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Abstract

We develop a simple general equilibrium framework to study the effects of global competition on banking industry dynamics and welfare. We apply the framework to the Mexican banking industry, which underwent a major structural change in the 1990s as a consequence of both government policy and external shocks. Given the high concentration in the Mexican banking industry, domestic and foreign banks act strategically in our framework. After calibrating the model to Mexican data, we examine the welfare consequences of government policies that promote global competition. We find relatively high economywide welfare gains from allowing foreign bank entry.

Keywords: global banks, foreign bank competition, bank industry dynamics
JEL Classifications: E60, F30, F41, G01, G21

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1 Introduction

The interaction between domestic and foreign banking institutions is a key aspect of modern financial systems.[1] Cetorelli and Goldberg ([13] and [14]) present empirical evidence on the tradeoffs for a given economy in the presence of global banks. They show that global institutions actively allocate funds across their banking organizations, in normal times as well as in stress periods. When shocks originate within emerging markets, foreign bank entry into local banking systems can be a stabilizing force. However, their papers also document that during the last financial crisis, a period of distress which originated in the developed economies, loan supply in emerging markets was significantly affected by a contraction in cross-border lending by foreign banks, local lending by foreign banks' affiliates in emerging markets, and a reduction in loan supply by domestic banks. The objective of our paper is to develop a general equilibrium model to study the effects of global competition on banking industry dynamics and welfare.

Several economies around the globe went through dramatic changes in the ownership structure of their banking sector. Among these, the Mexican experience is of particular interest because until the mid-1990s the regulatory regime banned foreign bank entry and deregulation resulted in a sudden increase of foreign bank participation. In 1982, following an oil price shock which brought on a major economic crisis (GDP declined by 4.7%), Mexico nationalized 58 of its 60 existing banks. The number of commercial banks was reduced to 29 in 1983 and in 1990, when the process of full re-privatization started, only 18 of these remained active. Deposit insurance was only established in 1986 and reformed in 1990 as part of the privatization process, unlike its antecedents in the U.S. (in 1934) and Canada (in 1967). Even though most major banks returned to the private sector, the Mexican banking system was protected from foreign competition until 1998. Figure 1 presents the evolution of the market share of foreign banks in the top 10 (sorted by assets) since 1998 until 2012.[2]

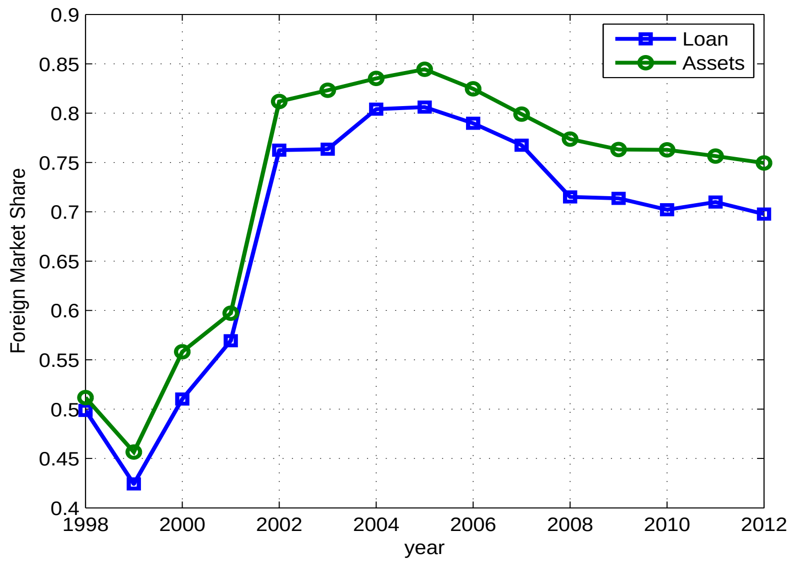
Foreign banks were not allowed to buy Mexican banks with a market share that exceeded 1.5% in 1992 and total participation of foreign banks was restricted to be less than 8% in 1995.[3] Another external shock, the Mexican "tequila crisis" in 1994, resulted in a large increase in nonperforming loans. Bank insolvency associated with this episode was estimated by Maudos and Solis [26] to cost Mexican taxpayers 19.3% of GDP. At that time, the Mexican government gradually removed restrictions on foreign participation. By the time they were completely removed in December 1998, the largest institutions (Bancomer, Banamex and Serfin) were acquired by foreign groups. Foreign participation rose from 5.5% in 1993 to 52.4% in 1996 and 67.2% in 2000. The banking industry in Mexico before and after the policy change remained very concentrated. The top three banks in Mexico held 68% of the loan market share on average during the last two decades. Interest rate spreads (the difference between lending and deposit rates) in 2005 were 7.2%.

[1] Claessens and Van Horen [15] document the importance of foreign banks across countries during the last three decades.

[2] Our Bankscope data only begins in 1998.

[3] See Figure 2 of Banco de Mexico [3].

Figure 1: Foreign Market Concentration in Mexico



Note: Commercial bank data from Mexico 1998-2012. Source: Bankscope

Motivated by these facts, we explore the welfare consequences of entry of global banks on Mexico's banking industry. Our question and methodology are much more general and can be applied to other small open economies. The macro banking literature has primarily focused on models with perfectly competitive financial intermediaries (see for example Bernanke, et al. [9] or Carlstrom and Fuerst [12]). Given the high concentration in the Mexican banking industry, we apply methods from the industrial organization literature developed by Ericson and Pakes [20]. In particular, we assume that in each period a representative domestic bank and a foreign bank strategically choose the quantity of loans they supply (i.e., we solve a Cournot game each period in the loan market).

Models with imperfectly competitive loan markets have also been proposed by Mandelman [24], Blas and Russ [18], and Bremus, Buch, Russ and Schnitzer [10]. Unlike those papers, our paper analyzes how banking industry equilibrium varies due to endogenous entry and exit over the business cycle. A closely related paper to ours is Faia and Ottaviano [22], who study bank loan and deposit decisions in a Cournot model with endogenous entry. Unlike our paper, they assume exogenous exit (banks do not make negative profits in any state of the world, so they must assume this) and symmetric banks.

The key elements of our paper are: (i) domestic and foreign banks can finance their loans through domestic deposits or costly equity issuance; (ii) it is more costly on average for domestic banks to obtain equity finance than foreign banks, but foreign bank finance is directly subject to shocks in the rest of the world and that when the world is in bad times foreign banks face high-equity finance costs; (iii) there is a representative household that supplies deposits and equity to banks. Shocks that affect foreign bank equity finance are intended to capture the "liquidity shocks" in Cetorelli and Goldberg ([13] and [14]). Our focus on costly external finance in a model of financial firm dynamics is similar to that for nonfinancial firms in Gomes [21]. However, given that financial firms have market power in our model, idiosyncratic shocks have aggregate effects, and we cannot focus on a stationary equilibrium as in Gomes.

After estimating the model parameters by matching moments from recent Mexican data with a large concentration of foreign banks, We perform two qualitative tests of the model: (*i*) we show that it is consistent with the empirical literature linking the probability of banking crises and default frequencies with the level of concentration in the banking sector; and (*ii*) we show that it is consistent with the business cycle correlations in Mexico. We consider these tests since neither of these sets of statistics were targeted in the calibration. At the estimated parameters, our model predicts that foreign banks do take on more risk than domestic banks and that credit expansions are larger when foreign banks are present.

We find that changes in competition can have important amplification effects in our model. In particular, we observe that a global crisis which induces an endogenous increase in concentration when global banks exit results in an output and credit reduction that extends well beyond the crisis period. Another important feature of the model is the possibility of propagation of global shocks via bank lending. We observe that output drops when a global shock hits the economy even when competition and local conditions are unchanged. Furthermore, the reduction is stronger when domestic conditions worsen, and this is mostly driven by changes in the loan supply of foreign banks. This is consistent with the evidence presented in Ongena, Peydro, and van Horen [29] who, using bank-level data across countries, find that the transmission of global shocks is stronger in countries with lower growth and that banks with exposure to international wholesale funding reduce lending the most during a crisis.

We evaluate the effects of global competition by a series of counterfactuals. First, we raise the foreign entry cost sufficiently high that there is no foreign entry maintaining all other parameters at their benchmark levels. This has two effects: There are no foreign banks, and there is a monopoly in the domestic banking industry. To disentangle these two effects, we conduct a second counterfactual in which we maintain the domestic entry cost at a level where a second domestic bank enters. The resulting domestic duopoly can then be compared to our benchmark duopoly with one representative foreign and one domestic bank. This counterfactual illustrates an important tradeoff. While the banking industry is more susceptible to global shocks in the benchmark, the domestic economy is less sensitive to purely domestic shocks. Which effect dominates in these counterfactuals is a quantitative question.

It is not surprising that lowering entry costs for foreign banks to compete with a domestic monopoly yields large welfare gains. However, we find the gain of going from a domestic duopoly to our benchmark can be sizable as well. Foreign bank entry can increase average consumption between 1.1% and 1.8%. Given our assumptions on entry, these welfare numbers constitute an upper bound on the welfare gain. While the effect is positive for both households and entrepreneurs, the bulk of the result comes from entrepreneurial gains. One one hand, the introduction of foreign banks increases loan supply (5.71%), lowers interest rates (a 3.96% reduction), and raises output (2.38%). The increase in loan supply derives from the cost advantage (operating and external finance) that foreign banks have over their domestic competitors which makes them resilient to domestic shocks. Foreign bank competition also leads to a higher frequency of bank exit, which requires collecting higher taxes (a 3.97% increase) to fund deposit insurance.

Since banks have market power, the model introduces a novel source of amplification. Fluctuations in the world economy have an impact on the loan supply of the foreign bank by affecting its funding cost. The strategic interaction between foreign and domestic banks results in larger credit expansions and contractions. The overall effect is an increase in the volatility of loan supply and output by over 3% (measured using the coefficient of variation). This (negative) volatility effect counterbalances the (positive) level effect for risk averse households and explains the differences in consumption equivalents between households and entrepreneurs (who are risk neutral). In summary, while opening up to foreign banking competition is a welfare benefit for both workers and entrepreneurs, it is much bigger for business.

Our paper is also related to the extensive literature analyzing the relationship between bank competition and bank risk taking (as measured by the likelihood of bank failure). Important theoretical contributions in this literature include Allen and Gale [2] and Boyd and DeNicolo [11]. There is a large empirical literature which tests these predictions. For example, a recent paper by Beck, De Jonghe, and Schepens [5] finds that more highly concentrated banking industries exhibit less risk taking (as measured by bank failure).[4] As with Martinez-Miera and Repullo [25], but unlike Boyd and De Nicolo [11], we allow shocks to borrower solvency to be correlated across agents. In particular, borrower solvency is correlated with the business cycle. The benefit of our analysis is that we pin down this correlation using data from Mexico. We find that in the economy with foreign bank competition, profitability of domestic banks is lower which results in higher exit probabilities. At the estimated parameters, the relation between risk taking and competition is increasing but nonlinear.

2 Model Environment

Our dynamic banking model is based upon the static industry framework of Allen and Gale [2] and Boyd and De Nicolo [11]. In those models, there is an exogenous number of banks that are Cournot competitors either in the loan and/or deposit market. We embed the earlier static strategic models into a dynamic framework which endogenizes entry and exit decisions as in Ericson and Pakes [20] since the Mexican banking industry is characterized by substantial imperfect competition. We embed the industry equilibrium model into a general equilibrium framework along the lines of corporate finance models like Gomes [21] extended to include strategic banks and aggregate shocks.

Time is infinite. Banks intermediate between a unit measure of infinitely lived ex-ante identical entrepreneurs who need a loan to finance a productive project and a unit measure of infinitely lived ex-ante identical households that decide where to deposit their endowment of non-storable goods. Banks diversify idiosyncratic shocks to the entrepreneur's project.

[4] This literature is also related to Jayaratne and Strahan [23] and Berger, Demsetz, and Strahan [7] who analyze deregulation of interstate banking in the U.S. during the 1990s. In Corbae and D'Erasmo [17], we provide a spatial model with imperfect competition in the banking sector and study the effects of the removal of branching restrictions.

2.1 Households

Each household is endowed with one unit of a perishable good at the beginning of each period. Households have strictly concave per period preferences denoted $u(C_t)$ with discount factor $\beta < 1$. Consumption occurs at the end of the period. Households have access to a risk free short-term (within period) storage technology yielding $1 + \bar{r}$ with $\bar{r} \geq 0$ at the end of the period. We denote the amount of goods stored in this technology by $a_t \geq 0$. The household can also choose to supply their endowment to a bank. If the household deposits $\delta_t \geq 0$ of its endowment with a bank at the beginning of a period, it receives $(1 + r_t^\delta)\delta_t \geq 0$ at the end of the period whether the bank succeeds or fails since we assume deposit insurance. As with storage, deposits are "short term" since they do not pass over periods. At the end of the period households pay lump sum taxes τ_t which are used to cover deposit insurance for failing banks. Households can also hold divisible shares of banks, in which we use the normalization that each bank issues one share. Shares S_{t+1} are traded at the end of the period at price P_t after dividends are paid.

2.2 Entrepreneurs

Entrepreneurs are infinitely lived, risk-neutral agents. They discount the future at rate β. Entrepreneurs demand bank loans in order to fund a project. The project requires one unit of investment at the beginning of period t and returns at the end of the period:

$$\begin{cases} 1 + z_{t+1}R_t & \text{with prob } p(R_t, z_{t+1}) \\ 1 - \lambda & \text{with prob } [1 - p(R_t, z_{t+1})] \end{cases} \tag{1}$$

units of the nonstorable good in the successful and unsuccessful states respectively. The gross return on the project is given by $1 + z_{t+1}R_t$ in the successful state and by $1 - \lambda$ in the unsuccessful state. As with the household's endowment, we assume that the return on the project is perishable across periods. The success of the entrepreneur's project, which occurs with probability $p(R_t, z_{t+1})$, is independent across entrepreneurs but depends on the entrepreneur's choice of technology $R_t \geq 0$ and an aggregate technology shock at the end of the period z_{t+1} (which will also be the beginning of the next period value).

At the beginning of the period when the entrepreneur makes his choice of R_t, z_{t+1} has not been realized. As for the likelihood of success or failure, a firm that chooses to run a project with higher returns has more risk of failure and there is less failure in good times. Specifically, $p(R_t, z_{t+1})$ is assumed to be decreasing in R_t and $p(R_t, z_g) > p(R_t, z_b)$. While firms are ex-ante identical, they are ex-post heterogeneous owing to the realizations of the shocks to the return on their project.

We assume that the technology shock process $z_{t+1} \in \{z_c, z_b, z_g\}$ is drawn from a three-state Markov process that also depends on the state of worldwide shocks $\eta_{t+1} \in \{\eta_g, \eta_b\}$. Thus, besides a domestic "crisis" state (e.g., tequila), there can be good and bad times in both the domestic (Mexican) economy and the world economy. In particular, we assume that the Markov transition matrix for domestic shocks is given by $F(z_t, z_{t+1}, \eta_{t+1})$ and the Markov transition matrix for foreign shocks is given by $G(\eta_t, \eta_{t+1})$.

There is limited liability on the part of the entrepreneurs. If r_t^L is the interest rate on bank loans that firms face, the firm receives $\max\{z_{t+1}R_t - r_t^L, 0\}$ in the successful state and

0 in the failure state. Specifically, in the unsuccessful state, the firm receives $1-\lambda$, which must be relinquished to the lender. Table 1 summarizes the risk-return tradeoff that the firm faces.

Table 1: Entrepreneur's Problem

Borrower Chooses R	Receive	Pay	Probability
Success	$1+z_{t+1}R_t$	$1+r_t^L$	$p(\overbrace{R_t}^{-},\overbrace{z_{t+1}}^{+})$
Failure	$1-\lambda$	$1-\lambda$	$1-p(R_t,z_{t+1})$

Every period, entrepreneurs have an outside option (reservation utility) $\omega_t \in [0,\overline{\omega}]$ drawn at the beginning of the period from distribution function $\Omega(\omega_t)$. The draws are i.i.d. over both entrepreneurs and time. Entrepreneurs with high outside option (proxying for low alternative funding costs) are less likely to take a loan which will generate a downward sloping loan demand curve.

2.3 Banks

We assume there are two types of banks, $\theta \in \{d,f\}$, for "domestic" and "foreign," respectively. To understand global competition, we will consider variation in entry costs $\Upsilon^f \geq \Upsilon^d \geq 0$. When $\Upsilon^f = \infty$, the banking industry is served only by domestic banks. Then, we can choose Υ^f such that there is entry by foreign banks generating an endogenous change in the level of competition across banks of different types.

The bank balance sheet is composed of loans on the asset side and deposits and equity on the liabilities side. We denote loans made by bank type θ to borrowers at the beginning of period t by ℓ_t^θ. A bank's deposit inflows constrain the amount of loans it can issue so that the bank's feasibility constraint at the beginning of the period is given by

$$\delta_t^\theta \geq \ell_t^\theta. \tag{2}$$

We assume that banks pay proportional non-interest expenses (net non-interest income) that can differ across banks of different types, which we denote c^θ. As in models with ex-post verification (e.g., Townsend [30]), we can generally let $c^\theta = \widetilde{c}^\theta + \overline{c}^\theta(1-p(R_t,z_{t+1}))$. Further, as in the data, we assume a fixed cost κ^θ.

Let π_t^θ denote the end-of-period profits (i.e. after the realization of z_{t+1}) of bank type θ as a function of its loans ℓ_t^θ and deposits δ_t^θ given by

$$\pi_t^\theta = \Big\{p(R_t,z_{t+1})(1+r_t^L) + (1-p(R,z_{t+1}))(1-\lambda)\Big\}\ell_t^\theta - (1+r_t^\delta)\delta_t^\theta - \Big\{c^\theta \ell_t^\theta + \kappa^\theta\Big\}. \tag{3}$$

The first two terms represent the gross return the bank receives from successful and unsuccessful loan projects, respectively; the third represents interest expenses (payments on deposits), and the fourth represents non-interest expenses.

As in Cooley and Quadrini [16], we assume that following the realization of z_{t+1}, and hence ex-post bank cash flow π_t^θ, banks have access to outside funding or equity financing at cost $\xi^\theta(x, \eta_{t+1})$ per x units of funds raised in state η_{t+1}, where $\xi^\theta(x, \eta_{t+1})$ is an increasing function of x. We will assume that the domestic bank has no uncertainty about its access to seasoned equity (so that $\xi^n(x, \eta_{t+1}) = \xi^n(x)$). The benefit of introducing external financing of this form is that it allows us to consider a problem in which banks face a dynamic exit decision (i.e. one where the future value of the bank plays a role in the exit decision) without the need to incorporate an extra state variable. A bank that has negative expected continuation value can exit, in which case, it receives value zero, or it can continue provided it accesses costly external equity. Bank dividends at the end of the period are

$$\mathcal{D}_t^\theta = \begin{cases} \pi_t^\theta & if \pi_t^\theta \geq 0 \\ \pi_t^\theta(1 + \xi^\theta(-\pi_t^\theta, \eta_{t+1})) & if \pi_t^\theta < 0 \end{cases} \tag{4}$$

There is limited liability on the part of banks. This imposes a lower bound equal to zero in the case that the bank exits.[5] In the context of our model, limited liability implies that upon exit, the bank gets:

$$\max\left\{\{p(R_t, z_{t+1})(1 + r_t^L) + (1 - p(R, z_{t+1}))(1 - \lambda) - c^\theta\}\ell_t^\theta - \delta_t^\theta(1 + r_t^\delta) - \kappa^\theta, 0\right\}.$$

Every period, a potential entrant makes the decision to enter the market or not. We assume that each entrant satisfies a zero expected discounted profits condition. As discussed before, entry costs are denoted by Υ^θ. We assume entry costs depend on the distribution of incumbent banks in the economy, which is a specific way to implement Pakes and McGuire's [28] algorithm. In particular, we assume that entry costs become infinite after the number of incumbents (n) becomes greater than or equal a certain number of firms ($\overline{n}$).[6] That is,

$$\Upsilon_{\overline{n}}^\theta(n) = \begin{cases} \Upsilon^\theta & \text{if } n < \overline{n} \\ \infty & \text{if } n \geq \overline{n} \end{cases}. \tag{5}$$

In our benchmark, we assume that there will be one domestic bank and one foreign bank (i.e. $\overline{n} = 1$ for $\theta \in \{d, f\}$) at most, so the industry will be served either by a domestic monopolist, a foreign monopolist or a duopoly formed by a domestic and a foreign bank.[7]

We denote the industry state by

$$\mu_t = \{\mu_t(d), \mu_t(f)\}, \tag{6}$$

[5]Since limited liability for foreign banks applies for its operations in Mexico, we are implicitly assuming that foreign banks enter as subsidiaries and not as branches. This is consistent with the way most foreign banks operate in Mexico.

[6]A different implementation requires verifying that the entry value is lower than Υ^θ when the number of incumbent banks is $\overline{n}$ (i.e., the upper bound is not binding).

[7]This is the simplest market structure sufficient to capture the main features of the highly concentrated Mexican banking sector. Without introducing further heterogeneity or considering a different type of equilibrium, additional foreign and domestic banks will behave identically to the representative bank of type θ we consider, so analyzing the case with a larger number of banks will not change our qualitative results. We discuss the possible impact of adding more banks on our quantitative results in Section 7.

where the two elements of μ_t are simply counting measures of *active* banks by type (i.e., whether there is an active incumbent bank of type θ or not). Since there will be at most one domestic bank and one foreign bank, the industry state can take four possible values: $\mu = \{1, 0\}$ when there is a domestic bank monopoly, $\mu = \{0, 1\}$ in the case of a foreign bank monopoly, $\mu = \{1, 1\}$ when there is duopoly composed of a domestic bank and a foreign bank, and $\mu = \{0, 0\}$ when there are no banks. Entry and exit decisions generate endogenous transitions among these states. More specifically, the distribution in period $t+1$ is given by $\mu_{t+1}(\theta) = \mu_t(\theta) - x_t^\theta + e_{t+1}^\theta$, where x_t^θ and e_{t+1}^θ denote the exit and entry decision of bank of type θ respectively.

2.4 Information

There is asymmetric information in the loan market. Only firms know the riskiness of the project they choose (R_t) and their outside option (ω_t). As in Carlstrom and Fuerst [12], we assume that any entrepreneur's history of past debt repayment is not observable (i.e., there is interperiod anonymity of entrepreneurs) so that only one-period borrowing is feasible. Project success or failure is verifiable only at a cost c^θ, as in Townsend [30]. All other information is observable.

2.5 Timing

At the beginning of period t:

1. Given the beginning of period state (μ_t, z_t, η_t), entrepreneurs draw ω_t.
2. Banks choose how many deposits to accept and how many loans to extend $(\delta_t^\theta, \ell_t^\theta)$.
3. Borrowers choose whether or not to undertake a project, and, if so, a level of technology R_t. Households choose whether to deposit δ_t or store a_t.
4. Aggregate return z_{t+1} and equity issuance η_{t+1} shocks are realized, as well as idiosyncratic project success shocks .
5. Incumbent banks choose whether to issue equity and/or dividends and whether to exit.
6. Banks make entry decisions e_t^θ.
7. Households choose how many shares to hold of bank stocks S_{t+1}^θ, pay taxes τ_t to fund deposit insurance, and consume.

3 Equilibrium

This section presents the equilibrium of the model. We start by describing the solution to the household, and entrepreneur's problems, to then move into the solution of the bank problem. For future reference, we let the exogenous shock vector be denoted by $s_t = (z_t, \eta_t)$.

3.1 Household's Problem

The problem of the representative household is

$$\max_{\{a_t,\delta_t,S^{\theta}_{t+1}\}_{t=0}^{\infty}} E_0\left[\sum_{t=0}^{\infty}\beta^t u(C_t)\right]$$

subject to

$$\begin{aligned} a_t+\delta_t &= 1 && (7)\\ & C_t+\sum_{\theta}[P^{\theta}_t+I_{\{e^{\theta}(\mu_{t+1},z_{t+1})=1\}}\Upsilon^{\theta}]S^{\theta}_{t+1}\mu_{t+1}(\theta) && (8)\\ &= \sum_{\theta}(\mathcal{D}^{\theta}_t+P^{\theta}_t)S^{\theta}_t\mu_t(\theta)+(1+\overline{r})a_t+(1+r^{\delta}_t)\delta_t-\tau_t. \end{aligned}$$

Note that the price of equity in the budget constraint P^{θ}_t must be measurable with respect to the state (μ_t, s_t, s_{t+1}) at the *end of the period* after dividends, which may depend on injections of seasoned equity η_{t+1}, have been distributed. Given (μ_t, s_t, s_{t+1}) and exit and entry decision rules, in cases in which a firm has exited, $P^{\theta}_t = 0$ on the right-hand side of the budget constraint, and, in cases in which a firm has entered, $P^{\theta}_t > 0$ on the left hand side of the budget constraint.[8]

The first order condition for S^{θ}_{t+1} is:

$$P^{\theta}(\mu_t,s_t,s_{t+1})\cdot u'(C_t)=\beta\cdot E_{s_{t+2}|s_{t+1}}\left[u'(C_{t+1})\cdot(\mathcal{D}^{\theta}(\mu_{t+1},s_{t+1},s_{t+2})+P^{\theta}(\mu_{t+1},s_{t+1},s_{t+2}))\right].,$$

This can be written:

$$P^{\theta}(\mu_t,s_t,s_{t+1})=E_{s_{t+2}|s_{t+1}}\left[M_{t,t+1}\cdot(\mathcal{D}^{\theta}(\mu_{t+1},s_{t+1},s_{t+2})+P^{\theta}(\mu_{t+1},s_{t+1},s_{t+2}))\right], \quad (9)$$

where $M_{t,t+1} = \beta E_{s_{t+2}|s_{t+1}}[u'(C_{t+1})/u'(C_t)]$ is the stochastic discount factor. We will derive the expression for the equilibrium price of a share after we present the bank's problem.

3.2 Entrepreneur's Problem

Every period, at a given state $\{r^L_t, s_t, \omega_t\}$ and before observing z_{t+1}, entrepreneurs choose whether or not to operate the technology ($\iota \in \{0, 1\}$) and if they do, they choose the type of technology to operate R_t to maximize their consumption C^e_t. Therefore,

$$\max_{\{C^e_t,\iota_t\in\{0,1\},R_t\}_{t=0}^{\infty}} E_0\left[\sum_{t=0}^{\infty}\beta^t C^e_t\right] \quad (10)$$

[8]It can be shown (see Corbae and D'Erasmo [17]) that a sufficiently risk averse household would never find it optimal to try to match with an entrepreneur to make a nonintermediated loan that exposes it to the firm's idiosyncratic uncertainty.

subject to

$$
\begin{aligned}
C_t^e &= \iota_t \omega_t + (1-\iota_t)\pi^e(R_t, z_{t+1}) \\
\pi^e(R_t, z_{t+1}) &= \begin{cases} \max\{0, z_{t+1}R_t - r_t^L\} & \text{with prob } p(R_t, z_{t+1}) \\ 0 & \text{with prob } [1 - p(R_t, z_{t+1})] \end{cases}
\end{aligned}
$$

An application of the envelope theorem implies

$$\frac{\partial E_{s_{t+1}|s_t} \pi^e(R_t, z_{t+1})}{\partial r^{L,j}} = -E_{s_{t+1}|s_t}[p(R_t, z_{t+1})] < 0. \tag{11}$$

Thus, participating borrowers are worse off the higher the borrowing rates are. This has implications for the demand for loans determined by the participation constraint. In particular, since the demand for loans is given by

$$L^d(r^L, s_t) = \int_0^{\overline{\omega}} 1_{\{\omega \leq E_{s_{t+1}|s_t} \pi^e(R_t, z_{t+1})\}} d\Omega(\omega), \tag{12}$$

then (11) implies $\frac{\partial L^d(r^L,s)}{\partial r^L} < 0$.

3.3 Bank's Problem

We use recursive notation to describe the bank's problem. An incumbent bank of type θ chooses loans ℓ^θ to maximize profits and chooses whether to exit ($x^\theta \in \{0,1\}$) after the realization of the aggregate shocks $s' = (z', \eta')$. It is simple to see that no bank would ever accept more total deposits than it makes total loans.[9] Further, the deposit rate $r^\delta = \overline{r}$. Simply put, a bank would not pay interest on deposits that it doesn't lend out and with excess supply of funds, households are forced to their reservation value associated with storage.

Let $\sigma_{-\theta} = (\ell_{-\theta}, x_{-\theta}, e_{-\theta})$ denote the industry state dependent lending, exit, and entry strategies of rival banks. The value function of an incumbent bank of type θ at the beginning of the period is given by

$$V^\theta(\mu, s; \sigma_{-\theta}) = \max_{\{\ell^\theta\}} E_{s'|s}\left[M(\mu, s, s')W^\theta(\mu, s, s'; \sigma_{-\theta})\right] \tag{13}$$

subject to

$$\sum_\theta \ell^\theta(\mu, s; \sigma_{-\theta})\mu(\theta) - L^d(r^L, s) = 0, \tag{14}$$

where $L^d(r^L, s)$ is given in (12). Constraint (14), which is simply the loan market clearing condition, is imposed as a consistency condition that banks take into account since they realize their loan supply will influence the interest rate r^L. Alternatively, one can think of it as a reaction function.

The end-of-period value of a bank is given by

$$W^\theta(\mu, s, s'; \sigma_{-\theta}) = \max_{\{x \in \{0,1\}\}} \left\{W^{\theta,x=0}(\mu, s, s'; \sigma_{-\theta}), W^{\theta,x=1}(\mu, s, s'; \sigma_{-\theta})\right\}, \tag{15}$$

[9] Suppose not and $\delta > \ell$. The net cost of doing so is $r^\delta \geq 0$, while the net gain on $\delta - \ell$ is zero, so it is weakly optimal not to do so.

which, in the case where the bank does not exit is given by

$$W^{\theta,x=0}(\mu,s,s';\sigma_{-\theta}) = \mathcal{D}^{\theta}(\mu,s,s';\sigma_{-\theta}) + V^{\theta}(\mu',s';\sigma_{-\theta}) \tag{16}$$

where

$$\mathcal{D}^{\theta}(\mu,s,s';\sigma_{-\theta}) = \begin{cases} \pi^{\theta}(\mu,s,s';\sigma_{-\theta}) & \text{if } \pi^{\theta}(\mu,s,s';\sigma_{-\theta}) \geq 0 \\ \pi^{\theta}(\mu,s,s';\sigma_{-\theta})[1+\xi^{\theta}(-\pi^{\theta}(\mu,s,s';\sigma_{-\theta}),\eta')] & \text{if } \pi^{\theta}(\mu,s,s';\sigma_{-\theta}) < 0 \end{cases} \tag{17}$$

and in the case where the bank exits is given by

$$W^{\theta,x=1}(\mu,s,s';\sigma_{-\theta}) = \max\left\{0,\pi^{\theta}(\mu,s,s';\sigma_{-\theta})\right\} \tag{18}$$

since only positive dividends can be paid and the bank has no value after exit. The exit decision rule is given by the solution to problem (15), which reflects the choice between continuing (and possibly obtaining outside funding in case of negative profits) or exiting. The value of exiting is bounded below by zero due to limited liability.

Now that we presented the problem of the incumbent bank, we can show how the price of bank's shares and the value of a bank are related. After normalizing the number of shares of each bank to 1, the price of a share of bank type θ after dividends have been paid is given by

$$P^{\theta}(\mu,s,s') = W^{\theta}(\mu,s,s') - \mathcal{D}^{\theta}(\mu,s,s').$$

Thus, equation (9) can be written as

$$\begin{aligned} W^{\theta}(\mu,s,s') - \mathcal{D}^{\theta}(\mu,s,s') &= E_{s''|s'}\left[M(\mu',s',s'')\cdot W^{\theta}(\mu',s',s'')\right] \Longleftrightarrow \\ W^{\theta}(\mu,s,s') &= \mathcal{D}^{\theta}(\mu,s,s') + E_{s''|s'}\left[M(\mu',s',s'')\cdot W^{\theta}(\mu',s',s'')\right]. \end{aligned} \tag{19}$$

Plugging expression (19) into the bank's objective (13) yields

$$V^{\theta}(\mu,s;\sigma_{-\theta}) = E_{s'|s}\left\{M(\mu,s,s')\left[\mathcal{D}^{\theta}(\mu,s,s') + E_{s''|s'}\left[M(\mu',s',s'')\cdot W^{\theta}(\mu',s',s'')\right]\right]\right\}$$

But equation (13) iterated forward one period can be substituted into the above equation for $W^{\theta}(\mu',s',s'')$ and applying the law of iterated expectations yields the dynamic programming problem of each bank type θ we are solving:

$$V^{\theta}(\mu,s;\sigma_{-\theta}) = E_{s'|s}\left\{M(\mu,s,s')\left[\mathcal{D}^{\theta}(\mu,s,s') + V^{\theta}(\mu',s';\sigma_{-\theta})\right]\right\}.$$

3.4 Entrant Bank Decision-Making

After the realization of s', new banks of type θ can enter the industry by paying the setup cost $\Upsilon^{\theta}_{\overline{n}}(n)$. They will enter the industry if the net present value of entry is nonnegative. Let μ^e denote the distribution that would arise if a bank decides to enter (taking as given the entry decision by other banks). Then, a bank of type θ will choose to enter $e^{\theta}(\mu^e,s') = 1$ if

$$V^{\theta}(\mu^e,s';\sigma_{-\theta}) - \Upsilon^{\theta}_{\overline{n}}(n)[1+\xi^{\theta}(\Upsilon^{\theta}_{\overline{n}}(n),\eta')] \geq 0. \tag{20}$$

3.5 Cross-Sectional Distribution

The new distribution of banks after entry and exit μ' is given by

$$\mu' = \{\mu(d) - x^d(\mu, s, s') + e^d(\mu', s'), \mu(f) - x^f(\mu, s, s') + e^f(\mu', s')\}. \tag{21}$$

3.6 Definition of Equilibrium

A pure strategy Markov Perfect Equilibrium (MPE) is a set of functions $\iota(\omega, r^L, s)$ and $R(r^L, s)$ describing borrower behavior; $S^\theta(\mu, s, s')$, $\delta(\mu, s)$ and $a(\mu, s)$ describing consumer behavior; a set of functions $\{V^\theta(\mu, s; \sigma_{-\theta}), \ell^\theta(\mu, s; \sigma_{-\theta}), x^\theta(\mu, s, s'; \sigma_{-\theta})$, and $e^\theta(\mu, s, s'; \sigma_{-\theta})\}$ describing bank behavior; a loan interest rate $r^L(\mu, s)$; a deposit interest rate $r^\delta = \overline{r}$; stock prices $P^\theta(\mu, s, s')$; an industry state μ; a tax function $\tau(\mu, s, s')$ and aggregate bank profits $\Pi(\mu, s, s')$ such that:

1. Given a loan interest rate r^L, $\iota(\omega, r^L, s)$ and $R(r^L, s)$ are consistent with borrower's optimization in (10).

2. For any given interest rate r^L, loan demand $L^d(r^L, s)$ is given by (12).

3. At $r^\delta = \overline{r}$, the household deposit participation constraint is satisfied, so $\delta(\mu, s) + a(\mu, s) = 1$ for all $\{\mu, s\}$. At $P^\theta(\mu, s, s')$, households demand for shares equals the supply, i.e., $S^\theta(\mu, s, s') = 1$ for all $\{\mu, s, s', \theta\}$.

4. Given the loan demand function, the value of the bank $V^\theta(\mu, s; \sigma_{-\theta})$, loan decision rules $\ell^\theta(\mu, s; \sigma_{-\theta})$, and exit rules $x^\theta(\mu, s, s'; \sigma_{-\theta})$ are consistent with bank optimization in (13) and (15).

5. The entry decision rules $e^\theta(\mu, s, s'; \sigma_{-\theta})$ are consistent with bank optimization in (20).

6. The law of motion for the industry state (21) is consistent with entry and exit decision rules.

7. Across all states (μ, s, s'), bank profits are given by:

$$\begin{aligned}\Pi(\mu, s, s') \;=\; & \sum_\theta \Big[(1 - x^\theta(\mu, s, s'; \sigma_{-\theta}))\mathcal{D}^\theta(\mu, s, s'; \sigma_{-\theta}) \\ & + x^\theta(\mu, s, s'; \sigma_{-\theta}) \max\{0, \pi^\theta(\mu, s, s'; \sigma_{-\theta})\} - e^\theta \Upsilon^\theta\Big].\end{aligned}$$

8. The interest rate $r^L(\mu, s)$ is such that the loan market (14) clears. That is,

$$L^d(r^L, s) = \cdot \int_0^{\overline{\omega}} 1_{\{\omega \le E_{z'|z}\pi^e(R, z')\}} d\Omega(\omega) = \sum_\theta \int \ell^\theta(\mu, z, \eta; \sigma_{-\theta})\mu(\theta) = L^s(\mu, s; \sigma_{-\theta}).$$

9. Across all states (μ, s, s'), taxes cover deposit insurance:

$$\tau(\mu, s, s') = \sum_\theta x^\theta(\mu, s, s'; \sigma_{-\theta}) \max\{0, -\pi^\theta(\mu, s, s'; \sigma_{-\theta})\}$$

In equilibrium, aggregate household consumption is given by

$$C(\mu, s, s') = (1 + \bar{r}) + \Pi(\mu, s, s') - \tau(\mu, s, s') \tag{22}$$

while aggregate entrepreneur consumption is given by

$$C^e(\mu, s, s') = \int_0^{\overline{\omega}} \left[1_{\{\omega > E_{z'|z}\pi^e(R,z')\}}\omega_t + 1_{\{\omega \leq E_{z'|z}\pi^e(R,z')\}}\pi^e(R, z')\right] d\Omega(\omega). \tag{23}$$

4 Calibration

We calibrate our model parameters to Mexico by minimizing the distance between relevant model moments and those from the data. Besides aggregate data, we also have access to a panel of commercial Mexican banks since 1998, a few years after the bank reform in Mexico. Hence, the model is calibrated to a sample in which foreign bank competition is permitted.[10] The data comes from Bankscope, a data set with balance sheet information on banks across the globe. A model period is set to be one year.

The stochastic process for the entrepreneur's project is parameterized as in our previous paper (see Corbae and D'Erasmo [17]). In particular, let $y = \alpha z' + (1-\alpha)\varepsilon_e - bR^{\psi}$ where ε_e is drawn from $N(0, \sigma_\varepsilon^2)$. The entrepreneur's idiosyncratic project uncertainty is i.i.d. across agents. We define success to be the event that $y > 0$, so in states with higher z or higher ε_e success is more likely. Then,

$$\begin{aligned} p(R, z') &= 1 - prob(y \leq 0|R, z') \\ &= 1 - prob\left(\varepsilon_e \leq \frac{-\alpha z' + bR^{\psi}}{(1-\alpha)}\right) \\ &= \Phi\left(\frac{\alpha z' - bR^{\psi}}{(1-\alpha)}\right) \end{aligned} \tag{24}$$

where $\Phi(x)$ is a normal cumulative distribution function with mean zero and variance σ_ε^2. As in Martinez-Miera and Repullo [25], the parameter α captures the correlation of solvency across borrowers. Further, we let the distribution of the entrepreneur's outside option $\Upsilon(\omega)$ be a uniform distribution with support defined by $[0, \overline{\omega}]$.

We let household preferences be given by $u(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma}$ and set the coefficient of relative risk aversion σ to 2, a standard value in the macro literature.

We let the external financing cost for domestic banks be parameterized as $\xi^d(x, \eta') = \xi_1 x$ while the foreign cost function is given by $\xi^f(x, \eta') = \eta' \xi_1 x$.

The full set of parameters of the model is divided into two groups. The first group of parameters can be estimated directly from the data (i.e., the parameters can be pinned down without solving the model). This set includes the following parameters

$$\Theta^1 = \{\overline{r}, \tilde{c}^f, \tilde{c}^d, \overline{c}^f, \overline{c}^d, F(z, z', \eta'), G(\eta, \eta')\}$$

[10] See the Appendix for a detailed description of sources and variables as well as the computational algorithm.

Since the only source of external funding is equity, we relate changes in the cost of equity issuance for foreign banks to changes in the corporate cost of borrowing in the U.S. We use data on the spread between a 10-year U.S. BAA corporate bond and a 10-year constant maturity U.S. Treasury bond (from 1970 to 2012) and identify periods with $\eta_t = \eta_g$ as periods in which the spread is below its mean and periods with $\eta_t = \eta_b$ as periods in which the spread is above one standard deviation from its mean. Then, the transition matrix for η is estimated via maximum likelihood, where G_{jk}, the $(j,\, k)th$ element of the transition matrix, is the ratio of the number of times the indicator on η switched from state j to state k to the number of times the spread was observed to be in state j. The estimated transition matrix
is

$$G(\eta, \eta') = \left[\begin{array}{c|cc} & \eta'_g & \eta'_b \\ \hline \eta_g & 0.93 & 0.07 \\ \eta_b & 0.25 & 0.75 \end{array} \right]. \tag{25}$$

The support of $G(\eta, \eta')$ is included in the set of parameters to be calibrated using moments from the banking sector.

To calibrate the process of z_t, we use information on real Mexican GDP (in 1985. U.S.$ from World Bank via Haver Analytics 1970-2012).[11] In particular, we identify periods with $z_t = z_c$ as periods where detrended real Mexican GDP is below one standard deviation from its mean, periods with $z_t = z_b$ as periods where detrended real Mexican GDP is below its mean but above one standard deviation from the mean, and periods with $z_t = z_g$ as periods in which detrended real Mexican GDP is above its mean. The transition matrix is estimated using the same maximum likelihood approach used to estimate the transition for η but taking into account that the domestic business cycle is correlated with the foreign state of the economy. While providing information about almost all combination of shocks, the short length of the sample prevents us from observing transitions into $z' = z_c$ when $\eta' = \eta_b$. For this reason, we set $F(z_c, z'_g, \eta'_b) = 0$ and calibrate $F(z_c, z'_c, \eta'_b) = \phi^b_{cc}$ and $F(z_b, z'_c, \eta'_b) = \phi^b_{bc}$ together with other parameters in the model. Note that given the estimated value for $F(z_b, z'_b, \eta'_b) = 0.66$ and the fact that probabilities add up to 1, the values of ϕ^b_{cc} and ϕ^b_{bc} pin down $F(z_c, z'_b, \eta'_b) = 1 - \phi^b_{cc}$ and $F(z_b, z'_g, \eta'_b) = 1 - 0.66 - \phi^b_{bc}$.

The estimated transition matrix when $\eta' = \eta_g$ is

$$F(z, z', \eta'_g) = \left[\begin{array}{c|ccc} & z'_c & z'_b & z'_g \\ \hline z_c & 0.57 & 0.43 & 0.0 \\ z_b & 0.12 & 0.65 & 0.23 \\ z_g & 0.0 & 0.09 & 0.91 \end{array} \right], \tag{26}$$

and the estimated transition matrix when $\eta' = \eta_b$ is

$$F(z, z', \eta'_b) = \left[\begin{array}{c|ccc} & z'_c & z'_b & z'_g \\ \hline z_c & \phi^b_{cc} & 1-\phi^b_{cc} & 0.0 \\ z_b & \phi^b_{bc} & 0.66 & 1-0.66-\phi^b_{bc} \\ z_g & 0.0 & 0.36 & 0.64 \end{array} \right]. \tag{27}$$

[11] To estimate the domestic productivity process we maximize the size of the data to capture periods of domestic crisis (such as those arising from fiscal or exchange rate crisis). Output fluctuations in the model (driven not only by exogenous factors but also by industry dynamics) capture all sources of GDP fluctuations in the data.

We normalize the value of $z_g = 1$, and we include z_b and z_c in the set of the parameters to calibrate.

Once those parameters in set Θ^1 are pinned down, a second group is calibrated by minimizing the weighted difference between model moments and data moments (data moments are mostly from our sample of Mexican banks). After normalizing $z_g = 1$, this group includes the following parameters

$$\Theta^2 = \{z_b, z_c, \phi^b_{cc}, \phi^b_{bc}, \alpha, b, \sigma_\epsilon, \psi, \overline{\omega}, \beta, \lambda, \kappa^d, \kappa^f, \zeta^1, \eta_g, \eta_b, \Upsilon^f, \Upsilon^n\}$$

We identify banks in our model as banks in the top 10 of the asset distribution in Mexico in any given year, so all averages reported are computed using banks in this group.[12] As we describe in detail in the Appendix, ownership information is constructed using Bankscope as the main source but complemented with other sources.[13]

We estimate $\bar{r} = r^\delta$ using the ratio of interest expenses on customer deposits to total customer deposits. The nominal interest rate is converted to a real interest rate by using the consumer price index in Mexico. The average for the period 1998-2012 is equal to 1.94%. After estimating the average chargeoff rate (net chargeoffs divided by gross loans) and the average default frequency (nonperforming loans divided by gross loans) to be 4.01% in our data, the parameter λ can be set to 0.20 since the model counterpart of the chargeoff rate is equal to $(1-p)\lambda$.

The marginal cost of making a loan is estimated using data from non-interest expenses and income. More specifically, c^θ is calibrated using marginal net non-interest expenses defined as personnel expenses minus total noninterest operating income divided by total assets. We estimate the relationship between marginal costs and past-90 days and non-accrual loans to be nonsignificant, so we set $c^{-f} = c^{-d} = 0$. Then, we let $c^{\tilde{}f} = 0.0202$, the average for foreign banks in the top ten of the asset distribution and $c^d = 0.0241$, the average for domestic banks in the top ten of the asset distribution in Mexico.

To calibrate Θ^2, a set with 18 parameters, we minimize the distance between data moments and moments generated from the simulated model. That is, the parameters are chosen to minimize

$$J(\Theta^2) = [M^{data} - M^m(\Theta^2)]W[M^{data} - M^m(\Theta^2)]' \tag{28}$$

with respect to parameters Θ^2, where M^{data} are the moments from the data, $M^m(\Theta^2)$ are the moments from the simulated model at parameters Θ^2 and W is some positive definite matrix.[14] We implement the calibration using W equal to the identity matrix to obtain consistent, but not necessarily efficient estimates.

Table 2 presents the parameters of the model in which parameters above the line correspond to Θ^1 and parameters below the line correspond to Θ^2.

[12] Top 10 banks banks hold, on average, well above 80% of total assets and total loans in Mexico during the period analyzed.

[13] Bankscope provides information on the nationality of the controlling shareholder and the history of ownership. When data were missing or incomplete we complemented Bankscope with information from the official websites of each bank, banking publications and country experts.

[14] For every set of parameters, we simulate 18 panels of banks for 7,000 periods. To compute the moments, we discard the initial 2,000 periods and average over all the panels created.

Table 2: Model Parameters

Parameter		Value	Target
Dep. preferences	σ	2.00	Standard value
Agg. shock in good state	z_g	1.00	Normalization
Deposit interest rate (%)	$\bar{r}$	1.94	Cost deposits
Net non-int. exp. f bank	$\tilde{c}^f$	2.02	Net non-interest expense
Net non-int. exp. d bank	$\tilde{c}^d$	2.41	Net non-interest expense
Agg. shock in bad state	z_b	0.95	Default frequency %
Agg. shock in crisis state	z_c	0.86	Borrower return %
Transition prob.	ϕ^b_{cc}	0.67	Std dev. asset return foreign %
Transition prob.	ϕ^b_{bc}	0.10	Std dev. asset return domestic %
Weight agg. shock	α	0.92	Asset return %
Success prob. param.	b	3.74	Loan return %
Volatility borrower's dist.	σ_ϵ	0.06	Std. dev. borrower return %
Success prob. param.	ψ	0.94	Dividend / asset foreign %
Max. reservation value	$\overline{\omega}$	0.24	Dividend / asset domestic %
Chargeoff rate	λ	0.20	Chargeoff rate %
Discount Factor	β	0.88	Loan market share foreign %
Fixed cost f bank	κ^f	0.004	Fixed cost over assets foreign %
Fixed cost d bank	κ^d	0.003	Fixed cost over assets domestic %
External finance param.	ζ_1	0.06	Loan interest margin %
External finance shock	η_g	0.30	Avg. equity issuance foreign %
External finance shock	η_b	1.05	Avg. equity issuance domestic %
Entry cost foreign	Υ^f	0.042	Exit rate foreign %
Entry cost domestic	Υ^d	0.041	Exit rate domestic %
			Entry rate %

All the moments generated by the model depend on the full set of parameters. However, we discuss our identification strategy by explaining which moment we understand as most useful in identifying each parameter. To calibrate z_b and z_c, we use information on default frequency (equal to 1.94%) and average equity return (18.98%).[15] To help with the calibration of the transition probability parameters ϕ^b_{cc} and ϕ^b_{bc}, we use the standard deviation of the asset return for foreign and domestic banks, respectively.[16] The parameters α and b are identified with information from average asset return (3.0%) and the loan return (7.84%) estimated from our sample of banks as the real interest return on loans (interest income on

[15]The average equity return and its volatility are taken from Diebold and Yilmaz [19], who study the evolution of the equity markets across countries from 1992 to 2007.

[16]As we describe later, exit by foreign banks is more likely when a global crisis is followed by a domestic crisis, and domestic banks are more likely to exit when we enter into a domestic crisis. Moreover, bank risk-taking is directly connected with the likelihood of moving into a crisis or staying in bad times. For these reasons, asset returns for domestic and foreign banks provide good information into the likelihood of moving into a crisis or staying in bad times.

loans divided by gross loans deflated using the consumer price index) minus the chargeoff rate (net chargeoffs over gross loans). The standard deviation of the borrower shock σ_ϵ is linked to the volatility of equity returns (2.12%) in Mexico. To calibrate ψ and $\overline{\omega}$, we use information on dividend to asset ratio for foreign and domestic banks.[17] The chargeoff rate (2.12%) allows us to recover the loss after default λ. The discount factor β is estimated using information on the loan market share of foreign banks. We estimate $\kappa^\theta/\ell^\theta$ to match total non-interest expenses minus personnel expenses over total assets for the top 10 Mexican foreign and domestic banks. We obtain values equal to 1.58% for foreign banks and 4.24% for domestic banks. The value of ζ_1 is chosen to match the loan interest margin (equal to 6.94%). The values of η_g and η_b are set so the model reproduces the average equity issuance by foreign (3.65%) and domestic banks (2.83%).[18] The entry cost parameters are pinned down using information on the exit rate of foreign and domestic banks (2.29% and 3.78% respectively). We also incorporate the average entry rate for banks in the top 10 (2.66%) in the set of moments to be matched, so effectively, we have an overidentified model.

Tables 3 and 4 present the model moments and a comparison with the moments from the data. The moments in Table 3 correspond to those targeted in the calibration and those in Table 4 are some additional and informative moments.

[17] The parameter $\overline{\omega}$ determines the slope of the loan demand and in place the elasticity of the loan interest rate to changes in the loan supply. Since a key component of the dividend to asset ratio is the loan return, $\overline{\omega}$ provides useful information on this moment.

[18] Equity issuance by domestic and foreign banks provides information on η_b and η_g since bank risk taking and the likelihood of a bank issuing equity (as opposed to exiting) depend on the strength of its competitor and whether the competitor decides to stay and issue equity or to exit.

Table 3: Targeted Model and Data Moments

Moment		Data	Model
Default frequency %	$1-p$	4.01	6.13
Borrower return %	$pz'R$	18.98	18.68
Std. dev. asset return foreign %		5.18	5.63
Std. dev. asset return domestic %		1.4	3.51
Asset return %	$\mathcal{D}^\theta/\ell^\theta$	3.00	3.21
Loan return %	$pr^L-(1-p)\lambda$	7.84	8.49
Std. dev. borrower return %		2.76	4.79
Fixed cost over assets foreign %	κ^f/ℓ^f	1.58	2.15
Fixed cost over assets domestic %	κ^d/ℓ^d	4.24	1.47
Chargeoff rate %	$(1-p)\lambda$	2.12	1.21
Loan market share foreign %	ℓ^f/L^s	69.49	56.63
Dividend / asset foreign %	$\max\{\pi^f,0\}/\ell^f$	4.15	3.94
Dividend / asset domestic %	$\max\{\pi^d,0\}/\ell^d$	2.07	4.11
Loan interest margin %	pr^L-r^D	6.94	7.76
Avg. equity issuance foreign %	$\max\{-\pi^f,0\}/\ell^f$	3.65	0.83
Avg. equity issuance domestic %	$\max\{-\pi^d,0\}/\ell^d$	2.83	0.30
Exit rate foreign %	$\sum_t x_t^f/T$	2.29	2.72
Exit rate domestic %	$\sum_t x_t^d/T$	3.78	3.98
Entry rate %	$\sum_t \sum_\theta e_t^\theta / \sum_\theta \mu(\theta)$	2.66	5.66

Note: Data moments are computed using commercial bank-level data from Mexico from 1998 to 2012. Source: Bankscope

The model does a good job in matching the moments from the data. We note that the model underpredicts the chargeoff rate, fixed costs for domestic banks, and the level of equity issuance. The model also overpredicts the default frequency, the standard deviation of borrower return, the standard deviation of asset return for domestic banks, and the entry rate.

Table 4: Additional Model and Data Moments

Moment		Data	Model
Exit rate %		2.67	3.89
Equity issuance all		3.34	1.00
Loan interest rate %	r^L	8.40	10.39
Frequency equity issuance all %		15.33	3.61
Frequency Equity Issuance Foreign %	$\sum_t I_{\{\pi_t^f<0\}}/T$	21.11	2.94
Frequency Equity Issuance domestic %	$\sum_t I_{\{\pi_t^d<0\}}/T$	6.66	1.12
Std. dev. equity issuance all %		3.34	5.19
Std. dev. equity issuance foreign %		3.65	4.75
Std. dev. equity issuance domestic %		2.83	2.83
Asset return foreign %		3.57	3.09
Asset return domestic %		1.93	3.79
Std. dev. asset return all %		3.67	6.21
Dividend / asset %		3.51	4.24

Note: Data moments are computed using commercial bank level data from Mexico from 1998 to 2012. Source: Bankscope

5 Equilibrium Characterization

Given the parameters of the model in Table 2, we can summarize the entry and exit decision rules (both on and off the equilibrium path) by foreign and domestic banks as follows:[19]

1. Foreign Entry:
   (a) If there are no competitors (i.e., $\mu = \{0, 0\}$), then enter when
      i. $\eta = \eta_g$ (i.e., whenever foreign external funding is cheap) or
      ii. $\eta = \eta_b$ and $z = z_g$ (foreign external funding is expensive, but Mexico is in a boom).
   (b) If there is a domestic competitor (i.e., $\mu = \{0, 1\}$), then enter when $z = z_g$ (i.e. when Mexico is in a boom).
   (c) Do not enter otherwise.
2. Domestic Entry:
   (a) If there are no competitors (i.e., $\mu = \{0, 0\}$), then enter when
      i. $\eta = \eta_g$ and $z = z_g$ (i.e., foreign external funding is cheap, but Mexico is in a boom) or
      ii. $\eta = \eta_b$ (i.e. foreign external funding is expensive).

[19]We do not report decision rules for zero probability events (i.e., recall that for $G(z, z', \eta')$ in equations (26) and (27), the probability of transiting from z_g to z_c is zero).

(b) If there is a foreign competitor (i.e., $\mu = \{1, 0\}$), then enter when $z = z_g$ (i.e., when Mexico is in a boom).

(c) Do not enter otherwise.

3. Foreign Exit:

   (a) If the Mexican economy goes into a crisis $z' = z_c$ from $z = z_b$ the foreign bank exits if

      i. there is no domestic competitor (i.e., $\mu = \{1, 0\}$)

      ii. there is a domestic competitor (i.e., $\mu = \{1, 1\}$) and $\eta = \eta_b$ (i.e., financing conditions are more favorable for the competitor)

   (b) Do not exit otherwise.

4. Domestic Exit:

   (a) If the Mexican economy goes into a crisis $z' = z_c$ from $z = z_b$ the domestic bank exits if

      i. there is no foreign competitor (i.e., $\mu = \{0, 1\}$)

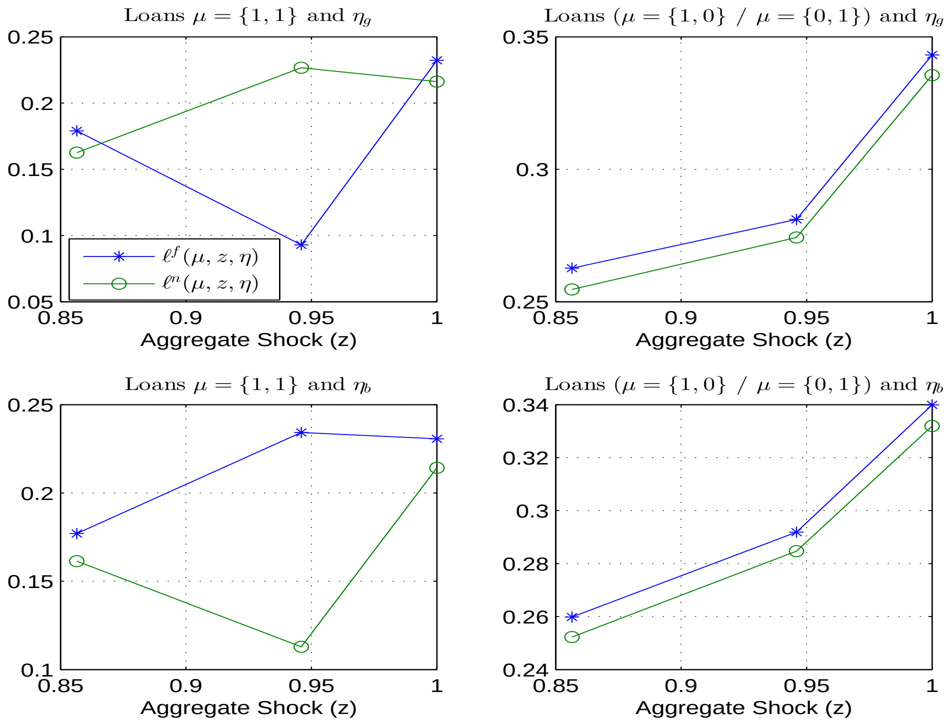
      ii. there is a foreign competitor (i.e., $\mu = \{1, 1\}$) and $\eta = \eta_g$ (i.e., financing conditions are more favorable for the competitor)

   (b) Do not exit otherwise.

In summary, the exit decision rules imply that when the Mexican economy enters a crisis, there is exit by domestic banks and, under certain conditions, by foreign banks. If the crisis leads to no incumbent banks at the end of the period (due to excessive losses of loans made in better times), then there will be entry by at least one type of bank.

To better understand entry and exit decisions, we need to examine incumbent loan decision rules since these (made in state (μ, s)) along with the shocks s, determine whether banks make profits or losses. Figure 2 shows the loan decision rules as a function of the industry and aggregate states. The left panels are decision rules when both domestic and foreign banks are present (i.e., $\mu = \{1, 1\}$) when foreign external funding is cheap (top left) and expensive (bottom left). The right panels are decision rules when only one bank is in the market (i.e., $\mu = \{1, 0\}$ or $\mu = \{0, 1\}$) when foreign external funding is cheap (top right) and expensive (bottom right). It is important to note that not all the points in the figure are realized in equilibrium.

Figure 2: Loan Decision Rules $\ell^{\theta}(\mu, z, \eta)$



Note: Each quadrant corresponds to a combination of μ and η and the $x-$axis corresponds to each possible value of z. Left panels are decision rules when both domestic and foreign banks are present ($\mu = \{1, 1\}$). The right panels are decision rules when only one bank is in the market (only domestic $\mu = \{1, 0\}$ or only foreign $\mu = \{0, 1\}$).

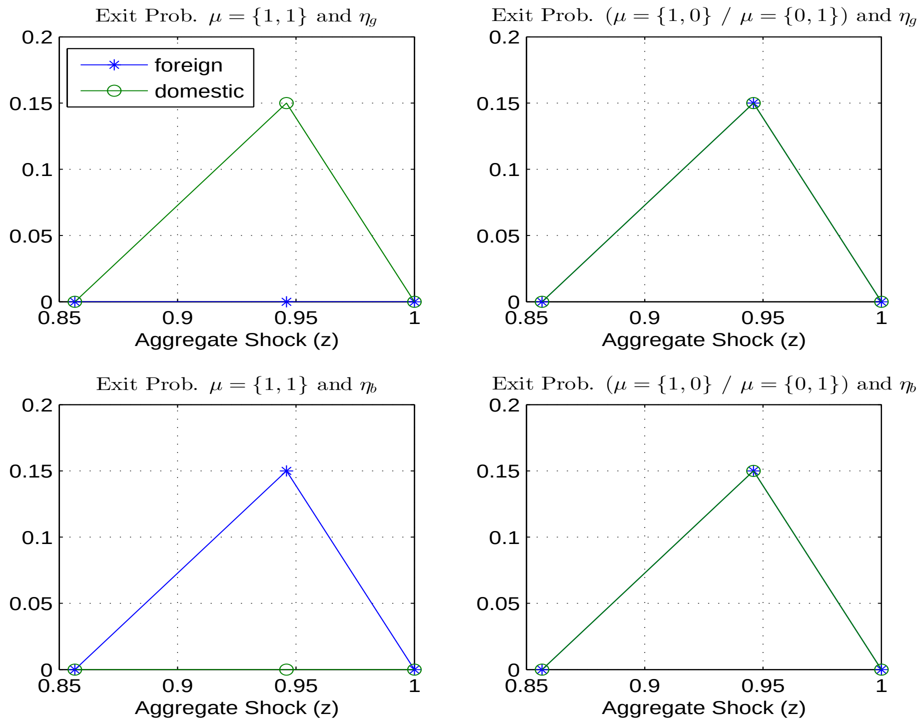
We see that when both banks are present, foreign banks make more loans than domestic banks in good times and in crisis states (the latter case is off-the-equilibrium path). We also note that there are big differences in lending practices in bad domestic times depending on global conditions. Recall that the probability of going into $z' = z_c$ is only positive when $z = z_b$. In particular, we see domestic banks making more loans (i.e. taking on more risk) while foreign banks make less loans (taking on less risk) when global conditions are favorable. The opposite is true when external funding for the foreign bank is expensive. The intuition is as follows. When global conditions are favorable, the foreign bank is able to finance potential losses if the economy enters into a domestic crisis (in which case the domestic bank exits), so it reduces its exposure to the Mexican economy to the point where continuation is viable. When global conditions are such that external funding is expensive for the foreign bank, financing negative profits if the economy enters into a crisis has a negative expected value, so it is optimal to take on more risk and maximize expected profits for the current period (the probability of staying in a global crisis and entering into a domestic crisis is only 6%). In this case, the domestic bank reduces its exposure to a domestic crisis in order to guarantee it will be able to continue operating and take advantage of being a monopoly in the case the crisis realizes and the foreign bank exits. If there is only one bank present (i.e., they are in a monopoly position), we see foreign banks are more cautious in bad times when external funding is cheap and extend less loans than in bad times when external funding is expensive.

To expand even further on the analysis of bank risk taking, Figure 3 presents the probability of bank exit, where the exit probability is defined as follows:

$$\rho^{\theta}(\mu, z, \eta) = \sum_{z', \eta'} x(\mu, z, \eta, z', \eta') G(\eta, \eta') F(z, z', \eta') \tag{29}$$

Figure 3 makes clear that, on average, banks take on more risk when the industry is more concentrated and that risk-taking depends not only on the industry state but also on external funding conditions. Banks take advantage of their monopoly position in certain states and choose to take on the risk of extending a lot of loans because they recognize that there will be future competition in certain states of the world and they might as well reap the benefits of their current monopoly power. In other states, we observe that when there is competition between foreign and domestic banks (i.e., right panels when $\mu\{1, 1\}$), foreign banks take on more risk when global conditions are bad, and domestic banks take on more risk when global conditions are good (i.e., competitors are strong). The intuition behind this result has to do with whether the foreign bank finds it profitable to pay the cost of external funding and continue or exit if a domestic crisis realizes. The foreign bank takes the least amount of risk when global conditions are favorable when facing a domestic competitor because, it understands that if a domestic crisis materializes the domestic bank will exit making the foreign bank a monopolist. It is also important to note, that when global conditions are bad and banks act as monopolists, the probability of entry of a competitor is the highest.

Figure 3: Bank Risk Taking and Exit Probability $\rho^{\theta}(\mu, z, \eta)$

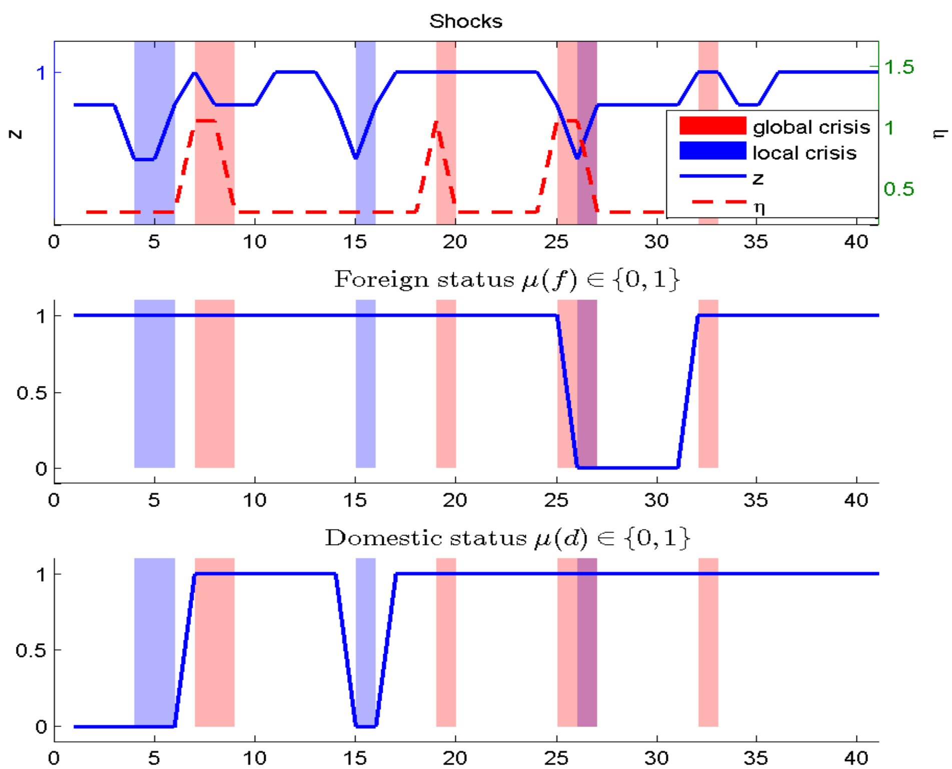


Note: Each quadrant corresponds to a combination of μ and η and the $x-$axis corresponds to each possible value of z. Left panels are exit probabilities when both domestic and foreign banks are present (i.e., $\mu = \{1,1\}$). The right panels are exit probabilities when only one bank is in the market (i.e. $\mu = \{1,0\}$ or $\mu = \{0,1\}$).

To further illustrate the workings of the model, we simulate the model and present the evolution of the banking industry during 50 representative periods in Figure 4. The top panel of this figure shows the evolution of the shocks. We use shaded bars to represent periods when there is a domestic crisis or a global crisis. In particular, periods where $z = z_c$ are presented with blue bars, periods where $\eta = \eta_b$ are presented with red bars and periods where both $z = z_c$ and $\eta = \eta_b$ occur together are presented in purple bars. The top panel of the figure displays the evolution of the shocks to make the connection between the bars and the value of the shocks clearer. The middle panel presents an indicator function that shows whether or not the foreign bank is active and the bottom panel presents the active indicator for the domestic bank.

Figure 4 makes evident the endogenous transitions of the distribution of banks presented in equation (21). It shows that when the level of competition is high (i.e., we have foreign and domestic banks competing in the loan market), a global crisis alone does not generate bank exit (periods 7 and 8). On the other hand, when a domestic crisis hits the economy (period 15) we observe domestic bank exit. This creates room for the foreign bank to operate as a monopoly. As we will explain in detail later, the model propagates the crisis via endogenous changes in competition. Figure 4 shows that when competition is high, if a global crisis hits together with a local crisis (period 26) the foreign bank exits. This is the result of bank risk taking as a function of domestic conditions. When the domestic economy is not in a crisis but external funding is costly, the foreign bank is willing to take on more risk since the probability of leaving the global crisis is 50%. We observe that even after the exogenous forces improve, the economy faces a highly concentrated industry for several periods (from period 16 to 33).

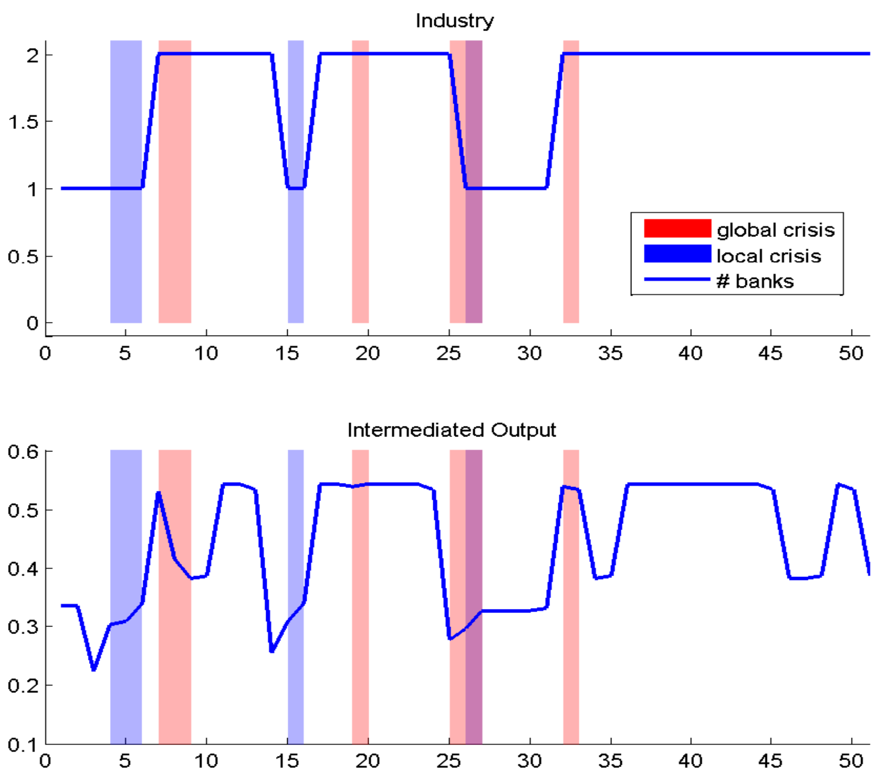
Figure 4: Industry Evolution: Amplification Effects



Note: Periods where $z = z_c$ are represented with blue bars, periods where $\eta = \eta_b$ are represented with red bars and periods where both $z = z_c$ and $\eta = \eta_b$ occur together are presented in purple bars.

Figure 5 shows the evolution of the number of banks (top panel) and intermediated output (bottom panel) together with the bars representing the different shocks the economy faces. It is clear that the level of concentration in the loan market (as measured by the number of active banks) is highly correlated with output. Figure 5 also makes clear the amplification effect of the model. It is evident that the level of output remains low (periods 25 to 32) even after exogenous domestic and global conditions improve provided concentration in the industry stays high. Output returns to a higher level than during these periods after competition increases (periods 33 and beyond). Another important feature of the model is the possibility of propagation of global shocks through bank lending. We observe that output drops when a global shock hits the economy even when competition is high (periods 7 and 8); however, some of this reduction is also the result of changes in domestic conditions.[20] This is consistent with the evidence presented in Ongena, Peydro, and van Horen (2013) who, using bank level data across countries, find that the transmission of global shocks is stronger in countries with lower growth. We explore the issue of global shock transmission next in more detail.

Figure 5: Evolution output and propagation mechanism

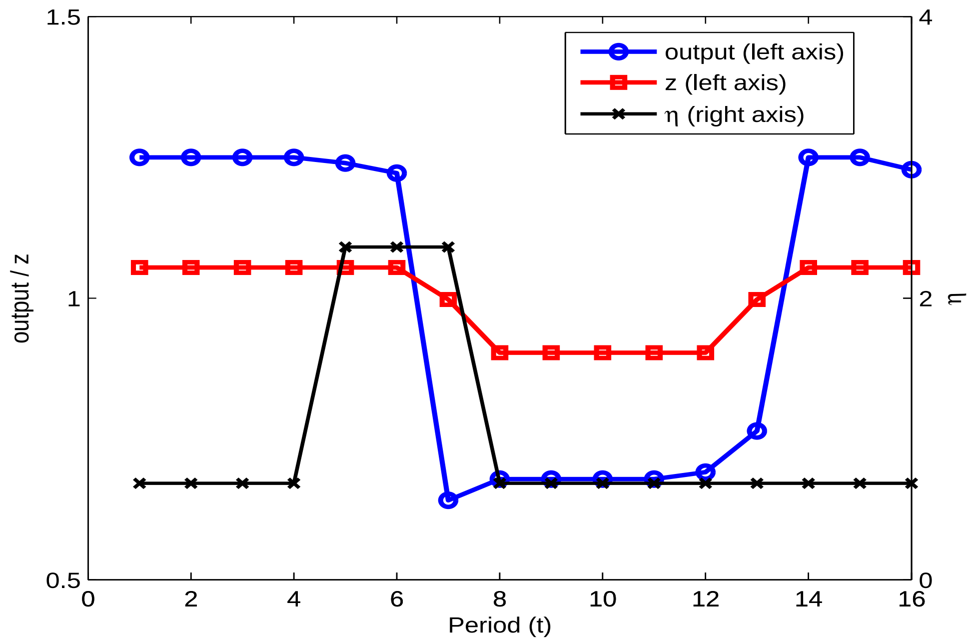


Note: periods where $z = z_c$ are represented with blue bars, periods where $\eta = \eta_L$ are represented with red bars and periods where both $z = z_c$ and $\eta = \eta_L$ occur together are presented in purple bars.

Figure 6 illustrates how global crisis are "imported" into Mexico when there is a foreign bank presence. We provide a sample realization from our model economy where we have normalized shocks and output to fit on the same graph.

[20]We note that the standard deviation of real HP filtered GDP in Mexico is 2.98%, while the figure for the model counterpart is 5.09%. One reason for this discrepancy between the model and the data is the parsimonious representation of the production sector in the model that assumes that all output is intermediated via the banking sector.

Figure 6: “Importing” a global crisis



In period 5 of Figure 6, we see that the domestic productivity shock is unchanged, but the cost of foreign external finance rises, which induces a drop in output that continues in period 6. This illustrates how opening up to foreign banks can increase domestic exposure to financial shocks. The drop that happens in period 7 is the result of bad economic conditions domestically and abroad. However, we note that as global conditions improve in period 8, output rises even though local conditions continue to deteriorate. This is mostly due to an expansion of loans by the foreign bank.

While foreign banks provide competition for domestic banks, the fact that their external funding is subject to fluctuations in the rest of the world can induce variability in loan supply (in the next sections we will see this can be substantial).

6 Tests of the model

Before moving into our main counterfactual experiment, we present a set of “qualitative tests” of the model to assess whether the model is consistent with the empirical evidence on the relationship between banking crisis, defaults, and concentration, as well as the cyclical properties observed in Mexico. We view these as tests since none of the model parameters were chosen to match these statistics.

6.1 Test of the Model I: Banking Crises, Default and Concentration

Many authors have estimated empirically the relationship between bank concentration, banking system fragility, and default frequency. In this section, we follow their approach using simulated data from our model to show that the model is qualitatively consistent with their empirical findings. As in Beck et al. [6], we estimate a logit model of the probability of a crisis as a function of the degree of banking industry concentration and other relevant aggregate variables. Moreover, as in Berger et al. [8], we estimate a linear model of the ag-gregate default frequency as a function of banking industry concentration and other relevant controls. The banking crisis indicator takes the value equal to one when: (i) the loan default frequency is higher than 10%; (ii) deposit insurance outlays as a fraction of GDP are higher than 2%, and (iii) the loan supply shrinks by more than 10%. Concentration is measured using the loan market's Herfindal index. We use as extra regressors the growth rate of GDP and growth rate of loan supply.[21] Table 5 displays the estimated coefficients.

Table 5: Banking Crises, Default Frequencies and Concentration

Model	Logit	Linear
Dependent Variable	Crisis_t	Default Freq._t
Concentration_t	-1.05	0.25
	$(0.273)^{***}$	$(0.014)^{***}$
Output growth_t	-1.35	-0.673
	$(0.04)^{***}$	$(0.015)^{***}$
$\text{Loan Supply Growth}_t$	-1.826	-0.13
	$(0.31)^{***}$	$(0.0164)^{***}$
R^2	0.76	0.53

Note: Standard errors in parenthesis. R^2 refers to Pseudo R^2 in the logit model. *** Statistically significant at 1%, ** at 5% and * at 10%, respectively.

Consistent with the empirical evidence in Beck, et al. [6], we find that banking system concentration is highly significant and negatively related to the probability of a banking crises. The results suggest that concentrated banking systems are less vulnerable to banking crises. Higher monopoly power induces periods of higher profits that prevent bank exit. This is in line with the findings of Allen and Gale [1]. Consistent with the evidence in Berger et al. [8], we find that the relationship between concentration and loan portfolio risk is positive. This is in line with the view of Boyd and De Nicolo [11], who show that higher concentration is associated with riskier loan portfolios.

[21] Beck et al. [6] also include other controls like "economic freedom," which are outside of our model.

6.2 Test of the Model II: Business Cycle Correlations

Our model makes predictions for cyclical properties of financial and real variables and since we do not target any cyclical correlation when calibrating the model, we can use these correlations to test the model predictions. To do so, we note that intermediated output in the model is given by

$$Y = \{p \cdot (1 + z'R) + (1 - p) \cdot (1 - \lambda)\} \cdot L^s. \tag{30}$$

Using this definition, Table 6 presents a set of relevant business cycle correlations.

Table 6: Model Business Cycle Correlations

Moment	Data	Benchmark
Corr(Y, L^s)	0.367	0.963
Corr(Y, ℓ^f)	0.231	0.289
Corr(Y, ℓ^d)	0.276	0.550
Corr(Y, r^L)	-0.194	-0.781
Corr$(Y, (1-p))$	-0.089	-0.445
Corr$(Y, entry)$	0.055	0.031
Corr$(Y, exit)$	-0.207	-0.430

Note: Output data corresponds to real Mexican GDP (in 1985 U.S.$ from the World Bank via Haver Analytics, 1970-2012). Bank data corresponds to commercial bank data in Mexico from 1998-2012. Source: Bankscope

Table 6 shows that the model is qualitatively consistent with the data. We see that loans are procyclical and less so for foreign banks than domestic banks. Interest rates and default frequencies are countercyclical. Entry is procyclical and exit is countercyclical. Finally, while we do not have a good measure in the data, we can also assess entrepreneurial risk-taking (i.e., choice of R). We find that entrepreneurial risk taking is procyclical (i.e. Corr$(Y, R) = 0.518$).

7 Counterfactual: Assessing Foreign Competition

As we described in the introduction, one important characteristic of the banking system in Mexico was that, prior to 1998, the Mexican banking system was protected from foreign competition. Foreign banks were not allowed to buy Mexican banks whose market share exceeded 1.5% and total participation of foreign banks was restricted to be less than 8%.

To evaluate the effects of such restrictions on welfare and the evolution of the economy, we compute a series of counterfactuals. First, we raise the foreign entry cost sufficiently high so there is no foreign entry maintaining all other parameters at their benchmark levels (i.e., we set $\overline{n} = 0$ in $\Upsilon^f_{\overline{n}}$ but maintain $\overline{n} = 1$ in $\Upsilon^d_{\overline{n}}$). This has two effects: There are no foreign banks and there is a monopoly in the domestic banking industry. To disentangle these two effects, we conduct a second counterfactual where we maintain the domestic entry cost at a level where a second domestic bank enters (i.e., we set $\overline{n} = 0$ in $\Upsilon^f_{\overline{n}}$ and set $\overline{n} = 2$ in $\Upsilon^d_{\overline{n}}$).[22] The resulting domestic duopoly can then be compared with our benchmark duopoly with one representative foreign and domestic bank. In all cases, market structure is endogenous and determined by entry and exit decisions.

7.1 Positive Effects of Foreign Bank Entry

Table 7 presents the positive results from these counterfactuals against the benchmark. Column 2 makes up the first counterfactual in which only foreign bank entry costs are raised (i.e. Υ^f_0). Column 3 makes up the second counterfactual in which not only foreign bank entry costs are raised but domestic bank entry costs are lowered (i.e., Υ^d_2) to foster domestic competition.

Table 7: Positive Effects of Foreign Bank Competition

Moment	Benchmark $(\Upsilon^d_1, \Upsilon^f_1)$	Counterfactual $(\Upsilon^d_1, \Upsilon^f_0)$	$(\Upsilon^d_2, \Upsilon^f_0)$
Loan market share domestic %	43.37	100.00	50.00
Loan interest margin %	7.76	9.89	8.08
Dividend / asset foreign %	3.94	-	-
Dividend / asset domestic %	4.11	6.56	4.55
Avg. equity issuance foreign %	0.83	-	-
Avg. equity issuance domestic %	0.30	1.44	1.01
Exit rate foreign %	2.72	-	-
Exit rate domestic %	3.98	0.00	3.78
Entry rate %	5.66	0.00	5.56
Default frequency %	6.13	6.31	6.15
Chargeoff rate %	1.21	1.25	1.25
Intermediated output (rel. to bench)	-	0.77	0.98
Loan supply (rel. to bench)	-	0.76	0.95
Taxes / output (rel. to bench)	-	0.00	0.96
C.V. output (rel. to bench)	-	0.91	0.97

Note: C.V. denotes coefficient of variation. Values below the line refer to the ratio of counterfactual to benchmark.

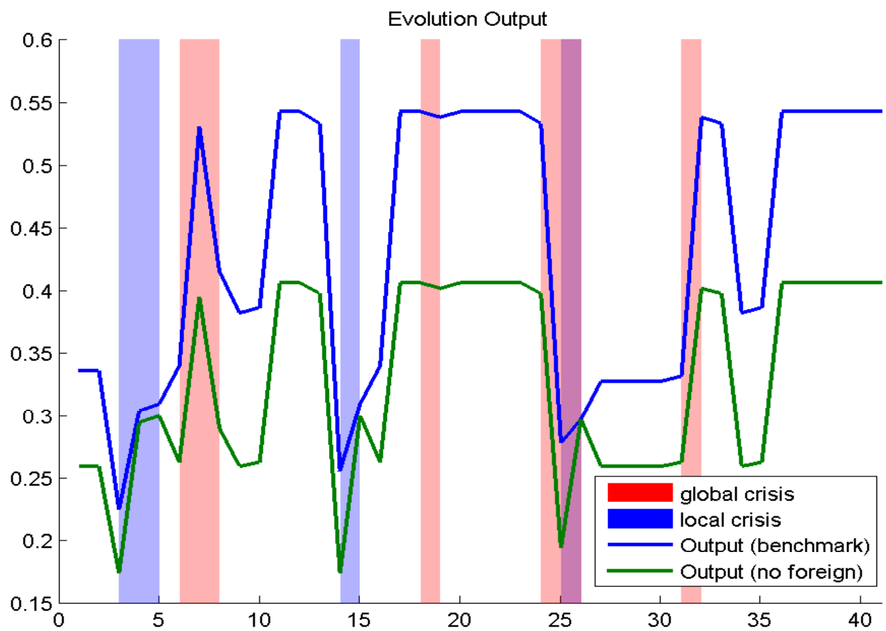
Comparing columns 1 and 2 shows that restricting foreign entry in a highly concentrated industry results in sizable amplification effects. In the highly concentrated industry without foreign and domestic competition, profit margins are high enough that it reduces domestic

[22] In the counterfactual economy, domestic banks are ex-ante identical (they have the same cost structure) and fully owned by the domestic consumers. Since profitability of both banks is exactly the same, multiple equilibria can arise. We assume that if at the exit stage there is more than one equilibrium (for example where one bank stays if the other exits and vice versa), we select the equilibrium where one of the active banks stays.

exit rates to zero compared with 3.98% in the benchmark. Higher profitability leads to more equity issuance to avoid exit, thereby maintaining bank charter value.

Figure 7 presents the evolution of output under both scenarios: the benchmark economy in which foreign bank competition is possible and the counterfactual economy in which the only parameter which has changed is ${\Upsilon^f}_0$ (i.e., foreign bank entry is prohibitively expensive and there is a domestic monopoly). The sequence of exogenous shocks is the same in both cases. This figure makes clear that, on average, output is higher in the presence of foreign bank competition. Importantly, credit expansions and contractions are more pronounced when foreign banks are present than in the counterfactual economy with no foreign banks. This results in output (and consumption) being higher and more volatile in the benchmark than in the counterfactual economy. We will see that these two effects have important welfare implications.

Figure 7: Evolution of Output: Benchmark versus Domestic Monopoly



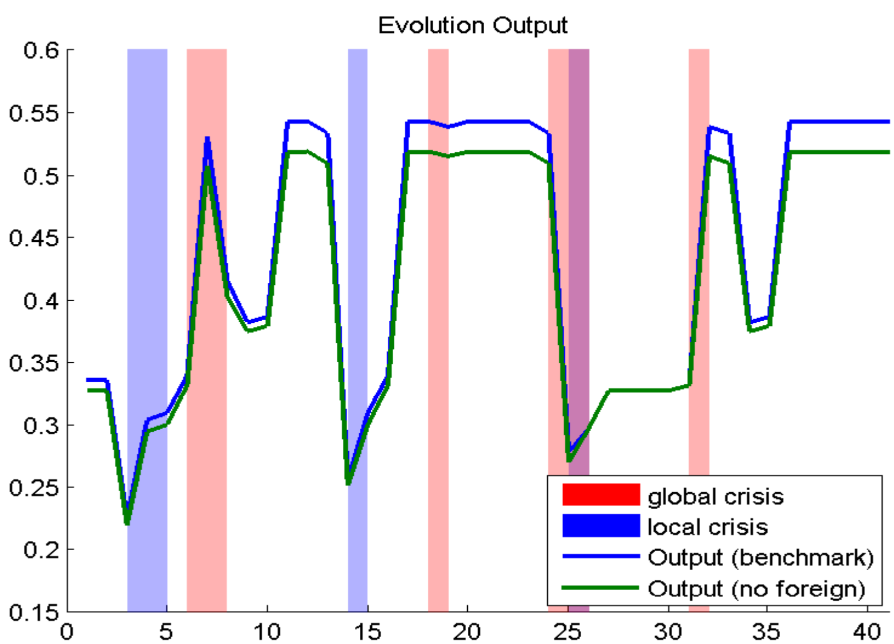
Note: Periods where $z = z_c$ are represented with blue bars, periods where $\eta = \eta_b$ are represented with red bars and periods where both $z = z_c$ and $\eta = \eta_b$ occur together are presented in purple bars. “no foreign” corresponds to the case $(\Upsilon^d_1, \Upsilon^f_0)$.

How much of the large amplification effects are due to the absence of foreign banks and how much is due to the monopolistic market structure? We can decompose the effect of the “type” of competition on the economy by comparing columns 1 and 3 of Table 7 (i.e., a duopoly composed of domestic and foreign banks in the benchmark versus only domestic banks). Allowing foreign entry and the resulting change in ownership composition in the industry has two effects: It increases the level of concentration (foreign banks market share is larger than 50%) and opens the economy to external funding crises and global shocks.

The advantage in external financing costs that foreign banks have results in an increase in the loan supply by 5.71%, which reduces interest margins by 3.96% (via a similar reduction in loan interest rates). The lower profitability in the banking sector results in much richer industry dynamics. The exit rates for domestic banks goes up. Banks find it less profitable to issue equity in order to continue when a shock hits. Since interest rates are lower and there is limited liability, the presence of foreign banks induces entrepreneurs to take on less risk which leads to lower default frequencies. The lower profitability of banks also leads them to issue less dividends.

Figure 8 presents the evolution of output under both scenarios: the benchmark economy where foreign bank competition is possible and the counterfactual economy where $(\Upsilon^{d}_{2} \Upsilon^{f}_{0})$ (i.e., foreign entry is prohibitively expensive but there is a domestic duopoly). Again, the sequence of exogenous shocks is the same in both cases. The figure makes clear while foreign bank entry leads to higher output and more volatility, it is much less pronounced when there is domestic competition than in Figure 7 where there is no domestic competition. The muted effects will account for smaller welfare gains in the presence of domestic competition.

Figure 8: Evolution of Output: Benchmark versus Domestic Duopoly



Note: Periods where $z = z_c$ are represented with blue bars, periods where $\eta = \eta_b$ are represented with red bars and periods where both $z = z_c$ and $\eta = \eta_b$ occur together are presented in purple bars. Output(no foreign) corresponds to the case $(\Upsilon^d_2, \Upsilon^f_0)$.

7.2 Welfare Effects of Foreign Bank Entry

To assess the welfare consequences of the Mexican government's policy of restricting foreign bank competition prior to 1998, we ask the question, "What would households and entrepreneurs be willing to pay (or be paid) to loosen the restrictions on foreign bank competition?"

To answer this question, we calculate consumption equivalents for each type of agent in each possible state of the world. Specifically, we let $V_h^{bench}(\mu, z, \eta)$ and $V_h^{count}(\mu, z, \eta)$ denote the value for the household of being the benchmark economy with foreign bank competition and the counterfactual economy without foreign banks, respectively.[23] Similarly, $V_e^{bench}(\mu, z, \eta)$ and $V_e^{count}(\mu, z, \eta)$ are the corresponding values for the entrepreneurs. Then, the household's consumption equivalent when the economy is in state $\{\mu, z, \eta\}$ is

$$\alpha_h(\mu, z, \eta) = \left\{ \frac{V_h^{bench}(\mu, z, \eta)}{V_h^{count}(\mu, z, \eta)} \right\}^{\sigma-1} - 1$$

and the consumption equivalent for entrepreneurs is given by

$$\alpha_e(\mu, z, \eta) = \left\{ \frac{V_e^{bench}(\mu, z, \eta)}{V_e^{count}(\mu, z, \eta)} \right\} - 1.$$

Since there is a unit mass of households and entrepreneurs, the aggregate consumption equivalent in state $\{\mu, z, \eta\}$ is given by

$$\alpha(\mu, z, \eta) = \alpha_h(\mu, z, \eta) + \alpha_e(\mu, z, \eta).$$

We denote the frequency our economy visits each state by $f(\mu, z, \eta)$ (i.e. the fraction of periods that the equilibrium visits each state) and use it to calculate an ex-ante consumption equivalent. In the case of households, this is given by

$$\overline{\alpha}_h = \sum_{\mu,z,\eta} \alpha_h(\mu, z, \eta) f(\mu, z, \eta),$$

while for entrepreneurs, it is

$$\overline{\alpha}_e = \sum_{\mu,z,\eta} \alpha_e(\mu, z, \eta) f(\mu, z, \eta).$$

In this case, the economy wide or aggregate consumption equivalent is

$$\overline{\alpha} = \overline{\alpha}_h + \overline{\alpha}_e.$$

Table 8 shows very large welfare benefits of increasing competition by lowering foreign entry costs (i.e., overall gain of 6.3% coming from 5.5% entrepreneurial gain and 0.8% household gain). As Table 7 shows, output is over 30% higher in an economy with foreign bank competition (the level effect). This output gain more than compensates for the lower taxes paid to cover deposit shortfalls since there is no exit with a domestic monopoly and the increase in volatility with foreign competition (the coefficient of variation of output is nearly 10% higher in Table 7).

[23]We assume that households can only hold shares in domestic banks.

Table 8: Consumption Equivalents: Benchmark versus Domestic Monopoly (in %)

	z_c		z_b		z_g	
	η_g	η_b	η_g	η_b	η_g	η_b
$f(\mu = \{1, 0\}, z, \eta)$	10.72	2.81	30.02	9.90	38.65	7.90
$\alpha_h(\mu = \{1, 0\}, z, \eta)$	0.54	0.52	0.72	0.73	0.93	0.96
Households $\overline{\alpha}_h$	0.799					
$\alpha_e(\mu = \{1, 0\}, z, \eta)$	4.09	3.89	5.44	5.27	6.11	5.87
Entrepreneurs $\overline{\alpha}_e$	5.527					
$\alpha(\mu = \{1, 0\}, z, \eta)$	4.63	4.42	6.17	6.00	7.04	6.83
Economy wide $\overline{\alpha}$	6.326					

Note: $\mu = \{1, 0\}$ corresponds to states where there is only one active domestic bank.

The large welfare gains from allowing foreign bank entry are not surprising because we are moving from a domestic monopoly to a duopoly. Table 9 presents the welfare results from moving from a domestic duopoly to a duopoly composed of domestic and foreign banks. The economy with only domestic banks can transit between states with one domestic $\mu = \{1, 0\}$ or two domestic banks $\mu = \{2, 0\}$. We find that in aggregate, there is still a 1.54% welfare gain from allowing foreign bank competition. The bulk of this value is coming from entrepreneurs since households would be willing to pay 0.58% of consumption each period compared to 0.96% for entrepreneurs in order to move to an economy with foreign bank competition. The fact that these gains are lower than in the case of a domestic monopoly are not surprising given the higher ratios (though still less than 1) of the counterfactual to benchmark (all are now above 90% in 7). Again, the volatility effect counterbalances the level effect and explains the differences in consumption equivalents between risk averse households and risk neutral entrepreneurs (those who do not care about the higher volatility).

Table 9: Consumption Equivalents: Benchmark versus Domestic Duopoly (in %)

	z_c		z_b		z_g	
	η_g	η_b	η_g	η_b	η_g	η_b
$f(\mu=\{1,0\},z,\eta)$	10.72	2.81	12.23	2.94	0.00	0.00
$f(\mu=\{2,0\},z,\eta)$	0.00	0.00	17.79	6.96	38.65	7.90
$\alpha_h(\mu=\{1,0\},z,\eta)$	0.56	0.59	0.36	0.59	0.45	0.58
$\alpha_h(\mu=\{2,0\},z,\eta)$	0.48	0.48	0.49	0.52	0.69	0.64
Households $\overline{\alpha}_h$	0.577					
$\alpha_e(\mu=\{1,0\},z,\eta)$	0.77	0.77	0.91	0.84	1.02	0.94
$\alpha_e(\mu=\{2,0\},z,\eta)$	0.85	0.82	0.86	0.80	1.11	1.04
Entrepreneurs $\overline{\alpha}_e$	0.960					
$\alpha(\mu=\{1,0\},z,\eta)$	1.33	1.36	1.27	1.44	1.47	1.51
$\alpha(\mu=\{2,0\},z,\eta)$	1.32	1.30	1.35	1.31	1.80	1.68
Economy-wide $\overline{\alpha}$	1.537					

Note: $\mu=\{1,0\}$ corresponds to states where there is only one active domestic bank and $\mu=\{2,0\}$ refers to states with a duopoly formed by domestic banks.

8 Directions for Future Research

We provide a general equilibrium model in which domestic banks coexist in equilibrium with foreign banks with better access to risky external funding. A contribution of our model is that the market structure is endogenous and imperfect competition amplifies the business cycle.

We analyze the welfare consequences of allowing foreign bank competition. Our quantitative results show that foreign competition (relative to domestic competition only) induces higher loan supply and lower interest rates and default by borrowers. On the other hand, taxes to fund bank exit and volatility are higher. Level effects dominate the increased volatility effects so that welfare rises for both households and entrepreneurs.

Quantitatively, we find that economywide welfare (as measured by consumption equivalents) rises by more than 1.5% when there is foreign competition relative to domestic competition only. Given how we model entry costs in (5), this estimate is an upper bound since we do not check, as in Pakes and McGuire [28], if the value of entry is less than Υ^θ when the number of incumbents n is equal to $\overline{n}$ since this requires solving the model with $n \in \{0, 1, \ldots, \overline{n}+1\}$. If the value of entry is greater, then the cost function assumption binds. That means that if we relax the constraint, entry would occur, and the welfare numbers would be lower. Computing an equilibrium where the cost function is not binding as in Pakes and McGuire so that we get a precise estimate of the welfare cost, rather than an upper bound, is a direction for future research.

Another direction for future research is to consider acquisitions. Most of the foreign entry occurred when foreign banks acquired nonperforming domestic banks.[24] We abstracted

[24] As stated (p. 52-53) by Beck and Peria [4] "Mostly, the increase in foreign bank participation in Mexico

from entry via acquisitions in our current paper. Important considerations when considering acquisitions depend on the form of bargaining game over sale price and liability for current losses when $\pi_t^d < 0$. For instance, if the foreign bank makes a take-it-or-leave-it offer and agrees to cover any current cash flow deficiencies in the case of an insolvent domestic bank, then instead of entry condition (20), entry via acquisition implies:

$$V^f(\mu^e, s'; \sigma_{-\theta}) - \Upsilon^a[1 + \xi^f(|\pi^d| + \Upsilon^a, \eta')] \geq 0,$$

where Υ^a are fixed costs associated with acquisition rather than "de novo" foreign entry costs.

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9 Data Appendix

Banking sector variables are from Bureau Van Dijks Bankscope data set. To create our sample, we first screen for location, focusing on Mexico, and then we screen for the banks specialization, i.e., commercial banks. We consider "active" and "inactive" banks at the moment of downloading the data to incorporate banks that may have existed in the sample but are currently inactive. This leaves us with a sample of 61 banks.[25] Our sample starts in 1998 and goes to 2012, the earliest date available through Bankscope to the most recent date with consistent data. For balance sheet variables as well as income statement variables, we censor the top and bottom 1% of the sample.

We use real Mexican GDP data from World Bank via Haver Analytics. We convert the data to United States Dollars (Thousands) with each periods closing date exchange rate.

9.1 Identifying Ownership

We follow Mico et al. [27] when coding ownership. This is time-consuming because there is no ownership identifier in the data. There is a field with a brief history of each institution that allows to track ownership changes. We also gathered information from individual bank websites as well as performed several internet searches, business week company profiles, and consulted country experts. For this reason, we focus on the the 10 largest banks in Mexico. The top 10 banks represent, on average, more than 80% of total assets in the industry.

Bankscopes Ownership Database shows an active banks organization hierarchy, the percentage of the bank owned by the parent, and the country where the parent is headquartered, all through time. For example, if Bank A is owned domestically by Bank B, which is ultimately owned by a foreign bank, Bank C, Bankscope will provide either the exact percentage of Bank A owned by Bank B and of Bank B owned by Bank C; or it will show if Banks A and B were wholly owned or majority owned. Looking through time, this allows us to check whether a bank is foreign or domestically held. Its worth noting that this data largely goes back only to 2002. We then complement the data with the "bank history" variable, which expounds on the banks story and explains if it was merged, liquidated, or altered in some way. As we explained above, we complement this with other sources.

Where Bankscope does not have complete information, we determine foreign/domestic ownership status by looking at total foreign ownership as a percentage of all information available. For example, in the case of Banco Del Bajio is owned by Temasek Holdings (13.3%), Banco De Sabadell SA (20%), International Finance Corporation (10%), and a number of foreign entities whose combined reported ownership is 85.3%. Foreign institutions hold 50.7% of the reported total, allowing us to designate Banco Del Bajio as a foreign institution. Banco Azteca SA was the final case where ultimate ownership was unclear. Here, Bankscope reports three individuals as owning 72% of Banco Azteca SA, and two of the three individuals are Mexican. As such, we designate the bank as being domestic.

[25] An important point to note here is how Bankscope treats consolidation of subsidiaries. We set our search settings to primarily pull consolidated statements, and if those are unavailable for a subset, pull unconsolidated statements. This avoids duplication issues if a bank is a subsidiary of another bank.

9.2 Computational Strategy

In this section, we describe the computational algorithm that allows as to compute bank strategies and the equilibrium of the model. We follow an extension of the algorithm proposed by Pakes and McGuire [28].

After giving a functional form to the utility function, the failure probability, the equity issuance cost and the distribution of net costs for domestic and foreign banks as well as defining a grid and a transition probability for the aggregate shocks the steps to compute the algorithm are the following:

1. Solve the entrepreneur's problem. This amounts to define a grid over r^L and for each 2-tuple $\{r^L, z\}$ obtain the type of project the entrepreneur operates $R^j(r^L, z)$ and the decision on whether to operate the technology or not $\iota(\omega, r^L, z)$. Using $\iota(\omega, r^L, z)$, we can derive the loan demand: $L^d(r^L, z)$.

2. Define a grid over the number of possible active domestic and foreign banks $\{\{0,0\},\{0,1\},\{1,0\},\{1,1\}\}$ where the first element in each set corresponds to an indicator of whether the representative domestic bank is active or not and the second element corresponds to an indicator for the foreign bank.

3. For each state $\{\mu, z, \eta\}$, solve the problem of foreign and domestic banks. We use value function iteration in this step:

   (a) Guess a loan decision rule and value function for each bank type: $\ell^0(\theta, \mu, z, \eta)$ and $V^0(\theta, \mu, z, \eta)$ for $\theta = d, f$.

   (b) For each bank, solve the optimal loan and exit decision rule taking as given the strategy of other banks. Note that the equilibrium in the loan market is derived from the following equation:

   $$\ell^0(d, \mu, z, \eta) + \ell^0(f, \mu, z, \eta) = L^d(r^L, z). \tag{31}$$

   The solution to this problem will provide a loan decision rule $\ell^1(\theta, mu, z, \eta)$, an exit decision rule and a new value function $V^1(\theta, \mu, z, \eta)$.

   (c) If $|V^1(\theta, \mu, z, \eta) - V^0(\theta, \mu, z, \eta)| < \epsilon^v$ and $|\ell^1(\theta, \mu, z, \eta) - \ell^0(\theta, \mu, z, \eta)| < \epsilon^\ell$ for ϵ^v and ϵ^ℓ small you have obtained the solution to the bank problem and can continue. If not, set $V^0(\theta, \mu, z, \eta) = V^1(\theta, \mu, z, \eta)$, $\ell^0(\theta, \mu, z, \eta) = \ell^1(\theta, \mu, z, \eta)$ and return to previous step.

   (d) The equilibrium loan decision rules determine the equilibrium loan interest rate $r^L(\mu, z, \eta)$.

4. For each state $\{\mu, z, \eta, z', \eta'\}$ define the distribution of survivors (i.e. the distribution of banks that arises after exit decisions but prior to entry):

   $$\mu^x(\theta, \mu, z, \eta, z', \eta') = \mu(\theta)(1 - x(\theta, z, \eta, z', \eta'))$$

5. Solve the entry problem of each bank type, that is select $e(\theta, \mu^x, z, \eta) \in \{0, 1\}$. Each bank will enter (i.e. $e(z, \eta) = 1$) if

$$-\Upsilon^\theta + V(\theta, \hat{\mu}(\mu^x), z, \eta) \geq 0.$$

where $\hat{\mu}$ is the distribution that would arise if the bank of type θ enters and takes into account the entry decision rule by other banks starting from μ^x.

6. Using the exit and entry decision rules of dominant banks, we can define the evolution of the distribution $\mu' = H(\mu, z, \eta, z', \eta')$:

$$\mu'(\theta, \mu, z, \eta, z', \eta') = \mu^x(\theta, \mu, z, \eta, z', \eta') + e(\theta, \mu^x, z', \eta')$$