from S&P Global Market Intelligence. These data enable us to have a complete picture of each bank's activities in the headquarter country and in the US. Second, we obtain reported sovereign debt holdings of European banks provided as part of the European Banking Authority's (EBA) Stress Test information. The EBA implemented annual stress tests in 2009, but only disclosed bank sovereign holdings starting in 2011. Each annual stress test is based on the banks' portfolios as of the previous year. Therefore, we use European banks' portfolio holdings as of the last quarter of 2010.

As a result of this data merge, we obtain a sample of 56 European banks that are the ultimate owners of US-based affiliates. We consolidate all the offices of the same type (i.e., all subsidiaries and all branches) belonging to the same ultimate owner. The full list of banks in our merged sample is contained in Table D.1 in the Appendix. With these data, we present evidence about the differential response to shocks of US branches and subsidiaries of foreign banks. Since the core of our empirical analysis focuses on how global banks responded to the European sovereign debt crisis, we restrict our sample period to 2007–2013.

2.2. The cross-section of foreign banks

Foreign institutions have a substantial presence in the US banking market. Of the total assets held by banks operating in the United States, between 15 and 20% belong to banking offices that are ultimately owned by a foreign parent. Foreign-owned banking offices account for about 20% of total deposits and between 20 and 30% of total commercial and industrial loans in the United States (see Fig. D.1 in the Appendix).

What are the activities of FBOs in the United States? The answer is complex, as a foreign bank may operate in the US market under different organizational forms, associated with very different activities and—most importantly—different regulations.

[4] The Federal Financial Institutions Examination Council (FFIEC) collects these data in two different reporting forms: FFIEC 031 and FFIEC 041. Banks with foreign offices must file the FFIEC 031 form and banks with only domestic offices must file the FFIEC 041 form. The information about domestic operations is identical across reports for all practical purposes. Form FFIEC 002 is similar to the Call Reports for branches of foreign banking organizations. Additionally, it also contains the balances "due from" and "due to" the head office (parent) and related depository institutions, wherever located. Foreign banking organizations may have several separate branches in the US and each of these branches typically have only one location. The FFIEC 002 report contains data at the branch level. It is important to point out that a foreign branch is not just a bank office of a domestic bank, typically open to retail walk-in customers, but a legal entity with its own reporting requirements. Appendix A summarizes the US regulatory framework and the changes it underwent in the past decades, with special focus on those regulations that had an impact on foreign banks operating in the United States. Changes to these regulations do not affect the approach and classification that we use in this paper.

A foreign bank may open a *subsidiary bank*, which for most purposes operates as a domestically owned US banking entity. A subsidiary is subject to US regulation and, thus, is subject to its own capital requirements (equity) distinct from the parent's own regulations in the home country. A subsidiary may accept both uninsured wholesale deposits and retail deposits, which are insured by the Federal Deposit Insurance Corporation (FDIC).[5] Any capital flow between the subsidiary and the foreign parent must happen "at arm's length," in the form of loans, equity injections, or capital distributions (dividends). This means that if a foreign parent wants to transfer funds to or from a subsidiary in the United States, there is no fluid internal channel to do so.[6] In our dataset, we count 47 US-based subsidiaries of foreign banks, with total assets of approximately $1.16tn, which represent 7.1% of all bank assets in the United States. Out of these 47 subsidiaries, 23 are ultimately owned by European banks, with total assets of $0.68tn in the United States.

The other most common form of operations is branching: a *branch* is also subject to US regulation, but –unlike a subsidiary– it does not raise independent equity. A branch is only subject to capital requirements at the holding company level in its home country (i.e., branch assets are consolidated with the foreign parent assets when evaluating the bank's capital ratio). Branches may offer loans, but may only accept uninsured wholesale deposits.[7] Unlike subsidiaries, branches have an intrafirm channel to transfer capital flows to/from the parent, and display large intrafirm capital flows with their foreign parents (more on this below). In our dataset, there are 182 US-based branches of foreign banks, with total assets of approximately $2.19tn, which represent 15% of all bank assets in the United States. Out of these 182 US-based branches, 66 are ultimately owned by European banks, with total assets of $1.19tn in the United States.

Subsidiaries and branches are the two most common FBOs in the US banking system. Taken together, they represent more than 99% of the assets held by foreign-owned banking offices. In terms of business lines, these two organization types also entail activities that are close to those of traditional banks.[8]

The foreign banking sector in the United States displays systematic patterns of selection by size akin to what is observed for multinational firms operating in nonbanking sectors. Fig. 1 compares the loans and deposits of European parents of US-based FBOs and European banks without US operations.[9] It is evident that the European banks that open affiliates in the US market are larger than the ones that do not.[10] Niepmann (2018) presents evidence of a similar pecking order based on bank efficiency (computed as the ratio of overhead costs to total assets): multinational banks appear to be systematically more efficient than nonmultinational banks. The model that we present in the next section features a positive relationship between bank efficiency and bank size, consistent with Fig. 1.[11] The figure further distinguishes parents of foreign subsidiaries from parents of foreign branches, and shows that the parents of foreign subsidiaries are on average larger banks compared with the parents of foreign branches.

At the affiliate level, there are large size differences between subsidiaries and branches of FBOs. Fig. 2 reports the average loans and deposits held by a US branch or subsidiary of a European bank. When comparing FBOs, the average subsidiary is substantially larger than the average branch, both in terms of deposits and loans. Size differences are persistent over the sample period, and are not driven by a few firms with extraordinarily large balance sheets: the deposits and loans size distributions of foreign subsidiaries first-order stochastically dominate the analogous size distributions of foreign branches (see Fig. D.2 in the Appendix).

Finally, consistent with what Buch et al. (2011) find for German banks, Appendix Fig. D.3 shows that the amount of assets foreign banks hold in the United States is positively related to their domestic size, indicating that banks that are "big" in their home country also have large foreign operations. This fact motivates an important assumption of the model: that parent banks transfer their efficiency to their foreign affiliates.

[5] Deposits in subsidiaries are classified as retail if they are under the FDIC threshold ($100,000 until 2005 and $250,000 thereafter). Wholesale deposits are those above the FDIC threshold.

[6] Equity injections are rare and subject to the home regulator. Equity flows to the parent are in the form of dividend distributions, which are limited by earnings and are typically semiannual. Recently, these distributions are even more limited by the performance in the stress testing exercise for those subsidiaries with more than $50 billion in assets.

[7] A branch's balance sheet is consolidated into the balance sheet of its parent institution. Branches do not have a capital account, and are not required to report income statement variables. Nonetheless, the US regulatory framework requires foreign-owned branches and agencies to report their assets and liabilities in the FFIEC 002 form.

[8] In addition to branches and subsidiaries, the data display two more types of organizations. *Edge and agreement corporations* cannot engage in business in the United States with US-based entities and are precluded from issuing domestic loans or accepting domestic deposits. *Representative offices and nondepository trusts* do not accept deposits or give loans, and their asset holdings are negligible compared with the other types of foreign entities. Given their small weight in aggregate banking activities, we drop edge and agreement corporations, representative offices, and nondepository trusts from our sample and focus the analysis on foreign-owned branches and subsidiaries.

[9] The pattern shown in Figure 1 holds also for overall assets. 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 (US treasuries, residential and commercial mortgage-backed securities, other asset-backed securities, and a small amount of stocks) and trading assets. The liabilities side includes deposits, short-term and long-term debt, and owners' equity.

[10] To properly argue about selection by size, ideally we would compare foreign parents of US-based FBOs and foreign banks without operations abroad. Unfortunately, with the available data, we cannot distinguish foreign nonmultinational banks from foreign parents of FBOs located in countries other than the United States. However, we argue that since the United States is one of the most popular markets for the activities of multinational banks, if foreign banks do not have operations in the US, it is unlikely that they have significant operations in other foreign markets.

[11] There is a large and long-standing literature documenting the relationship between bank efficiency and bank scale. Berger and Mester (1997), Hughes and Mester (1998), and Wheelock and Wilson (2012) find evidence of scale economies across the entire size distribution of banks. Feng and Serletis (2010) find that also the largest banks exhibit economies of scale.

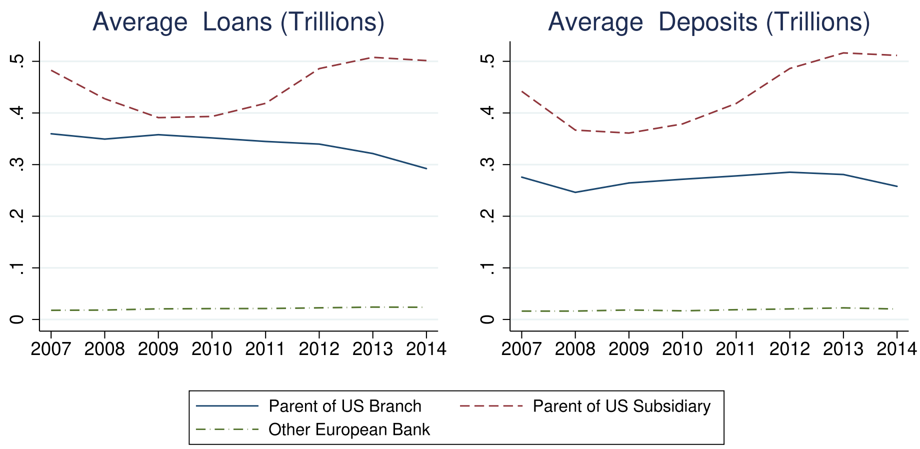


Fig. 1. Foreign Parents versus Foreign Nonmultinational Banks. Comparison of loans and deposits of foreign parents of US-based FBOs (subsidiaries and branches) versus European banks without US operations. Data are in trillions of US dollars.
Source: S&P Global Market Intelligence data for top-tier European parents of US branches and subsidiaries.

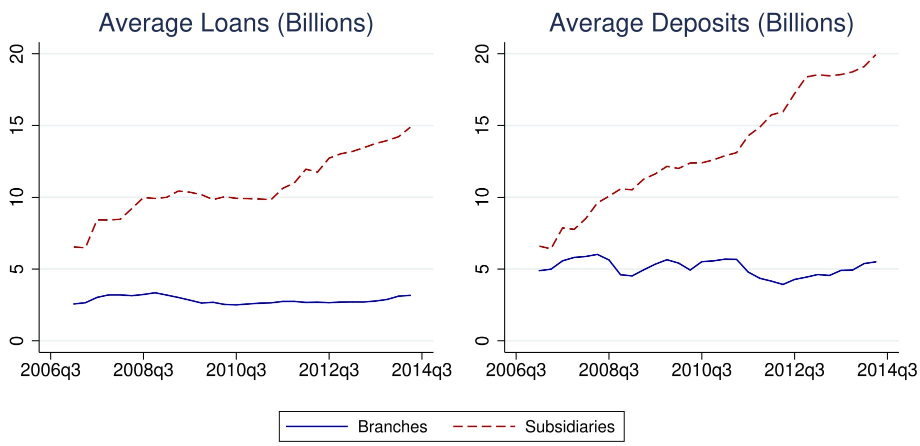


Fig. 2. US-Based Branches versus US-Based Subsidiaries of Foreign Banks. Comparison of loans and deposits of US-based subsidiaries and branches of FBOs. Data are in billions of US dollars.
Source: US Structure Data for US Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign-Owned US Commercial Banks plus US Branches and Agencies of Foreign Banks.

2.3. Foreign banks' response to shocks

We use the European sovereign debt crisis as a natural experiment to analyze how global banks respond to shocks and the extent to which these institutions transmit shocks across countries. More precisely, we analyze the differential effects on banks' balance sheets due to differences across bank portfolio holdings of sovereign debt from Greece, Italy, Ireland, Portugal, and Spain (GIIPS). We argue that the sovereign debt crisis in these European countries is largely exogenous to the US economy and banking system.[12] The exogeneity of the shock allows us to identify the transmission mechanism through foreign banks in the US. The analysis in this section is similar in spirit to the one in Cetorelli and Goldberg (2012b) and Correa et al. (2021), but with an emphasis on the distinction between foreign subsidiaries and foreign branches operating in the United States. We find that after the European sovereign debt crisis: 1) US-based branches of exposed European banks reduced their loans in the United States while US-based subsidiaries of exposed European banks did not experience a decline in loans; 2) the probability that a US branch received an intrafirm transfer from an exposed parent increased, and the amount of the transfer increased; and 3) there was a flight of uninsured wholesale deposits from the US branches of exposed European parents, while both the insured and uninsured deposits of US subsidiaries of exposed European parents were not affected.

[12] US banks could have been directly affected by the European sovereign debt crisis. European sovereign securities on US banks' balance sheets could have resulted in the deterioration of the banks' equity. Unfortunately, data on the exposure to foreign sovereign debt securities are not available. However, US banks' exposure to foreign public sector, in general, is very limited. The 2010 BIS Country Exposure Lending Survey shows that claims by US banks on European countries' public sector represented 2% of the total assets held by all US banks, and this figure includes all European sovereign debt, not only that issued by GIIPS.

Before showing the results of our regression analysis, Fig. 3 illustrates the evolution of all variables of interest before and after the sovereign debt crisis, for exposed versus non-exposed branches and subsidiaries separately.[13]

Loans. To examine the response of branches' versus subsidiaries' loans, we run the following regression:

$$l_{b,t}^{e} = \alpha + \beta \text{Crisis}_t \times \text{Exp}_b + \delta_b + \delta_t + \varepsilon_{b,t}^{e}, \tag{1}$$

where $l_{b,t}^{e}$ is the natural log of the total loans issued by entity e belonging to bank b at time t. An entity is either an aggregate of US-based branches or an aggregate of US-based subsidiaries belonging to a European bank b. We run the regression separately for branches and for subsidiaries. The dummy variable Crisis_t takes the value of 1 for all quarter-years after Q1–2011 (included), while the dummy variable Exp_b takes the value of 1 when parent bank b of entity e is exposed to GIIPS sovereign debt as of December 2010. We classify a bank as exposed if it has positive GIIPS sovereign debt holdings. The regression includes bank fixed effects, denoted by δ_b, to control for heterogeneity across banks, and quarter fixed effects, denoted by δ_t.

The results are reported in Table 1 and show that, after the European sovereign debt crisis, US branches of exposed European banks decreased their loans in the United States, while the loans of US subsidiaries of exposed European banks were unaffected.[14]

The estimated coefficient in the second column of Table 1 implies that total loans held in US branches owned by exposed parents experienced a 52% decline—about $368 billions, after the crisis. As a comparison, Peek and Rosengren (2000) estimate the effects of the Japanese crises in the early 1990s and find that assets held by Japanese branches in California, New York, and Illinois, declined by 53%, 50%, and 70%, respectively, with a total asset contraction of $42 billion in 2013 dollars.[15]

There is some concern that the exposure to GIIPS sovereign debt is not predetermined. The exact timing of the European sovereign debt crisis played out over a longer stretch than is captured by our annual data frequency, that is, banks may have started to adjust their sovereign holdings before December 2010. Possible declines in banks' sovereign debt holdings prior to December 2010 would bias our estimates downwards, as our quarterly data may induce us to consider as non-treated (non-exposed) banks that in reality were treated (exposed) *prior* to December 2010. For this reason, our estimated differential decline in loans may be lower than what it would have been if we were able to measure exposure with higher frequency data.

Internal transfers. Given that the sovereign debt crisis affected the balance sheets of the European parents of these FBOs, one might think that the drop in loans of their US-based branches was associated with an increase in the internal transfer of resources from the United States to Europe. The evidence is in fact quite the opposite. The left panel of Fig. 4 shows the evolution of the aggregate net flows to and from related institutions. From 2000 to 2011, the amounts that European parent banks were borrowing from their US branches were much larger than the amounts that US branches were borrowing from their European parents, producing a net transfer from branches to parents. This is consistent with the evidence shown by Cetorelli and Goldberg (2012a, 2012b) and Correa et al. (2021) about foreign branches being a source of funding to their US parents. Surprisingly, the pattern sharply reverts at the onset of the European sovereign debt crisis in 2011. Transfers from EU parents to US branches increase, despite the fact that the European parents were directly hit by the shock. The right panel of Fig. 4 illustrates the intrafirm flows broken down between exposed and nonexposed banks. It is evident from the figure that the sign reversal in intrafirm capital flows between parents and branches is mostly due to FBOs whose parents were exposed to the crisis.[16]

We run the following regression to establish precisely the sharp distinction between intrafirm flows of exposed versus nonexposed European banks with foreign branches:

$$T_{b,t}^{e} = \alpha + \beta \text{Crisis}_t \times \text{Exp}_b + \delta_b + \delta_t + \varepsilon_{b,t}^{e}. \tag{2}$$

To study both the intensive and extensive margin of the intrafirm transfers, $T_{b,t}^{e}$ is either a dummy variable taking the value of one if parent bank b has a claim on branch e's assets in period t (zero if the branch has a claim on the parent), or the size of the intrafirm transfer of parent bank b to branch e at time t. The other variables have been defined above.

The results are reported in Table 2, and show that, at the onset of the European sovereign debt crisis, both the intensive and the extensive margin of the intrafirm transfer between an exposed European parent and its US branches increased. The probability that a US branch received an intrafirm transfer from the exposed parent increased, and the amount of the transfer also increased. Appendix Table D.4 illustrates the robustness of these results to different definitions of exposure.

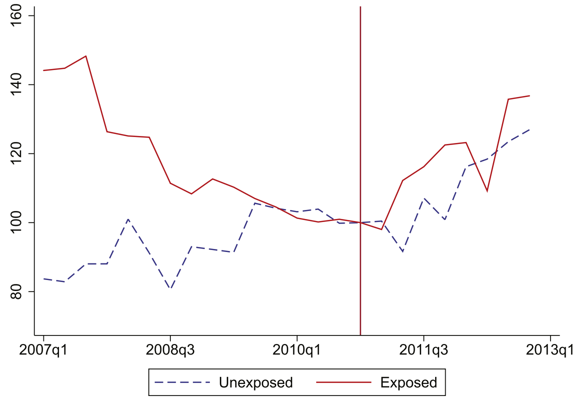
Deposits. So far we have documented a drop in loans for US branches accompanied by a transfer of resources from the already-exposed European parents to their branches. To shed light on this apparent puzzle, we examine the funding side of US FBOs' balance sheets by running regressions of deposits on a set of dummies that are analogous to the ones previously

[13] Appendix Table D.2 reports summary statistics for all variables of interest (loans, deposits, and intrafirm transfers). Figure 3 also shows that the parallel trend assumptions hold for exposed versus non exposed branches and subsidiaries across all variables of interest.

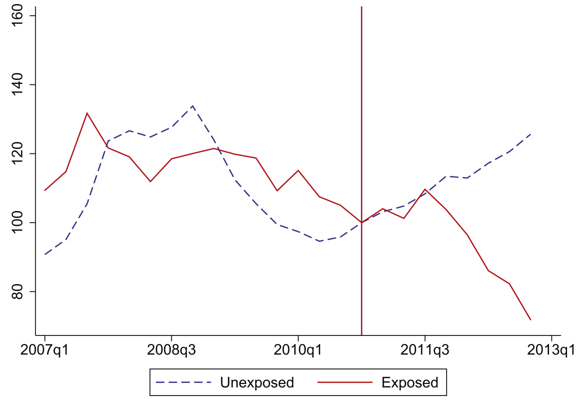
[14] Our results are robust to alternative definitions of exposed banks, as Appendix Table D.3 shows. Precisely,we also performed the empirical analysis reported in this section using the following alternative definitions of "exposed parent": (1) if from a country in the euro zone; (2) if from a country in Europe; (3) if it has GIIPS sovereign debt holdings above the sample median; (4) if its ratio of GIIPS sovereign debt holdings over assets is above the sample median; (5) if its ratio of GIIPS sovereign debt holdings over Tier one capital is above the sample median. We define exposure using coarse dummies rather than using exposure levels as explanatory variables because GIIPS sovereign debt holdings constitute a very small share of these banks' balance sheets: among exposed parents, the mean (median) exposure is only 3.07% (1.7%) of assets. This said, running the regressions using actual exposure levels produces the same qualitative results, also shown in Appendix Table D.3.

[15] The $368 billion decline in loans is computed as a 52% decline in the loans of 182 branches which have average loans of $3.89 billions. Peek and Rosengren (2000)'s original estimate is $28.3 billion in 1996 dollars.

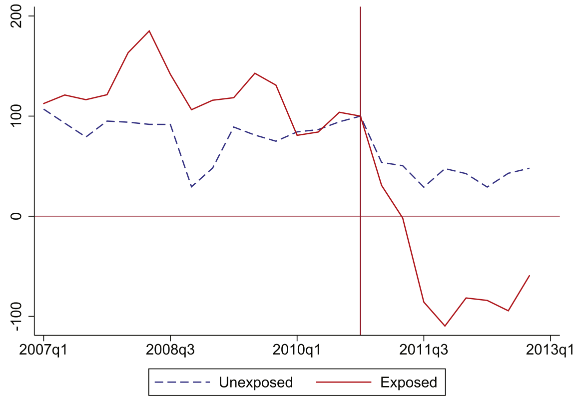
[16] Figure D.4 in the Appendix illustrates the breakdown of intrafirm flows by origin country.



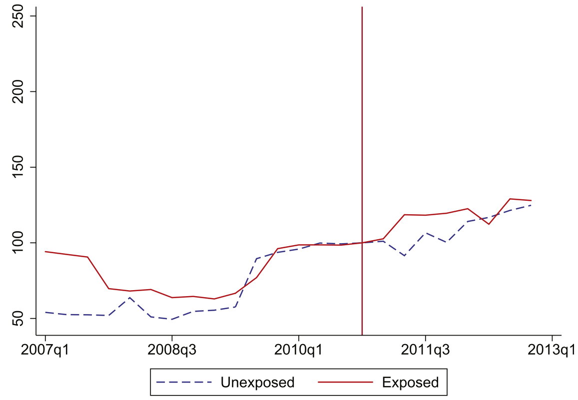
(a) Loans by US subsidiaries of EU banks



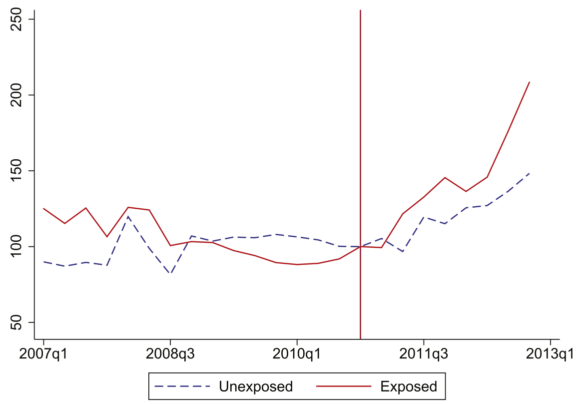
(b) Loans by US branches of EU banks



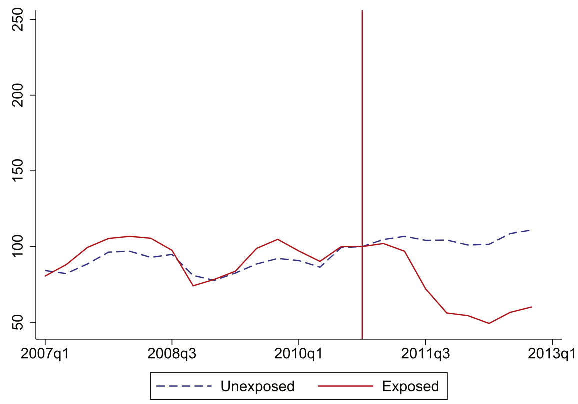
(c) Transfers between US branches and their EU parents



(d) Retail deposits by US subsidiaries of EU banks



(e) Wholesale deposits by US subsidiaries of EU banks



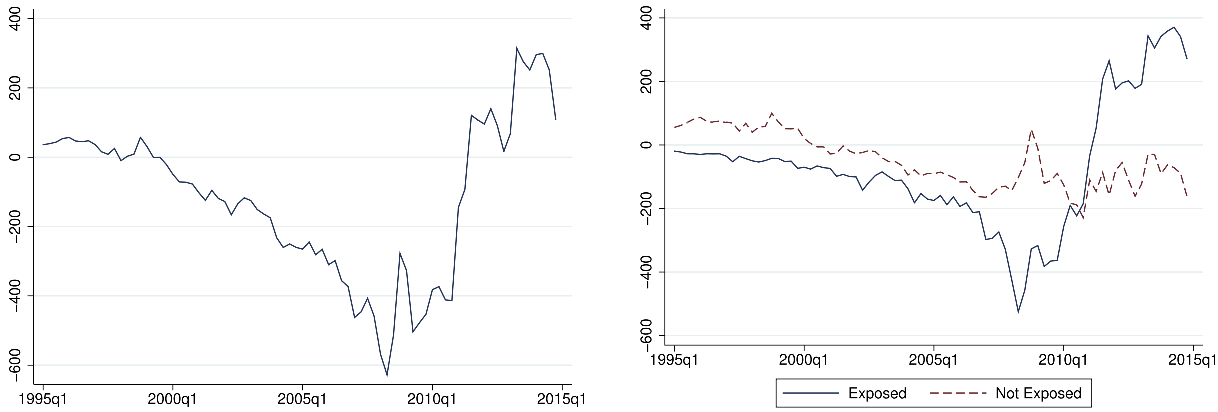
(f) Wholesale deposits by US branches of EU banks

Fig. 3. Evolution of loans, transfers, and deposits in exposed versus unexposed US foreign bank entities. Each panel illustrates the evolution of each variable before and after the crisis, for exposed and unexposed banks separately. Each series is normalized so that the value for 2010 Q4 is equal to 100.
Source: US Structure Data for US Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign-Owned US Commercial Banks plus US Branches and Agencies of Foreign Banks.

Table 1
Intensive Margin of Loans: Branches versus Subsidiaries.

	ln (*Total Loans*)	
	Subsidiaries	Branches
Crisis × Exposed	−0.171	−0.740**
	(0.231)	(0.282)
Constant	14.60***	13.50***
	(0.0126)	(0.0222)
Parent bank FE	Yes	Yes
Quarter FE	Yes	Yes
Observations	1074	2947
R-squared	0.896	0.927

Note: Robust standard errors in parentheses. Levels of significance are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$. Source: US Structure Data for US Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign-Owned US Commercial Banks plus US Branches and Agencies of Foreign Banks.



(a) Net Transfer from EU parents to US branches

(b) Net Transfer from EU parents to US branches, by exposure

Fig. 4. Net Intrafirm Flows from European parents of FBOs to their US-based Branches. Difference between *Net due from related depository institutions* and *Net due to related depository institutions* (items 2 and 5, respectively, from the "Schedule RAL - Assets and Liabilities"). Data are in billions of US dollars.
Source: Report of Assets and Liabilities of US Branches and Agencies of Foreign Banks (FFIEC 002).

used:

$$d^{e}_{b,t} = \alpha + \beta \text{Crisis}_t \times \text{Exp}_b + \delta_b + \delta_t + \varepsilon^{e}_{b,t}, \quad (3)$$

where $d^{e}_{b,t}$ is the natural log of total deposits of entity e belonging to bank b at time t. We run three separate regressions: one for insured retail deposits, which are accepted only by subsidiaries, one for uninsured wholesale deposits held by subsidiaries, and one for uninsured wholesale deposits held by branches.

The results are shown in Table 3. Both retail and wholesale deposits in subsidiaries of exposed parents appear to be unaffected by the crisis. We find that the flight in wholesale deposits appears to be unique to branches owned by exposed European parents. Other papers have documented a flight of wholesale deposits during the European sovereign debt crisis, but did not highlight the different behavior of banks with different organizational forms.[17] The fact that the flight affected only those wholesale deposits that were held in branches suggests that this less-regulated organizational form was perceived as less stable by large wholesale depositors. This result is consistent with the idea that the chain of events in 2010 resulted in a fear of contagion regarding sovereign default in the GIIPS countries which, at the same time, fueled concerns about the stability of the euro and the euro zone more broadly, since exposed banks were headquartered in many countries in Europe, not only the GIIPS (see Appendix Fig. D.4). Appendix Tables D.5 - D.6 illustrate the robustness of these results to different definitions of exposure.

To summarize, the results of this analysis depict a scenario in which distress among some European parents was associated with a flight of uninsured deposits from their foreign branches in the United States. The reaction on the funding side of foreign

[17] See Correa et al. (2021) and Egan et al. (2017).

Table 2
Intensive and Extensive Margin of Net Intrafirm Transfers from European Parents to their US Branches.

	prob($T > 0$)	T
Crisis	0.252***	
	(0.0523)	
Exposed	−0.902***	
	(0.0789)	
Crisis × Exposed	0.955***	13.71**
	(0.124)	(5.153)
Constant	0.324***	−3.041***
	(0.0336)	(0.394)
Parent bank FE	No	Yes
Quarter FE	No	Yes
Observations	3138	3132
R-squared		0.550

Note: Robust standard errors in parentheses. Levels of significance are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$. Source: Report of Assets and Liabilities of US Branches and Agencies of Foreign Banks (FFIEC 002).

Table 3
Intensive Margin of Wholesale and Retail Deposits: Branches vs. Subsidiaries.

	ln (Retail Dep.)	*ln* (Wholesale Dep.)	*ln* (Wholesale Dep.)
	Subsidiaries		Branches
Crisis × Exposed	0.640	0.538	−1.047***
	(0.651)	(0.389)	(0.283)
Constant	13.59***	13.97***	13.09***
	(0.0346)	(0.0190)	(0.0204)
Parent bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Observations	1095	1087	3018
R-squared	0.871	0.904	0.912

Note: Robust standard errors in parentheses. Levels of significance are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$. Sources: US Structure Data for US Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign-Owned US Commercial Banks plus US Branches and Agencies of Foreign Banks; Quarterly Report of Condition and Income.

branches has the effect of changing the direction of intrafirm banking flows: foreign branches were a source of funding to their parents until 2011, while after the crisis parents started acting as a source of funding to their branches. This evidence indicates that branching appears to transmit shocks across countries more than subsidiarization does, as the latter institutional arrangement effectively isolates FBOs from potential distress affecting their parents. It could be argued that the transmission of shocks is in response to regulatory pressures in the home country. Such narrative is consistent with ours, since the regulatory pressures arise as a result of the deterioration of capital ratios at the bank holding company level. This deterioration of capital ratios is ultimately the driver behind the mechanism described in this paper.

In the next section we introduce a structural model of foreign banking that is consistent with the institutional features of the foreign banking sector in the United States and with the empirical evidence presented so far.

3. A model of foreign banking

The model illustrates the main tradeoffs that a bank faces when deciding whether and how to operate in a foreign country. We extend the Monti-Klein model (see Klein, 1971, and Monti, 1972) to a setting with monopolistic competition among heterogeneous banks, featuring the institutional characteristics of different bank types. The model enables us to understand banks' decisions as responses to various shocks and the consequences of these choices for the banking sector on aggregate, and lays the ground for the quantitative analysis developed in the next section.

3.1. Setup

The economy is composed of two countries, Home and Foreign. Variables referring to the Foreign country are denoted by an asterisk (*). Each country is populated by a large mass of banks. Banks issue loans and accept deposits, both to non-bank borrowers and lenders and in the interbank market, taking aggregate loan demand and deposit supply as given. We assume that every bank has market power in the markets for non-bank loans and deposits, originating from some type of differentiation (e.g., spatial or product). This differentiation, together with customers' love of variety in banking products, is the rationale for why many banks coexist in the economy.

Banks are heterogeneous in the efficiency with which they manage their activities, and operate under monopolistic competition in the market for loans and deposits. For simplicity, the interbank market is assumed to be perfectly competitive. We do not model domestic entry: all banks operate in their home market. In addition, each bank may open an affiliate in the other country, either as a branch or as a subsidiary, and thus become the parent of a multinational bank.

In order to examine the effect of shocks like the European sovereign debt crisis, we develop the model in two periods. In the first period, each bank chooses whether and how to operate in the foreign market, makes profits, and accumulates equity. At the end of the first period, an unexpected shock hits the economy, affecting equity accumulation and the decisions banks make in the second period.

We start by describing the profit maximization problem of a bank conditional on each one of the three international status choices: local bank (a bank that chooses not to operate in the foreign market), parent with foreign subsidiary, or parent with foreign branch. Then we model selection into international status.

In each period and in each market where they operate, banks offer one-period loans (L). With a certain probability of default $(1-p)$, loans are delinquent and the principal is not repaid. Each bank accepts deposits (D), and borrows/lends in the interbank market (M). During each period, banks incur a cost to manage deposits and loans, described by the cost function $a \cdot C(D,L)$. The bank-specific parameter a is the source of heterogeneity across banks, so that "low a" banks are more efficient than "high a" banks. It has to be noted, however, that bank efficiency only affects the cost that a bank has to bear to manage its assets and liabilities, and it is independent on loans' and deposits' quality, which is assumed to be homogeneous across banks. Lastly, each bank is endowed with a given amount of equity $E(a)$, which is an exogenous function of bank efficiency.[18]

In order to assess the importance of regulatory policies for the response to shocks, we model deposit insurance and capital requirements.

Deposit Insurance. In the United States, all banks accepting retail deposits have to pay deposit insurance to the FDIC, which determines the deposit insurance premium (IP), or assessment, on a risk basis. A bank's assessment is calculated by multiplying its assessment rate by its assessment base, where a bank's assessment base is equal to its average consolidated total assets minus its average tangible equity. The assessment rate expresses the bank's ability to withstand funding and asset stress, so we model it as a function of the bank's equity and liabilities:

$$IP(D,M^-) = \underbrace{f(D,M^-)}_{\text{assessment rate}} \cdot \underbrace{(D+M^-)}_{\text{assessment base}} \equiv \left[f_1 + f_2 \cdot \frac{M^-}{E(a)}\right](D+M^-), \tag{4}$$

where M^- denotes interbank borrowing, and $f_1, f_2 > 0$.[19] This functional form results in an insurance premium which is higher the more a bank resorts to interbank borrowing to fund its activities. This parameterization of deposit insurance provides a disincentive for banks to compensate for a funding shock by resorting to excessive interbank borrowing, something that the regulation prevents banks from doing.

Capital Requirements. Banks are subject to capital requirements every period, i.e., there is a lower bound on the ratio of equity to risk-weighted assets that they are allowed to sustain:

$$\frac{E(a)}{\omega_L L + \omega_M M^+} \geq k, \tag{5}$$

where the value of k is set in the United States under the implementation of the Basel II/Basel III Accords. The parameters ω_L and ω_M are appropriate weights that reflect the riskiness of a bank's loans and investments, and are determined by the regulatory agencies (in the US case, by the Federal Reserve, FDIC, and Office of the Comptroller of the Currency).

3.2. Local banks

A local bank chooses the optimal amounts of loans, L, deposits, D, and interbank activity, M, to maximize its profits:

$$\max_{L,D,M} \quad p \cdot r_L(L) \cdot L - (1-p)L - r_D(D) \cdot D + r_M M - aC(D,L) - IP(D,M^-) \tag{6}$$

[18] In Section 4, we back up the distribution of equity from data on the loans distribution and the equity over assets ratio of banks in our sample.
[19] The functional form in expression (4) broadly follows the FDIC Current Assessment Rate Calculator for Highly Complex Institutions. Appendix C contains more institutional details about the calculation of deposit insurance assessments.

$$
\begin{aligned}
s.t.\ & E(a) + D \geq L + M && \text{(resource constraint)} \\
& \frac{E(a)}{\omega_L L + \omega_M M^+} \geq k && \text{(capital requirement)},
\end{aligned}
$$

where $r_L(L)$, denotes a downward-sloping demand for loans, and $p \in (0,1)$ is the probability of loan repayment. The function $r_D(D)$ is an upward-sloping supply of insured retail deposits,[20] while r_M is the interbank rate, which the bank takes as exogenous, but is endogenously determined in industry equilibrium. Each bank maximizes profits subject to two constraints. First, its assets must not exceed its liabilities (the resource constraint). Second, the ratio of equity to risk-weighted assets must be maintained above the capital requirement, k. Notice also that the bank's management cost and its equity level depend on the bank's efficiency, which is the exogenous source of heterogeneity in the model.

In normal times, we observe in the data that banks choose to operate with a buffer on their capital requirements, i.e., capital requirement constraints are normally not binding.[21] For this reason, we assume that the equilibrium in normal times is one where the resource constraint binds, but the capital requirement does not. We refer to this solution of the model as the "unconstrained equilibrium." The unconstrained equilibrium is characterized by an interior solution for (L, D), described by the following first-order conditions:

$$
[L] \quad p\left[\frac{\partial r_L(L)}{\partial L} L + r_L(L)\right] = a\frac{\partial C(\cdot)}{\partial L} + (1 - p) + r_M \tag{7}
$$

$$
[D] \quad \left[\frac{\partial r_D(D)}{\partial D} D + r_D(D)\right] + a\frac{\partial C(\cdot)}{\partial D} + \frac{\partial IP(\cdot)}{\partial D} = r_M, \tag{8}
$$

where the functions' arguments have been omitted to simplify the notation. The resource constraint pins down interbank activity: $M = E(a) + D - L$.

The first-order conditions are intuitive. A bank chooses the optimal amount of loans such that the marginal revenue from lending (the left hand side of Eq. (7) is equal to the sum of the marginal management costs of loans ($\partial C(\cdot)/\partial L$), the expected marginal loss from delinquent loans $(1 - p)$, and the opportunity cost of forgone alternatives, namely lending to other financial institutions in the interbank market (r_M). Similarly, optimal deposits are such that their "total" marginal cost, inclusive of management costs and the insurance premium (the left hand side of Eq. (8)), is equal to the marginal cost of borrowing in the interbank market (r_M). In Appendix C, we illustrate that—under some simple parametric assumptions—a bank's maximal profit is an increasing function of the bank's efficiency, $1/a$, and the bank's equity, $E(a)$.

In the model, shocks to the economy may induce situations where the capital constraint of a local bank is binding. We refer to this scenario as the model's "constrained equilibrium".

3.3. The parent-subsidiary pair

Given that foreign-owned subsidiaries are subject to the same regulation as US banks, a parent-subsidiary pair solves the same profit maximization problem that a local bank faces in each market in which it operates:

$$
\begin{aligned}
\max_{\substack{L,D,M \\ L^*,D^*,M^*}} \ & pr_L(L)\cdot L - (1-p)L - r_D(D) + r_M M \cdot D - aC(D,L) - IP(D,M^-) + \dots \\
& p^* r_L^*(L^*)\cdot L^* - (1-p^*)L^* - r_D^*(D^*)D^* + r_M M^* - aC(D^*,L^*) - IP(D^*, M^{-*})
\end{aligned} \tag{9}
$$

$$
\begin{aligned}
s.t.\ & (1 - s_E)E(a) + D \geq L + M \\
& s_E E(a) + D^* \geq L^* + M^* \\
& \frac{(1 - s_E)E(a)}{\omega_L L + \omega_M M^+} \geq k \\
& \frac{s_E E(a)}{\omega_L L^* + \omega_M M^{*+}} \geq k,
\end{aligned}
$$

[20] In the data, parent banks and their subsidiaries can accept all kinds of deposits, both wholesale and retail. For simplicity, in the model we assume that parent banks and subsidiaries hold only retail deposits. The results are robust to the removal of this simplifying assumption.

[21] Appendix Figure D.5 shows that banks in our sample have ratios of equity to risk-weighted assets well above the capital requirement of 0.045 set by the Basel accords.

where asterisks denote foreign-market variables, and s_E denotes the share of bank equity that is funding the operations of the foreign subsidiary.[22] Consistent with the evidence presented in Section 2, we assume that a parent transfers its efficiency level $1/a$ to its foreign subsidiary. While loans and deposits markets are segmented, we assume that there is a frictionless international interbank market, clearing at the rate r_M. We also assume that the deposit insurance premium, the capital requirement, and the risk weights on assets are symmetric across countries.

Given that the country-level profit functions associated with the two entities forming the pair are identical, and the US regulation treats foreign subsidiaries as independent US banks, the equilibrium for each entity of a parent-subsidiary pair takes the same form as the equilibrium for a local bank, with the appropriate equity levels, both in the unconstrained and in the constrained case.

3.4. The parent-branch pair

When a parent bank operates in the foreign market with a branch, the activities of the affiliate differ from those of the parent. Branches do not raise independent equity, they are not subject to capital requirements, and can only accept uninsured wholesale deposits. Moreover, there exists an intrafirm channel linking the assets and liabilities of the parent and its branch: parents of foreign branches can borrow from or lend to their branches at no cost.

A parent-branch pair solves:

$$\begin{aligned} \max_{\substack{L,D,M,T \\ L^*,D^*_w}} \; & pr_L(L)\cdot L-(1-p)L-r_D(D)\cdot D+r_M M-aC(D,L)-IP(D,M^-)+ \\ & \ldots p^* r^*_{L^*}(L^*)\cdot L^*-(1-p^*)L^*-r^{*w}_{D}\left(D^*_w;\left(\frac{E(a)}{k\cdot RW\,A}\right)\right)\cdot D^*_w-aC(D^*_w,L^*) \end{aligned} \tag{10}$$

$$\begin{aligned} s.t.\quad & E(a)+D\geq L+M+T \\ & D^*_w+T\geq L^* \\ & \frac{E(a)}{\omega_L(L+L^*)+\omega_M M^+}\geq k. \end{aligned}$$

The profit function reflects the institutional restrictions that make branches different from local banks and subsidiaries. First, the balance sheet of a branch is effectively "merged" with that of its parent: branches do not raise independent equity and can transfer funds to/from the parent at no cost (T, which is positive when the parent is lending to the branch).[23] As a result, if a branch has excess funds, it may transfer these funds to the parent to finance its domestic lending (as it appears in the pre-crisis period). Similarly, a parent can fund its branch in the event of a shortage of deposits (as it appears in the post-crisis period). Second, the lack of independent equity requirements for branches implies that they are subject to capital requirements only at the level of the entire bank holding company. Finally, on the liabilities side, branches can only accept uninsured wholesale deposits. The term $r^{*w}_{D}\left(D^*_w;\left(\frac{E(a)}{k\cdot RWA}\right)\right)$ is the supply of wholesale deposits, where RWA denotes risk-weighted assets: $RWA=\omega_L(L+L^*)+\omega_M M^+$.

We rely on the estimates by Egan et al. (2017) and assume that the supply of uninsured wholesale deposits is less elastic than the supply of insured retail deposits, and that wholesale deposits are sensitive to some measure of "distress" experienced by the banking organization. Our model-based measure of distress is inversely related to the buffer in the capital requirement that banks hold in normal times, given by the ratio of equity to risk-weighted assets divided by the capital requirement k. When $\frac{E(a)}{k\cdot RWA}=1$, the capital requirement is binding and the bank experiences maximum distress, resulting in all its wholesale deposits being withdrawn. Distress (and the severity of the wholesale deposits flight) decreases as $\frac{E(a)}{k\cdot RWA}$ grows bigger than one. This specification is also consistent with Ivashina et al. (2015), who conclude that wholesale funding is sensitive to changing perceptions of a bank's creditworthiness.

3.5. Selection, equity accumulation and industry equilibrium

A bank decides whether to operate only locally or to open a foreign affiliate (branch or subsidiary) depending on which option is associated with the highest expected profits. We assume that entering the Foreign market involves a fixed cost, which is higher

[22] In Section 4, we calibrate s_E directly as subsidiary equity divided by parent equity. An alternative would have been to solve for the optimal equity distribution of a parent-subsidiary pair across countries. Since the profit functions of the parent and the subsidiary have the same form, this would have resulted in s_E being pinned down by relative market size, which would have generated subsidiary equity shares much larger than in the data.

[23] Because intrabank transfers are costless, the location of interbank activity for parent-branch pairs is undetermined in the model. For this reason, and without loss of generality, we assume that all interbank activity M is managed by the parent. It is possible to relax the assumption of costless transfers: a model where transfers between parents and FBOs are costly would have the same qualitative implications as the current model, as long as the cost of transfers is higher for parent-subsidiary pairs than for parent-branch pairs.

if the bank enters with a subsidiary rather than a branch: $F_S > F_B > 0$. The fixed costs of opening a subsidiary may include the cost of setting up a network of affiliates, acquiring customers, and learning about the host country's regulatory framework. As the activities of branches are more limited compared to those of subsidiaries, we assume that the fixed cost of branching is lower than the fixed cost of subsidiarization.

In the first period, a bank chooses the organizational form that maximizes its total profits net of entry costs:

$$\tilde{\pi}^1(a) \equiv \max\{\tilde{\pi}_D(a); \tilde{\pi}_{PS}(a) - F_S; \tilde{\pi}_{PB}(a) - F_B\} \tag{11}$$

where $\tilde{\pi}_D(a)$, $\tilde{\pi}_{PS}(a)$, and $\tilde{\pi}_{PB}(a)$ denote the maximal profits of a local bank, of a parent-subsidiary pair, and of a parent-branch pair, respectively.

At the end of the first period, the economy is hit by the sovereign debt crisis shock, which in the model takes the form of a decline in the probability of repayment in Europe, p. In the second period, banks take decisions conditional on the international status they chose in the first period. Local banks and parent-branch pairs continue operations as long as the shock does not drive their equity below zero, in which case they shut down. Since foreign subsidiaries are separately capitalized, we assume that events that drive to zero either the equity of the subsidiary or the equity of the parent result in the bank shutting down an unprofitable subsidiary in the first case, or repatriating subsidiary's equity to revive an unprofitable parent in the second case. In both cases, the outcome is exit from the foreign market.[24] When both entities of a parent-subsidiary pair become not profitable, the entire bank shuts down. Hence profits in the second period are:

$$\tilde{\pi}^2(a) \equiv \begin{cases} \max\{\tilde{\pi}_D(a), 0\} & \text{if } \tilde{\pi}^1(a) = \tilde{\pi}_D(a); \\ \max\{\tilde{\pi}_{PB}(a), 0\} & \text{if } \tilde{\pi}^1(a) = \tilde{\pi}_{PB}(a); \\ \max\{\tilde{\pi}_{PS}(a), \tilde{\pi}_D(a), 0\} & \text{if } \tilde{\pi}^1(a) = \tilde{\pi}_{PS}(a). \end{cases} \tag{12}$$

To close the model in a banking industry equilibrium, we assume that each country is populated by a continuum of banks that draw their bank-specific efficiency, $1/a$, from the exogenous distributions $F(a)$ and $F^*(a)$. Selection into the foreign market implies that there are endogenous equilibrium distributions of banks operating in each country, which we denote with $G(a)$, $G^*(a)$.

The interest rate in the interbank market is given by the market-clearing condition:

$$\int M(a; r_M)G(a)da + \int M^*(a; r_M)G^*(a)da = 0. \tag{13}$$

Each bank starts the first period with a given level of equity, $E^1(a)$, and accumulates equity over time through reinvested profits:

$$E^2(a) = E^1(a) + \tilde{\pi}^1(a). \tag{14}$$

3.6. Selection: matching cross-sectional facts

The modeling choices driving selection into the foreign market and the trade-off between branching and subsidiarization are consistent with the facts reported in Section 2.

First, due to the presence of fixed entry costs, only the largest (most efficient) banks decide to open foreign entities, becoming multinational banks, consistent with Fig. 1.[25]

Second, in the model, branching and subsidiarization are alternative choices; hence, no bank chooses both options to operate in a foreign market. This result is consistent with most of the observations in our sample. Among the 47 European banks in our sample, 37 operate in the US market exclusively with branches or exclusively with subsidiaries. Six of the remaining banks adopt both options, but have more than 70% of their assets in one organizational form.

Third, the choice between branching versus subsidiarization is driven by the trade-off between different forces: branches are less costly than subsidiaries because of lower entry costs and the lack of deposit insurance premium to pay, and provide a flexible channel (T) to redistribute capital across countries, but are linked to a more volatile source of funding compared to subsidiaries. In the next section, we calibrate the model to match the fact that foreign subsidiaries are larger than foreign branches in terms of both loans and deposits.

[24] The model doesn't feature organizational changes from branching to subsidiarization and vice versa, because we don't observe those in the data. Organizational changes take the form of entities closing and opening, but we cannot ascertain whether such changes involve the same entity or two separate entities.

[25] This fact is also consistent with evidence of selection by size for multinational corporations in other sectors (see Bernard et al., 2009).

4. Quantitative analysis

We quantify the model and use it for counterfactual analysis. We start by calibrating the model to be quantitatively consistent with a set of moments describing FBOs' activities in the US. The calibrated model is able to reproduce the differential response of global banks with different organizational structures to the shock we studied empirically, the European sovereign debt crisis. To answer a set of policy-relevant questions, we perform counterfactual exercises that shed light on the strength and weaknesses of the current US regulatory framework.

4.1. Calibration

Our calibration exercise proceeds in three steps. First, a subset of the model's parameters can be directly matched to empirical observations or to previous studies. Second, we use the empirical distribution of loans to discipline the parameters of the banks' efficiency and equity distributions. Third, we use the model to jointly calibrate the remaining parameters by matching some moments of interest. Since we want to calibrate the economy prior to the European sovereign debt crisis, all the data moments are for the year 2010.

We parameterize the model to preserve tractability and make possible the identification of key parameters. We assume a constant-elasticity loan demand function: $L(r_L) = r_L^{-\varepsilon}A$, where $\varepsilon > 1$ is the elasticity of loan demand, and A is a parameter describing the aggregate size of the loan market. Similarly, we assume a constant-elasticity retail deposit supply function: $D(r_D) = r_D^{\vartheta}B$, where $\vartheta > 0$ is the elasticity of retail deposit supply, and B is a parameter describing the aggregate size of the retail deposit market. For wholesale deposits, this specification is augmented to include sensitivity to a measure of distress of the bank holding company: $D_w(r_D^w) = (r_D^w)^{\vartheta_w} \log\left(\frac{E(a)}{k \cdot RWA}\right)B_w$, where $\vartheta_w < \vartheta$ is the elasticity of wholesale deposits, and B_w is a parameter describing the aggregate size of the wholesale deposit market. This functional form implies that the quantity of deposits supplied decreases as the buffer on the capital requirement decreases, and that there is a complete deposit flight ($D_w = 0$) when the capital requirement is binding. Finally, we assume that the management cost function is linear: $C(D, L) = c_L L + c_D D$, where $c_L, c_D > 0$. We directly calibrate the probability of loan repayment p, the parameters of the deposit insurance assessment rate f_1 and f_2, the capital requirement k, the risk weights ω_L and ω_M, the elasticities of deposit supply ϑ and ϑ_w, and the subsidiary equity share s_E.

In our model, one minus the probability of loan repayment is equivalent to the bank's expected loss per dollar, which is equal to the probability of default multiplied by the loss given default (one minus the recovery rate). The recovery rate is calibrated to a standard value of 40%. In normal times, we calibrate the probability of default to a baseline value of 2.5%.[26] Hence we set the probability of loan repayment in normal times to $1 - 0.025 \times 0.6 = 0.99$. Consistent with the assessment rates reported in Appendix Table C.1, we set $f_1 = 0.025$ percent to match the minimum possible assessment rate in the scenario in which a bank lends in the interbank market ($M > 0$), while $f_2 = 0.0224$ percent is set such that the bank will be assessed the maximum possible rate if its capital constraint binds and if it relies on the money markets for 95% or more of its funding. We set the capital requirement to $k = 0.045$, which is the Basel III capital requirement for common equity over risk-weighted assets. The Basel II/Basel III regulation also gives guidelines on the weights used to compute risk-weighted assets: we choose $\omega_L = 0.5$, based on corporate loans, consumer loans, and residential mortgage exposures, and $\omega_M = 0.1$, based on exposures to US depository institutions and credit unions. Egan et al. (2017) provide structural estimates of the elasticity of supply for both the retail and wholesale deposit market in the United States. Since the way in which we model deposit supply is a special parametric form of what they estimate, we use their estimated elasticities and set $\vartheta = 0.56$ and $\vartheta_w = 0.16$. Finally, in our dataset, a subsidiary's equity is on average 11% of the equity of the parent. As such, we set $s_E = 0.11$. Table 4 summarizes the parameters that we calibrate directly from the data. We also assume that these parameters are symmetric across the two countries.

In order to discipline the parameters of the banks' efficiency distribution, we start by observing that we cannot reject the hypothesis that the empirical distribution of interest revenues from loans is log-normal. In Appendix C.3, we show that if the banks' efficiency distribution is log-normal with mean μ and standard deviation σ, the distribution of interest revenues from loans is approximately log-normal with mean $\mu_L = (\varepsilon - 1)\mu + \log\left[\left(\frac{\varepsilon c_L}{p(\varepsilon-1)}\right)^{1-\varepsilon} A\right]$ and standard deviation $\sigma_L = (\varepsilon - 1)\sigma$. Maximum likelihood estimates of the parameters of the empirical distribution of interest revenues from loans deliver $\mu_L = 5.95$ and $\sigma_L = 1.93$. Hence, we model a bank's efficiency as a random draw from a log-normal distribution whose parameters μ and σ are calibrated such that:

$$\mu_L = (\varepsilon - 1)\mu + \log\left[\left(\frac{\varepsilon c_L}{p(\varepsilon-1)}\right)^{1-\varepsilon} A\right] = 5.96$$
$$\sigma_L = (\varepsilon - 1)\sigma = 1.93.$$

Banks are heterogeneous, both in their efficiency level and in their initial equity level. Given that we observe nonbinding capital requirements in the data, we target a pre-crisis calibrated economy that is populated by unconstrained banks. The empirical distribution of equity is well-approximated by a log-normal distribution. Since the model abstracts from uses of equity other than

[26] This is an approximate middle-range measure based on estimated probabilities of default on debt with credit ratings ranging from AAA to BB. Source: http://www.newyorkfed.org/research/staff_reports/sr190.pdf.

Table 4
Direct Calibration.

Parameter	Definition	Value	Source
p	Probability of Loan Repayment	0.99	World Bank
f_1, f_2	Insurance Premium Parameters	0.00025,0.000224	FDIC
k	Capital Requirement	0.045	Basel II/III
ω_L, ω_M	Risk Weights	0.5, 0.1	Basel II/III
s_E	Subsidiary's Equity Share	0.11	Call Reports
ϑ, ϑ_W	Elasticities of Retail and Wholesale Deposit Supply	0.56, 0.16	Egan et al. (2017)

loans, we assume that each bank's pre-crisis equity position is drawn from the same distribution as its loans, scaled by the capital requirement ($k = 0.045$) plus a 4% capital buffer.[27] We impose this buffer because the 2008–2010 period coincides with the implementation of stress testing. As banks were getting ready to undergo stress testing, their ratios of equity to risk-weighted assets increased in this period (see Appendix Fig. D.5).

It remains to calibrate the relative management cost of loans versus deposits c_L/c_D, the elasticity of loan demand ε, the aggregate parameters of loan demand and deposit supply in each country (A, A^*, B, B^*, B_W, and B_W^*), and the fixed entry costs F_S and F_B. We assume symmetry across countries and use the model to choose values for these parameters in order to match relevant moments from the data. More precisely, we assume that c_L/c_D and ε are symmetric across countries; that the relative sizes of loans, retail deposits, and wholesale deposits are the same across countries: $A/A^* = B/B^* = B_W/B_W^*$; and that fixed costs imply the same distribution of banks by type in each country. We are left with seven parameters to be calibrated (c_L/c_D, ε, A^*, B^*, B_W^*, F_S, and F_B), for which we choose the following set of target moments: the relative size of the average subsidiary/ average branch, in terms of loans and deposits; the relative presence of foreign branches versus foreign subsidiaries; the share of US loans extended by subsidiaries or branches of foreign banking organizations; the average interest rates on retail deposits and loans; and the average interbank market rate.

The average foreign subsidiary in our data has loans equal to 3.44 times the loans of the average foreign branch, and deposits equal to 2.85 times the deposits of the average foreign branch. In our merged dataset, subsidiaries account for about one-third of US-based FBOs, and in turn FBOs account for about 30% of the total loans extended in the United States. As a target for the average interest rate paid on retail deposits, we use a 0.11% rate paid on checking accounts. We use LIBOR to pin down the value of the interbank market interest rate, 0.92%. Finally, in the model, loans encompass a variety of products, including mortgages, home equity, consumer, and commercial and industrial loans. We take an average of these rates in the data and set our target average interest rates on loans to 6.14%.[28]

Table 5 reports the model-generated moments alongside the corresponding moments in the data. The model does a good job at replicating the relative presence of foreign branches versus subsidiaries and the overall size of the foreign banking sector. We underpredict the relative size of loans and deposits, possibly due to an imperfect fit of the parametric efficiency and size distributions. The target interest rates also fit reasonably well. The corresponding calibrated parameters are reported in Appendix Table D.7. The calibration reveals a sizable elasticity of loan demand, $\varepsilon = 4.4$, corresponding to an average mark-up of 31%. Calibrated management costs are higher for loans than for deposits: this is intuitive, as issuing loans entails monitoring and screening costs, while managing deposits mostly involves providing liquidity through ATMs, which has economies of scale. The reported fixed costs imply that the cost of opening a subsidiary (branch) is equal to 52.3% (82.3%) of the average per-period profits of the subsidiary (branch) itself. Finally, calibrated values of the deposit supply shifters B^*, B_W^* mimic the fact that the wholesale deposit market in the US is smaller than the retail deposit market.

Despite its conceptual simplicity, the model is difficult to compute because of the presence of corner solutions. As such, it is hard to talk precisely about identification. Numerical simulations of the model suggest that the relative number of subsidiaries versus branches and the share of loans issued by FBOs are very sensitive to the calibration of the fixed costs. Moments related to an FBO's relative size are important for quantifying the management cost and market size parameters.

4.2. Global banks' organization and the European sovereign debt crisis

In this section, we use the calibrated model to perform a numerical exercise with the goal of illustrating the consequences of the European sovereign debt crisis for the global banking sector under different policy scenarios.

Starting from the baseline model economy, we simulate the European sovereign debt crisis as follows. We first solve the model with the baseline value of the probability of repayment (period 1). This amounts to computing optimal bank status, optimal values of loans, deposits, and interbank activity for each bank, and the interbank rate which clears the market. At the end of period 1, we introduce an unexpected drop in the probability of loan repayment in Europe, p, which has the effect of reducing

[27] We parameterize the buffer as the average hypothetical worst loss that a bank under stress would experience. This assumption ensures that banks are "far" from the constraint in the pre-crisis equilibrium.

[28] The data moments slightly fluctuate over the years, but not significantly, so that the model fit does not depend on the year of choice for the moments calculation.

Table 5
Moments: Model versus Data.

Moment	Data	Model
Nr. of Subsidiaries/Nr. of Branches	0.36	0.32
Share of US Loans issued by FBOs	29.13%	34.16%
Average Subsidiary Loans/Branch Loans	3.44	2.10
Average Subsidiary Deposits/Branch Deposits	2.85	1.19
Avg. Interest Rate On Deposits	0.11%	0.23%
LIBOR One-Year Interbank Rate	0.92%	0.86%
Avg. Interest Rate on Loans	6.14%	7.22%

Note: Parameters are matched to moments for the year 2010. Data Sources: FRB Structure and Share Data for US Banking Offices of Foreign Entities, Report of Condition and Income (Call Reports), RateWatch Retail Deposit Rates on Checking Accounts, and Intercontinental Exchange (LIBOR).

revenues from loans, profits, and equity accumulation into the next period. In period 2, banks decide the optimal values of loans, deposits, and interbank activity, and whether to shut down their FBOs or keep them in operation.

We present the results of two specifications. In the baseline specification, which we refer to as a "3.6 percent default," we decrease p to $p' = 0.964$. This change generates a reduction in equity accumulation that is heterogeneous across banks, with an average reduction of 10%, similar in size to what we see in the data (see Appendix Fig. D.5). In an alternate specification, we impose a homogeneous 10% drop in equity at the end of the first period, with the same average effect, but balanced across all banks. In both exercises, the decline in bank equity reduces European banks' buffers on capital requirements: $E(a)/RWA$ decreases. This decline differs across banks according to the share of loans in their portfolio.

Table 6 displays the results of this exercise expressed as ratios relative to the baseline pre-crisis economy, reporting both partial equilibrium (keeping the interbank rate r_M constant) and industry equilibrium effects (letting r_M adjust). The two exercises display similar qualitative effects. The drop in parent equity drives a decrease in the buffer on the capital requirement for European parents. Since wholesale deposits supply critically depends on this buffer, and parent-branch balance sheets are integrated, wholesale deposit supply in US-based branches decreases. In our calibrated economy, the decline in wholesale deposits ranges from 8% to 12% across specifications. As branches experience a funding shock, their demand for borrowing increases, and intrafirm borrowing from their parents ($T > 0$) increases by 10–19% across specifications.

Parent banks are willing to provide this funding. In the "3.6 percent default" exercise, assets in the US are relatively more productive than assets in Europe, where the probability of default is higher after the shock. In the exercise where we impose a homogeneous 10% equity decline, branches suffer a disproportionate shock to funding, since —in addition to the equity loss at the parent level—, they also experience a substantial deposit flight. It is then optimal for the parent to reallocate resources to the branch to substitute some of the lost funding. As we observe in the data, the need for extra funding is not entirely fulfilled by the intrafirm transfer in either exercise, and loans decline moderately by 1–3%, less than what we observe in the data. At the same time, consistent with our empirical observations, the balance sheet of US-based subsidiaries is unaffected by the shock that occurs in Europe, despite the large drop in parents' equity.[29] Finally, the shock has a sizable negative effect on aggregate loans in the United States, which experience a decline of 3%.

Our results on the decline in aggregate loans in the US should be interpreted with caution. On the one hand, in the model, branches are the only entities accepting wholesale deposits, so—following the deposit flight associated with the sovereign debt crisis—a source of funding disappears. Empirically, it is possible that those deposits were transferred to other domestic banks or financial institutions (Table 3 indicates that those foreign branch deposits did *not* go to foreign subsidiaries). On the other hand, all banks in the model issue loans, but the deposit flight has the effect of reducing the loans issued by large multinational banks, so even if part of these loans were taken over by other banks, those other banks may not have the scale to absorb them all, driving an aggregate decline. While our data suggest that both local US banks and foreign branches of non-EU banks increase their loans after the crisis (see Appendix Table D.8), the fact that we have no information on the corresponding firm-level borrowing implies that we cannot apply the methodology of Amiti and Weinstein (2018) to disentangle whether the shock to EU banks had any aggregate effects in the US. Other papers in the credit supply literature, such as Ivashina et al. (2022), suggest that there is no perfect substitution of borrowing across banks, so that it is likely that the decline in lending by FBOs in the US was not seamlessly absorbed by other banks, making the possibility of an aggregate decline in loans, like the one predicted by our model, a plausible outcome.[30]

Next, we use the model to evaluate changes in regulatory policies. Table 7 illustrates the effects of a loan repayment shock under several counterfactual scenarios. All the results are reported as percentage changes relative to the pre-crisis scenario, in industry equilibrium.

[29] The only changes in subsidiaries' loans and deposits are due to industry equilibrium responses to changes in the interbank rate.

[30] In the context of the Italian banking sector, for example, Hassan et al. (2022) show that there were frictions to the reallocation of credit from Italian banks exposed to the China shock to other banks, so that the shock had negative effects on aggregate credit supply in Italy.

Table 6
Response to a Loan Repayment Shock in the Model.

	3.6% default		$E'(a) = 0.9 \times E(a)$	
	PE	IE	PE	IE
Average P—B Parent Equity	0.92	0.92	0.90	0.90
Average Branch Wholesale Deposits	0.92	0.90	0.89	0.88
Average P—B Transfers	1.10	1.19	1.14	1.18
Average Branch Loans	0.98	0.99	0.97	0.98
Average P—S Parent Equity	0.81	0.81	0.90	0.90
Average Subsidiary Retail Deposits	1	0.98	1	0.99
Average Subsidiary Loans	1	1.02	1	1.01
Aggregate Loans	0.95	0.97	0.99	0.99
Interbank Rate	0.86%	0.82%	0.86%	0.85%

Note: Ratios relative to baseline pre-crisis economy.

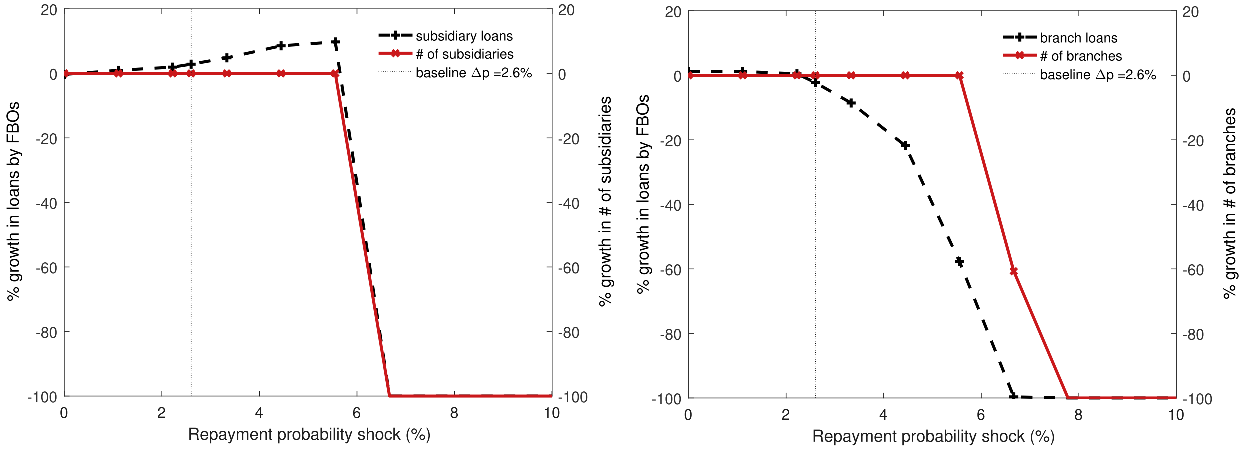
Table 7
Response to a Loan Repayment Shock Under Different Policy Scenarios.

	Baseline (3.6% default)	Only Subs	Only Branch	k = 6% (EU,US)	k = 6% (US only)	Monetary Policy intervention
Avg. P—B Parent Equity	0.92	–	0.90	–	0.93	0.92
Avg. Branch Wholesale Deposits	0.90	–	0.92	–	1.08	0.80
Avg. P—B Transfers	1.19	–	1.04	–	0.96	1.58
Avg. Branch Loans	0.99	–	0.97	–	1.04	1.05
Avg. P—S Parent Equity	0.81	0.84	–	0.86	0.84	0.81
Avg. Subsidiary Retail Deposits	0.98	0.98	–	0.98	0.97	0.93
Avg. Subsidiary Loans	1.02	1.02	–	1.05	1.08	1.09
Aggregate Loans	0.97	1.02	0.94	1.02	1.02	1.01
Interbank Rate Change	−0.04%	−0.05%	−0.02%	−0.02%	−0.03%	−0.18%

Note: Percentage changes relative to baseline pre-crisis economy. Industry Equilibrium.

The first column in Table 7 is the same as in Table 6, where the shock hits the baseline calibrated economy. In the second column, we compute the response to the shock in the counterfactual scenario in which only subsidiarization is allowed. As expected, since subsidiaries in the model are isolated from the shock in Europe, lending in the United States does not decline in this scenario, while the small decline in retail deposits is due to industry equilibrium interest rate changes. The “subsidiaries only” economy is associated with aggregate loans that are 2% higher than in the baseline case: since subsidiaries' activities are independent from their parents, subsidiarization prevents the transmission of the European shock to the US economy. The third column shows the results of the opposite scenario, in which only branching is allowed. This is the scenario that has the most dramatic implications for the US banking sector: the shock generates an 8% decline in average branch deposits, a 3% decline in average branch lending, and a 6% decline in aggregate loans. This is a substantially larger effect than in the baseline case. This result is not surprising since branching is the organizational form that most facilitates the transmission of shocks across countries. It would be shortsighted, however, to conclude from these results that moving to a system where only subsidiaries are allowed is an effective way to minimize the negative effects of repayment probability shocks on aggregate lending. Fig. 5 shows the effects of shocks of different magnitudes to the probability of repayment p in the counterfactual scenarios where only branches or only subsidiaries are allowed. The figure illustrates that the “only branches” scenario generates the largest reduction in aggregate loans for relatively small shocks to the probability of repayment. When the shock to the probability of repayment is large, however, expected losses in the European market may induce parents of subsidiaries to shut down subsidiaries' operations in the US, leading to a decline in aggregate loans in the US which is comparable to the only-branches scenario.

Going back to the counterfactuals, in the fourth column of Table 7, we report the effects of the shock under a counterfactual higher capital requirement $k = 0.06$ both in Europe and in the US. In the calibrated economy, this has the effect of reducing the incentives for branching. The reason is that, in the baseline economy, the buffer on the capital requirement is smaller for branches than for subsidiaries. Since branches are more constrained than subsidiaries, increasing the capital requirement makes them less profitable. Hence, all global banks have subsidiaries and the results are very similar to the ones in the subsidiaries-only case. We also consider a scenario in which the capital requirements are asymmetrically higher in the US ($k = 0.06$) while they remain at the baseline level of 4% in Europe. In this counterfactual scenario, branches enjoy a competitive advantage since lower capital requirements at the parent level make them more profitable. Given this competitive advantage, branches are still able to attract more wholesale deposits after the shock, and continue to provide US funding to their parents, as it was the case before the crisis (see Fig. 4). Since branches thrive, and subsidiaries are not affected by the shocks, there is no transmission of the EU sovereign debt crisis to the US economy. Finally, in the last column, we illustrate the effects of the shock under an ad hoc monetary policy



(a) Loans by US subsidiaries of European banks

(b) Loans by US branches of European banks

Fig. 5. Response of US FBOs loans to different loan repayment shocks in Europe. Subsidiaries-only and branches-only scenarios.
Source: Authors' calculations.

intervention: after the equity decline induced by the default, the Government makes a “helicopter drop” equal to 40% of the aggregate M^+. As a result of this intervention, the interbank rate decreases substantially, the transfer from parents to branches increases, and lending in the United States does not decline, contrary to the result in the baseline scenario.

Lastly, we quantify the magnitude of the monetary intervention needed to dampen the negative effects on lending driven by shocks to the probability of repayment. Fig. 6 shows the decline in aggregate loans in the US associated with different magnitudes of the probability of repayment p, for different values of the interbank rate r_M, following a traditional narrative of central bank interest rate targeting. Obviously, larger shocks to p are associated with larger declines in loans in the US. Aggressive monetary policy can help mitigate the decline in loans: for a large decline in the probability of repayment of –say– 4 %, a reduction in r_M from 0.86% to 0.4% is needed in order to maintain the pre-crisis level of lending.

5. The international transmission of shocks: more evidence

In this section we provide further empirical evidence in support of the mechanisms featured in the model.

5.1. Response to a positive shock: “whatever it takes”

As the European sovereign debt crisis unfolded in 2011 and 2012, widespread fears were mounting about the overall stability of the Euro area and its resilience to the financial crisis. While the analysis in the previous sections of this paper considers 2011–2013 as a homogeneous “crisis” period, we can dissect these three years based on the interventions that took place to ameliorate economic conditions in the Euro area. Among these interventions, Mario Draghi's famous *“Whatever it takes”* speech (henceforth, WIT) marked a turning point in the Euro area's response to the crisis.

In the WIT speech, the ECB President implicitly promised to provide all the support needed to financial institutions in the euro area, in order to restore normal banking activity and liquidity flows, within and across countries, and to prevent retrenchments due to risk aversion of the interested parties.

In this section we ask: what would the model presented in Section 3 predict in terms of US branches and subsidiaries' responses to the WIT speech? The speech itself was not immediately associated with any concrete action, but served more as a “confirmation” of Euro area banks' overall solvency abilities. In our model, concerns about the health of banking institutions appear in the form of the wholesale deposit supply function $r^{*W}_{D}\left(D^{*}_{W}; \left(\frac{E(a)}{k \cdot RWA}\right)\right)$. Wholesale deposits are sensitive to the “distress” experienced by the banking organization, where our measure of distress is inversely related to the buffer in excess of the capital requirement. The WIT speech had the effect of increasing wholesale depositors' trust in the solvency of Euro area banks. This could be seen as a decrease in the derivative of the wholesale deposit supply function with respect to the buffer, or in a decrease in the sensitivity of wholesale deposits to the buffer. Our model further assumes that only the flows of US branches of European banks are affected by credit conditions in the Euro area: since US subsidiaries are separately capitalized, their liquidity is independent on what happens in the European market (provided that the European parent is healthy, as shown in Fig. 5). As a result, we

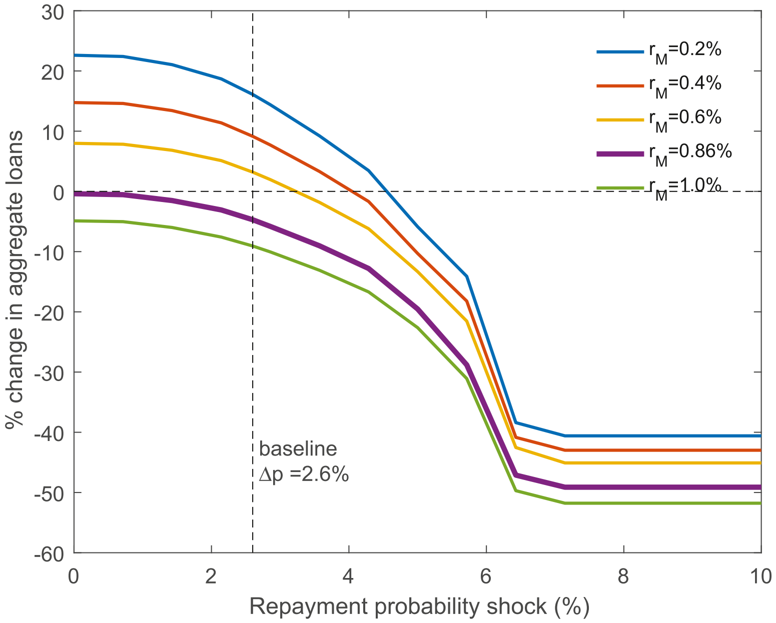


Fig. 6. Response of US aggregate loans to different loan repayment shocks in Europe. Effect of ad-hoc monetary policy interventions. The figure includes loans from US local banks and from subsidiaries and branches of European banks.
Source: Authors' calculations.

expect the WIT speech to slow down the wholesale deposit flight experienced by US branches after the onset of the crisis (and documented in Table 3), but not to affect US subsidiaries' wholesale or retail deposit supply.

To verify this conjecture, we regress:

$$\Delta d^e_{b,t} = \alpha + \beta_1 \text{Crisis}_t \times \text{Exp}_b + \beta_2 \text{WIT}_t \times \text{Exp}_b + \delta_b + \delta_t + \varepsilon^e_{b,t}, \tag{15}$$

where $\Delta d^e_{b,t}$ is the log -difference of total deposits of entity e belonging to bank b at time t. The dummy variable WIT_t takes the value of 1 for all quarter-years after Q2–2012 (included), as the WIT speech took place on July 26, 2012. The other variables are the same as in our baseline regressions. Also for this exercise, we run three separate regressions: one for insured retail deposits, which are accepted only by subsidiaries, one for uninsured wholesale deposits held by subsidiaries, and one for uninsured wholesale deposits held by branches.

The results are shown in Table 8.[31] Consistent with the model, the WIT speech has the effect of slowing down the deposit flight in US branches of European banks, while it has no effect on the deposits held in subsidiaries, either wholesale or retail. We interpret this finding as a confirmation of the channels that are at play in the model: on the one hand, the frictionless nature of parent-branch pairs' balance sheets makes them amenable to spread the effect of shocks across countries, and this is true for both negative and positive shocks. On the other hand, the restrictions to the transfer of funds between parents and subsidiaries limit this transmission.[32]

5.2. Intensive versus extensive margin adjustments

While the analysis so far has focused on the European sovereign debt crisis, the model we developed in this paper allows us to think more broadly about how banks respond to episodes of crisis and the consequences for the international transmission of shocks. The counterfactual analysis has shown that, following a shock to domestic equity, profits drop across the distribution of banks, but banks with differing global status show different responses. For small shocks, we have shown that parent-branch conglomerates act as vehicles of transmission, while subsidiaries have the effect of isolating shocks within countries. However, the fact that subsidiaries are separately capitalized limits the ability of parent-subsidiary conglomerates to reallocate resources internally, so the global profits of these banks are affected by shocks. This implies that—for large enough shocks— parents may decide to repatriate funds by shutting down subsidiaries, like Fig. 5 shows.

[31] Robustness of the results to different definitions of exposure is shown in Appendix Tables D.9-D.10.

[32] Appendix Table D.11 show that –after the WIT speech– we observe a decline in the intrafirm transfers from European parents to US branches, reflecting branches' improved funding conditions. However, these improved conditions were not reflected into branches' loans, as shown in Appendix Table D.12. Robustness of these results to different definitions of exposure is available upon request.

Table 8
Intensive Margin of Wholesale and Retail Deposits after the WIT Speech.

	ln (*Retail Dep.*)	ln (*Wholesale Dep.*)	ln (*Wholesale Dep.*)
	Subsidiaries		Branches
Crisis × Exposed	−0.105	−0.0508	−0.157***
	(0.111)	(0.0827)	(0.0185)
WIT × Exposed	−0.0773	0.00809	0.176***
	(0.0710)	(0.0578)	(0.0555)
Constant	0.0582***	0.0155**	0.0377***
	(0.00927)	(0.00580)	(0.00124)
Parent bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Observations	1031	1022	2827
R-squared	0.058	0.049	0.069

Note: The dependent variable is the log quarterly change in deposits. Robust standard errors in parentheses. Levels of significance are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$. Source: US Structure Data for US Offices of Foreign Banking Organizations - Selected Assets and Liabilities of Domestic and Foreign-Owned US Commercial Banks plus US Branches and Agencies of Foreign Banks.

Fig. 7 shows evidence of FBO exit in the data. We superimpose the time series of parent equity-over-assets growth on a histogram reporting the exit rates of US-based branches and subsidiaries of European banks. In the data, "exit" means that a foreign banking office is no longer reported in the Structure and Share Data for US Offices of Foreign Banking Organizations as published by the Federal Reserve Board.[33] Exits are typically executed as asset sales to domestic banks, not necessarily as closures or liquidations. These large asset sales are typically subject to frictions, which are a function of the size and timing of the sale. The figure suggests that a) episodes of exits of FBOs are widespread, b) periods of more pronounced exits tend to be periods when a parent's equity position declines, and c) compared to branches, subsidiaries are unconditionally more likely to exit, consistent with the presence of frictions to intensive margin equity repatriation.

Fig. 7 provides external validity to the mechanism put forward in this paper. We can use these insights to evaluate the pros and cons of how the two different organizational forms may act as vehicles of shock transmission across countries. On the one hand, the counterfactual analysis of our model, based on intensive margin changes, shows that branches transmit shocks across countries through their internal capital market. However, the same internal capital market allows for international intrabank reallocations that may smooth the global consequences of a negative shock. On the other hand, subsidiaries are isolated from shocks to their parents in terms of their balance sheet adjustments on the intensive margin, but the presence of frictions to the internal capital market among the different units of the corporation makes global banks that own subsidiaries less resilient to shocks.

These different responses on the intensive and extensive margins make the task of regulating global banks extremely difficult. Our analysis reveals that regulations have to balance a tradeoff between important policy priorities: limiting the transmission of shocks across countries and promoting the stability of large, globally important banks.

6. Conclusions

In this paper, we studied how different organizational forms of global banking shape the transmission of shocks across countries. Our analysis focused on banks' endogenous choice to serve foreign markets via branching or subsidiarization.

We started by establishing a series of stylized facts about the cross-section of global banks and their response to the European sovereign debt crisis. Informed by the data, we developed a micro-founded structural model of foreign entry in the banking sector. The model explicitly distinguishes foreign banking institutions by their mode of operations, which is endogenous and responds to differences in cost structure, management efficiency, and banking regulations. Thanks to these features, the model highlights the economic channels through which banks' mode of operations matters for the extent of the transmission of shocks across countries.

In order to study the effects of the European sovereign debt crisis through the lens of the theory, we calibrated the model and used it to perform a series of exercises that shed light on the implications of the current US regulatory framework for the extent of shock transmission. Our most important finding clarifies the relationship between global banks' organizational structure and shock transmission. We show that subsidiarization isolates a global bank's balance sheets by location; hence, subsidiarization minimizes contagion for relatively "small" shocks. However, subsidiarization is associated with a limited internal capital market between parent and affiliate, so that the parent has limited ability to dampen the global effect of shocks, resulting in possible reorganizations and exits from the foreign market, especially when shocks are severe. Conversely, branching can take advantage of a frictionless internal capital market within the corporation and smooth the effect of a shock across countries, but in so doing it allows also small shocks to propagate.

[33] https://www.federalreserve.gov/releases/iba/default.htm.

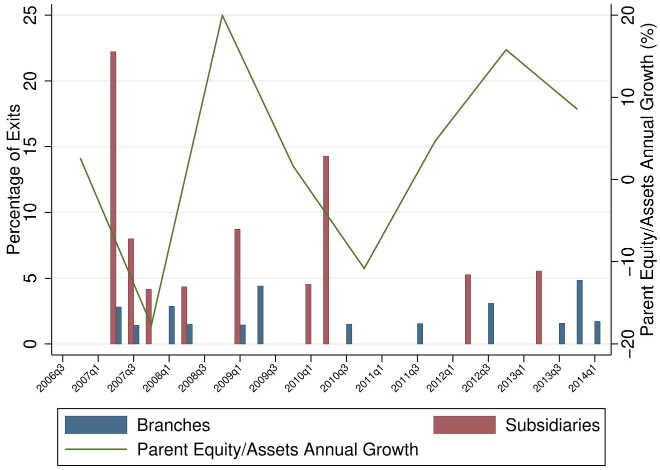


Fig. 7. Exit and Equity Dynamics in the Data. The solid line (right axis) is given by the total equity of European banks in the sample divided by the annual growth of their total assets. The histogram (left axis) plots the percentage of branches and subsidiaries which stop being reported in the data each quarter.
Source: S&P Global Market Intelligence and Structure and Share Data for US Offices of Foreign Banking Organizations .

Our counterfactual analysis highlights the pros and cons of the current regulatory policies and provides insights on alternative ones: pervasive subsidiarization, higher capital requirements, or an ad hoc monetary policy intervention would have avoided entirely the negative effects of the sovereign debt crisis on US lending.

Lastly, the framework we present is not only useful to rationalize the response of US banks to the European sovereign debt crisis, but constributes to our broader understanding of the effects of shocks in the global banking sector.

We see this paper as the starting point of a research agenda whose goal is to use careful quantitative analysis to inform the banking policy discussion. There are many important aspects of this problem which go beyond the scope of this paper, and we plan to tackle some of these issues in future research.

Data availability

Global Banking and the International Transmission of Shocks: a Quantitative Analysis (Original data) (Mendeley Data)

Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jinteco.2023.103808.

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