Three Essays on Debt

Lijun Wang

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ABSTRACT

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Lijun Wang

This dissertation contains three essays on debts of different forms that make contributions to the areas of international macroeconomics and spatial economics. In particular, the first two essays study sovereign debts. They examine sovereign default behaviors together with interactions between sovereign defaults and countries’ costs of borrowing. The third essay looks at bank loans. It explores the possibility of understanding economic agglomeration through distance-related financial frictions firms face when borrowing from banks.
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To my wife,

Amy,

who has kept me company

in this marathon of the mind.
Preface

Economic agents use debt as a vehicle for external financing in different contexts. Households take on debts such as credit card balances to finance daily spendings, firms take on debts such as bank loans to finance productions and investments, and governments take on debts such as sovereign bonds to finance public operations and programs.

This dissertation contains three essays on debts of different forms that make contributions to the areas of international macroeconomics and spatial economics. In particular, the first two essays study sovereign debts. They examine sovereign default behaviors together with interactions between sovereign defaults and countries’ costs of borrowing. The third essay looks at bank loans. It explores the possibility of understanding economic agglomeration through distance-related financial frictions firms face when borrowing from banks.

Chapter 1 is titled Defaultable Sovereign Debts under Plausible Risk-Averse Pricing. It addresses an asset-pricing anomaly in structural sovereign default models. When calibrated to match historical default probabilities, these models imply a level of sovereign bond credit spread that is too low to be commensurate with data. One
line of research attempts to improve the model by building an extension of risk-averse investors into it; however, such efforts have not entirely resolved the problem. Rather than making another attempt in this direction, chapter 1 takes a step back and examines the feasibility of this entire approach. Can any plausible extension of risk-averse investors into the standard model resolve the low-spread anomaly? If not, it is meaningless trying to build one in the first place.

To be precise, chapter 1 deems an investor extension plausible as long as it implies an investor pricing behavior that does not allow arbitrage relative to existing bonds in this market. However, by incorporating a pricing kernel that is consistent with the “market price of risk” in the data (and hence leaving no room for arbitrage), the low-spread anomaly in sovereign default models can barely be improved. Relying on this result, chapter 1 concludes that no plausible extensions of risk-averse investors can resolve the low-spread anomaly. To improve the structural sovereign default models in this regard, we should look elsewhere for theoretical resolutions.

Chapter 2 is titled The Home Bias of Sovereign Borrowing. It looks at the issue of domestic debt being missing from existing sovereign finance theories. Notably, domestic debt accounts for nearly two-thirds of total sovereign borrowing, and yet existing theories remain completely agnostic on this and assume countries only borrow externally. To properly account for both domestic and external debts in one theoretical framework, what are the relevant trade-offs to consider? How does the “home bias” arise? What is driving the cross-country heterogeneity in these behaviors?

To answer these questions, chapter 2 develops a novel general equilibrium model, in which the benevolent government can strategically choose to borrow from domestic
or external markets. The model can generate the observed “home bias” in sovereign borrowing as an equilibrium outcome through the government’s strategic financing behaviors. By introducing a capital control constraint on foreign investments within the domestic market, the model implies that looser inflow capital controls for a country are associated with a stronger home bias in its sovereign borrowing. Using a cross-country dataset, chapter 2 also finds support for this association in the data.

Chapter 3 is titled *The Financial Channel of Economic Agglomeration*. It revisits a classic question of how economic agglomeration arises from a novel financial perspective. Traditionally, urban economists interpret economic agglomeration as an outcome of firms choosing to locate near each other, because doing so begets increasing returns to scale in their productions. Alternatively, chapter 3 presents evidence that explains economic agglomeration as a result of firms more likely emerging together near banks, because proximity to banks reduces frictions to obtain loans.

To show that a bank can *cause* firms to agglomerate in its proximity by easing their financial frictions, chapter 3 carefully designs a natural experiment to examine what a quasi-exogenous bank relocation does to the bank’s surroundings. A standard difference-in-difference approach shows that relocation of a bank closer to a region indeed *causes* more supply of bank loans in that region, and subsequently *causes* more firm establishments to emerge and agglomerate within the same area. This result supports the financial channel of economic agglomeration, and it also suggests the importance of credit availabilities for regional economic growths.

Without further ado, we now begin expositions of the entire dissertation below.
Chapter I.

Defaultable Sovereign Debts under Plausible Risk-Averse Pricing

There is an asset-pricing anomaly in structural models that examine sovereign defaults among emerging economies (e.g., Eaton and Gersovitz, 1981; Arellano, 2008).\(^1\) When calibrated to match historical default probabilities, these models imply a level of sovereign bond credit spread that is too low to be commensurate with data.\(^2\)

For a quick illustration, one such model is calibrated to match the Argentine economy per Arellano (2008) in Figure I-1. Given a fitted output process, the model can predict the observed sovereign default around 2001. For the years leading up to

\(^1\)Eaton and Gersovitz (1981) make a seminal contribution to modeling sovereign defaults. By introducing debt market exclusion for countries in default, they present a stylized model to analyze sovereign defaults as a country’s strategic choices. Arellano (2008) later develops this approach into a full-fledged structural model, which one can calibrate for quantitative simulations.

\(^2\)There is another strand of literature that explicitly studies sovereign bond yields and credit spreads (e.g., Duffie and Singleton, 1999; Duffie, Pedersen, and Singleton, 2003). Unlike those structural sovereign default models mentioned above, this literature treats sovereign defaults as exogenous credit events.
the default, it also successfully simulates the observed dynamics in macroeconomic variables such as the trade balance. However, the model implies a time series of Argentine bond credit spread\(^3\) that is too low to be comparable with its empirical counterpart.\(^4\)

---

\(^3\)The model defines the credit spread as the interest rate at which the Argentine government is borrowing, less the international risk-free interest rate benchmark. Its empirical counterpart is the prevailing interest rate at which the Argentine government is borrowing, less the 5-year U.S. bond yield.

\(^4\)Yue (2010) shows that model-implied credit spread becomes even lower when she incorporates post-default debt recoveries into the standard model. In her set-up, the model’s asset-pricing performance is even more problematic.
To resolve this low-spread anomaly, one line of research attempts to improve the model by building an extension of risk-averse investors into it, hence replacing the current risk-neutral pricing set-up.\(^5\) By doing so, bond investors in the model can charge, on top of actuarially fair compensations, an additional premium for bearing default risks. This idea also finds empirical support. Longstaff et al. (2011) study an extensive set of sovereign CDS data and find that the risk premium indeed accounts for a significant portion of the sovereign bond credit spread.\(^6\)

A few attempts have been made to extend the model in this direction, resulting in minimal success. Lizarazo (2013) introduces bond investors whose preferences exhibit decreasing absolute risk aversion (DARA). In her model, the wildest parameter assumptions can only resolve nearly half of the low-spread anomaly. Uribe and Schmitt-Grohe (2017) bring U.S. household investors with constant relative risk aversion (CRRA) utilities into the model. However, this set-up can barely improve the low-spread anomaly across all parameter specifications.

Rather than making another attempt in this direction, chapter 1 takes a step back and examines the feasibility of this entire approach. Can any plausible extension of risk-averse investors into the model resolve the low-spread anomaly? If not, it is meaningless trying to build one in the first place. This question is challenging because

\(^5\)Alternatively, another line of research by Chatterjee and Eyigungor (2012) and Arellano and Ramanarayanan (2012) builds an extension of debt maturity structures into the model, hence replacing the current one-period bond set-up. These efforts have proven helpful in improving the model’s asset-pricing performance. On a side note, Garcia-Schmidt (2015) introduces asymmetric information on debtor country incomes between bond investors and debtor countries. The idea is to see if adverse selection by bond investors increases the credit spread to a level that resolves the model’s asset-pricing anomaly. However, this approach achieves very minimal quantitative success.

\(^6\)Longstaff et al. (2011) find that “[o]n average, the risk premium represents about a third of the credit spread” in sovereign bonds.
it aims to make a statement on not *one* but *all* possible extensions that are plausible.

However, being *plausible* sounds vague and subjective. What exactly does it mean when we use it to describe an extension of risk-averse investors into the model? To clarify, chapter 1 deems an investor extension plausible as long as it implies an investor pricing behavior that is consistent with the “market price of risk” in the data. In other words, an equivalent way of asking the question is: can we resolve the low-spread anomaly by introducing risk-averse investors who price risk in a way that does not allow arbitrage with existing bonds in this market?

To introduce such risk-averse pricing behaviors into the standard model, chapter 1 uses directly the investors’ stochastic discount factor (SDF, or equivalently the pricing kernel, denoted as $M_{t+1}$). Doing so has three advantages. First, it abstracts away from specific economic models of risk-averse investors while pricing bonds. Second, it adapts to the standard sovereign default model without compromising tractability in modeling sovereign defaults (Arellano, 2008). Third, it is possible to construct a risk-averse pricing kernel that is plausible per our discussions above (Cochrane and Piazzesi, 2005).

To construct a pricing kernel that is arbitrage-free relative to existing bonds in the market, we follow an algebraic procedure in Cochrane and Piazzesi (2005), who use prices and forward rates on one- through five-year zero-coupon U.S. government

---

7Existence of the SDF does show that there is an economic model that implies a pricing behavior consistent with the SDF; however, an examination of the SDF does not quickly lead one to the correct economic model. Hansen and Jagannathan (1991) have performed such an inquiry on discount factors for stocks.

8Recall that the SDF prices risk based on the law of one price and the condition of no-arbitrage via the primitive pricing equation $P_t^{(n)} = E_t(M_{t+1}M_{t+2}...M_{t+n-1})$, in which $P_t^{(n)}$ denotes the period-$t$ price of a discount bond that returns 1 unit of consumption in $n$ periods.
bonds. Notably, running forecasting regressions of excess bond returns on a combination of forward rates, they find unprecedented forecastability (with $R^2$ up to 0.44). To account for this forecastability while modeling how investors price risk in these bonds, they algebraically derive a pricing kernel that leaves no room of arbitrage relative to the included bonds in those regressions. It is this kernel we now introduce into the standard sovereign default model as the plausible risk-averse pricing kernel (denoted as $M^*_{t+1}$).

With the plausible risk-averse pricing kernel, the model yields only minimal improvements on its simulated credit spread. Again, for the years leading up to the 2001 Argentine default episode, the standard model implies an average credit spread of 3.39%, while the model with the plausible risk-averse pricing kernel yields an average credit spread of 3.65%. Despite the 0.26 percentage point increase, the observed Argentine bond credit spread for the same period has an average of an unreachable 10.25%. These results suggest that no plausible extensions of risk-averse investors into the model could satisfactorily resolve the low-spread anomaly. To improve the model’s asset-pricing performance, we should look elsewhere for theoretical resolutions.

This chapter organizes itself as follows. Section A outlines a benchmark sovereign default model with risk-neutral pricing per Arellano (2008). Section B modifies the model to introduce risk-averse pricing via the SDF framework. Section C constructs

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9 Also, see Campbell and Shiller (1991) and Fama and Bliss (1987) for earlier work on this matter.

10 One implicit assumption in applying $M^*_{t+1}$ here is that investors on emerging market sovereign bonds also have access to these zero-coupon U.S. government bonds and the associated forward contracts; otherwise, being arbitrage-free relative to these bonds does nothing in restricting pricing behaviors.
the plausible risk-averse pricing kernel $M_{t+1}$ and adapts it into the model. Finally, section D concludes the chapter.

A. Benchmark Model with Risk-Neutral Pricing

The benchmark model closely follows Arellano (2008). It is a dynamic stochastic general equilibrium model containing a continuum of households, risk-neutral international investors, and a benevolent government.

**Households** solve a standard inter-temporal consumption problem. Their representative agent receives a Markov stochastic stream of tradable consumption goods $y_t$ that follows a transition function $f(y_{t+1}, y_t)$ and has compact support $Y$.\(^{11}\) Its objective is to maximize its expected lifetime utility, and in doing so, it chooses its consumption $c_t$ in each period.

Formally, households try to

$$\max_{\{c_t\}} \sum_{t=0}^{+\infty} \beta^t E_0 [u(c_t)],$$

subject to their inter-temporal budget constraint that takes shape after the government makes its borrowing and default decisions each period. $\beta \in (0, 1)$ denotes the households’ subjective period discount factor. $u(c_t)$ denotes the households’ period utility function. It takes a standard constant relative risk aversion (CRRA) utility functional form $u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}$, in which $\sigma$ denotes the households’ coefficient of

\(^{11}\)In other words, $y_t \in Y, \forall t$. 


relative risk aversion.

Households borrow from the international financial market through their government via its issued sovereign bonds. If the government is not in default of its bonds, households’ budget constraint is

\[ c_t = y_t + B_t - q_t B_{t+1}, \]

in which \( B_t \) is the nominal value of previously issued bonds households have to repay in period \( t \), \( B_{t+1} \) is the nominal value of bonds due next period, and \( q_t \) is the current-period price for each nominal unit of bonds due next period.\(^{12}\)

If the government is in default, prior debt contracts are no longer honored (i.e., \( B_t = 0 \)), and the debtor country is temporarily excluded from the international financial market (i.e., \( B_{t+1} = 0 \)). In this case, households follow a simple hand-to-mouth budget constraint

\[ c_t = y_t^{def}, \]

in which they consume everything from their endowment income \( y_t^{def} \). \( y_t^{def} \) denotes the period endowment income during a default; it is assumed to be a depressed level of \( y_t \) because sovereign default imposes output costs on the debtor country.

**International investors** are risk-neutral. As long as they are compensated with an expected return at the constant international lending rate \( r^f > 0 \), they can borrow or lend as much as they need to.

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\(^{12}\)A positive \( B_{t+1} \) means the debtor country saves \( q_t B_{t+1} \) in the current period \( t \) and receives \( B_{t+1} \) in period \( t + 1 \). A negative \( B_{t+1} \) means the debtor borrows \( q_t (-B_{t+1}) \) in the current period, and pays back, conditioning on non-default, \((-B_{t+1}) \) in period \( t + 1 \).
With perfect information on the debtor country income process, investors price the defaultable bonds in a risk-neutral manner so that they break even in expected value in every bond contract. Formally, taking bond prices $q_t$ as given in every period, lenders choose loans $B_{t+1}$ to maximize expected profits $\Phi_t = q_t B_{t+1} - \frac{1 - \delta_{t+1}}{1 + r_f} B_{t+1}$, in which $\delta_{t+1}$ denotes the expected probability of debtor country default in period $t + 1$. This requires bond prices $q_t$ to satisfy the risk-neutral pricing equation (I..1):

$$q_t = \frac{1 - \delta_{t+1}}{1 + r_f}.$$  \hspace{1cm} (I..1)

The next-period default risk $\delta_{t+1}$ is endogenous to the model. It depends on the government’s incentives to default under different possible $y_{t+1}$ realizations. In equilibrium, it is the sum of probabilities for $y_{t+1}$ realizations in the next period, in which the government finds it optimal to default. Formally,

$$\delta_{t+1} = \int_{D(B_{t+1})} f(y_{t+1}, y_t) dy_{t+1},$$

in which $D(B_{t+1}) \equiv \{y_{t+1} \in Y : \text{government finds it optimal to default on } B_{t+1}\}.$\(^{13}\)

Using the endogenous discount bond price $q_t$, the model defines the interest rate at which the government is borrowing using its reciprocal $1 + r_t = \frac{1}{q_t}$. Following this, the credit spread of the defaultable bonds $r_t^\Delta$ is defined as $r_t^\Delta \equiv \frac{1}{q_t} - (1 + r_f)$.

The benevolent government solves a strategic borrowing and default problem on behalf of households in this economy. Entering each period, it observes its current-

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\(^{13}\)A formal introduction of $D(B_{t+1})$ is deferred until expositions on the government’s strategic default problem.
period income $y_t$, and decides whether to repay on its maturing debts $B_t$. If it does, it continues to borrow by selling bonds with face value $B_{t+1}$ at a unit price of $q_t$, and rebates all proceeds back to the households in lump-sum transfers. If not, it declares a default. Maturing debts $B_t$ are ignored but no new bonds could be issued.

Being in default has two consequences in this model — temporary financial exclusion and direct output loss. First of all, the debtor country loses its access to the international financial market and only re-enters with an exogenous probability $\theta \in [0, 1)$ during each subsequent period. Secondly, its output remains at a depressed level $y_t^{\text{def}}$. $y_t^{\text{def}}$ is assumed to be a concave piecewise liner function with a kink at a threshold $\hat{y}$, which denotes the maximum output level receivable by the debtor country while it is in default. Formally, $y_t^{\text{def}} = \min\{\hat{y}, y_t\}$.

The government’s strategic borrowing and default problem is outlined below. (For brevity of notations, I drop all $t-$subscripts and replace $t + 1$ notations with $'$ variables.) Entering each period, the government is maximizing its welfare value function $v^o(B, y)$ by choosing between continuing to repay debts $v^c(B, y)$ and declaring default $v^d(y)$,

$$v^o(B, y) = \max_{\{v^c, v^d\}} \{v^c(B, y), v^d(y)\}.$$ 

The value function of continuing repayments $v^c(B, y)$ is

$$v^c(B, y) = \max_{B'} \left\{ u(y - q(B', y)B' + B) + \beta \int_{y'} v^o(B', y') f(y', y) dy' \right\},$$
and the value function of declaring default $v^d(y)$ is

$$v^d(y) = u(y^{def}) + \beta \int_y [\theta v^o(0, y') + (1 - \theta) v^d(y')] f(y', y) dy'.$$

The choices between $v^d(y)$ and $v^c(B, y)$ constitute the government’s default policy set $D(B)$. Formally, $D(B) \equiv \{y \in Y : v^d(y) > v^c(B, y)\}$. In correspondence, the government’s repayment policy set is $A(B) \equiv \{y \in Y : v^d(y) \leq v^c(B, y)\}$.

With the households, the international investors, and the government in place, we now define the **recursive equilibrium** in this economy.

**Definition.** The recursive equilibrium in this economy is formally defined as the policy functions/sets $\{c_t\}_{0}^{+\infty}, D(B), \{B_{t+1}\}_{0}^{+\infty}$, and market prices $\{q_t\}_{0}^{+\infty}$ such that

1. households maximize their expected lifetime utility subject to their budget constraint, taking as given the government policies;

2. the government default policies and borrowing choices satisfy its optimization problem, taking as given the endogenous prices for their bonds;

3. endogenous bond prices reflect corresponding default probabilities, and are consistent with international investors’ expected zero profits condition, taking as given the stochastic endowment process $\{y_t\}_{0}^{+\infty}$.

To be able to use the model for simulations, we first need to solve for its equilibrium solutions, using a calibration matched to the simulated empirical episode. For instance, we now simulate the Argentina 2001 default episode as in Figure I-1.
First, we start by calibrating the model to Argentina. The goal of the calibration is to have the model predict an equilibrium sovereign default at about 3% annualized probability — an observed default probability in Argentina at the annual frequency, while we assume its income process follows a demeaned log AR(1), \( \ln y_{t+1} - \ln y = \rho (\ln y_t - \ln y) + \eta \epsilon_{t+1} \), in which \( \ln y = \ln 10 \) and \( \epsilon_{t+1} \) is a standard white noise. Table I-1 outlines all parameters for the calibration in its top panel.

### Table I-1: Benchmark Calibration & Solution Algorithm Parameters

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-free interest rate</td>
<td>( r^f = 1.7% )</td>
<td>5-year U.S. bond quarterly yield</td>
</tr>
<tr>
<td>HH risk aversion</td>
<td>( \sigma = 2 )</td>
<td>standard</td>
</tr>
<tr>
<td>AR(1) for ( \ln y_{t+1} )</td>
<td>( \rho = 0.945, \eta = 0.025 )</td>
<td>Argentine quarterly GDP</td>
</tr>
<tr>
<td>Discount factor</td>
<td>( \beta = 0.953 )</td>
<td>Target 3% default prob.</td>
</tr>
<tr>
<td>Prob. of re-entry</td>
<td>( \theta = 0.282 )</td>
<td>Argentine historical re-entry prob.</td>
</tr>
<tr>
<td>Depressed output</td>
<td>( \hat{y} = 0.969E(y), E(y) = 10 )</td>
<td>Target 3% default prob.</td>
</tr>
<tr>
<td>Grid for ( B )</td>
<td>([-3.475, 1.5]], equally spaced</td>
<td>standard</td>
</tr>
<tr>
<td>Grid for ( y )</td>
<td>discretized AR(1)</td>
<td>Tauchen-Hussey algorithm</td>
</tr>
<tr>
<td>No. of grid points for ( B )</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>No. of grid points for ( y )</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Convergence criterion</td>
<td>( 10^{-8} )</td>
<td></td>
</tr>
<tr>
<td>Maximum iterations</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td><strong>Target Statistics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default prob.</td>
<td>3.0%</td>
<td>Argentine historical default prob.</td>
</tr>
</tbody>
</table>

We then proceed to computationally solve for equilibrium solutions using standard value function iterations\(^{14}\) on discretized grids. Table I-1 outlines all parameters for the solution algorithm in its second panel. For brevity of expositions, we plot the numerical equilibrium solutions in Appendix A2. Overall, these solutions comply with our intuition in that a higher debtor country income drives lower default probabilities, which in turn increases bond prices and decreases the country’s cost of borrowing.

\(^{14}\)See Appendix A1 for a detailed solution algorithm.
Equipped with these solutions, we can simulate the Argentina bond credit spread prior to its 2001 default episode at last. To compare with the quarterly time series data between 1983Q3 and 2001Q4, we simulate the model until it predicts 100 default events, and extract the simulated credit spread over 74 periods just before each default.\footnote{Exactly 74 periods of simulated credit spread are extracted because there are 74 quarters in the period between 1983Q3 and 2001Q4.} To demonstrate the low-spread anomaly, we report annualized mean statistics across these 100 simulated time series together with the data in Table I-2.

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Model</th>
<th>Data</th>
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</thead>
<tbody>
<tr>
<td>annual conditional default probability</td>
<td>3.09</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>mean($r_{annualized}^A$)</td>
<td>3.39</td>
<td>10.25</td>
<td></td>
</tr>
</tbody>
</table>

**B. Introducing Risk-Averse Pricing via the SDF Framework**

To augment the benchmark model with risk-averse pricing, we introduce directly the investors’ stochastic discount factor (SDF) $M_{t+1}$. To accommodate such a change, the benchmark model requires three changes.

First, endogenous bond prices $q_t$ no longer satisfy the risk-neutral pricing equation (I.1). Instead, the risk-averse pricing equation (I.2) is

$$q_t = \int_{A(B_{t+1})} M_{t+1} f(y_{t+1}, y_t) dy_{t+1}, \quad (I.2)$$

$$15$$
in which $M_{t+1}$ measures how much investors value one unit of next-period consumption in the current period. Intuitively, $q_t$ is the sum of discounted future pay-offs coming from bonds if there is no default.

Second, the risk-free interest rate $r_f^t$ is now time-changing as well. By the same token, the risk-free interest rate $r_f^t$ satisfies

$$1 = (1 + r_f^t) \int M_{t+1} f(y_{t+1}, y_t) dy_{t+1},$$

which intuitively says the current-period risk-free yield has to enable a risk-free pay-off of one unit of future consumption across all possible states. Subsequently, the credit spread of defaultable bonds $r_d^t \equiv \frac{1}{q_t} - (1 + r_f^t)$ in this framework correspondingly translates into

$$r_d^t = \frac{1}{\int A(y_{t+1} + 1) M_{t+1} f(y_{t+1}, y_t) dy_{t+1}} - \frac{1}{\int M_{t+1} f(y_{t+1}, y_t) dy_{t+1}}.$$

Third, the exogenous stochastic structure for the economy is now a joint process between $M_{t+1}$ and $y_{t+1}$

$$\begin{bmatrix}
\ln y_{t+1} - \ln y \\
M_{t+1} - \bar{M}
\end{bmatrix} = \begin{bmatrix}
\rho^y & 0 \\
0 & \rho^M
\end{bmatrix} \begin{bmatrix}
\ln y_t - \ln y \\
M_t - \bar{M}
\end{bmatrix} + \begin{bmatrix}
\eta_y & 0 \\
0 & \eta_M
\end{bmatrix} \begin{bmatrix}
\varepsilon^y_{t+1} \\
\varepsilon^M_{t+1}
\end{bmatrix},$$

in which $E[\varepsilon^y_{t+1}] = E[\varepsilon^M_{t+1}] = 0$, and $E[(\varepsilon^y_{t+1})^2] = E[(\varepsilon^M_{t+1})^2] = 1$. This is assuming $M_{t+1}$ and $y_{t+1}$ are two independent stochastic processes. Intuitively, this is to say that the debtor country is too small to affect pricing behaviors on international creditors in the rest of the world, and the pricing kernel $M_{t+1}$ is independent of economic conditions in the debtor country.
C. Adapting a Plausible Risk-Averse SDF

To construct a pricing kernel that is arbitrage-free relative to existing bonds in the market, we follow an algebraic procedure in Cochrane and Piazzesi (2005), who use prices and forward rates on one- through five-year zero coupon U.S. government bonds.

Formally, the plausible risk-averse pricing kernel $M^*_t$ is constructed as

$$M^*_t = \exp(-y_t^{(1)} - \frac{1}{2} \lambda_t^{T} \Sigma \lambda_t - \lambda_t^{T} \varepsilon_{t+1}),$$

in which $t$ denotes a month, $y_t^{(1)}$ denotes the log yield of one-year discount bond, $\lambda_t$, $\Sigma$, and $\varepsilon_{t+1}$ are mathematical constructs from pre-defined forecasting regressions. These regressions are specified as

$$\mathbf{r}x_{t+1} = \beta f_t + \varepsilon_{t+1}; \text{cov} \left( \varepsilon_{t+1} \varepsilon_{t+1}^{T} \right) = \Sigma,$$

in which excess log returns $\mathbf{r}x_{t+1} \equiv \left[ \mathbf{r}x_{t+1}^{(2)} \, \mathbf{r}x_{t+1}^{(3)} \, \mathbf{r}x_{t+1}^{(4)} \, \mathbf{r}x_{t+1}^{(5)} \right]^{T}$ and log forward rates $f_t \equiv \left[ 1 \, y_t^{(1)} \, f_t^{(2)} \, f_t^{(3)} \, f_t^{(4)} \, f_t^{(5)} \right]^{T}$ cover maturities and time horizons of one through five years (denoted in parenthesized superscripts). We construct $\lambda_t = \Sigma^{-1} [\beta f_t + \frac{1}{2} \text{diag} (\Sigma)].$

Using the Cochrane-Piazzesi data and procedure, we obtain a monthly-frequency time series process $M^*_t$ that prices annual returns. Adapting it into the benchmark model requires frequency and pricing horizon adjustments to make it a quarterly-

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16Refer to Appendix A3 for more details on the notations here.
frequency SDF that prices quarterly returns. Theoretically making these adjustments is no easy task (Collin-Dufresne and Goldstein, 2003); but for our purpose we can perform some ad-hoc adjustments. To transform from monthly to quarterly frequencies, we take the quarterly average over constituent monthly values; to shift pricing horizons from a year to a quarter, we modify the SDF so that it approximately “de-annualizes” an annual risk-free rate into a quarterly yield via the standard pricing equation \( 1 = E_t[(1 + r_f^t)M_{t+1}] \).\(^{17}\) We sanity-check these adjustments by plotting the \( M_{t+1}^* \) process before and after in Appendix A5.

Table I-3: Plausible Risk-Averse Pricing Calibration and Simulation

<table>
<thead>
<tr>
<th>Argentina</th>
<th>Plausible</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration (only those changed from Benchmark)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho^M )</td>
<td>0.710</td>
<td>n.a.</td>
</tr>
<tr>
<td>( \eta_M )</td>
<td>0.012</td>
<td>n.a.</td>
</tr>
<tr>
<td>( \bar{M} )</td>
<td>0.949</td>
<td>n.a.</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.926</td>
<td>0.953</td>
</tr>
<tr>
<td>Simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>annual conditional default probability</td>
<td>3.01</td>
<td>3.09</td>
</tr>
<tr>
<td>mean((r_{t+1}^{\Delta})) annualized)</td>
<td>3.65</td>
<td>3.39</td>
</tr>
</tbody>
</table>

With the adapted \( M_{t+1}^* \) process, we can calibrate, solve, and simulate the model as before to generate a model-implied Argentine bond credit spread for the years leading up to the 2001 default episode. Table I-3 outlines the changed calibration parameters and simulation results. Notably, despite the small improvement on the model-implied average credit spread from 3.39% to 3.65%, the observed average Argentine bond credit spread for the same period is 10.25% (Table I-2). The stark contrast in these

\(^{17}\)Refer to Appendix A4 for more details on the adjustments here.
numbers suggest that the low-spread anomaly cannot be resolved by incorporating risk-averse investors who price risk in a way consistent with the market price of risk in the data.

To further check on robustness of this conclusion, we perform robustness model simulations while allowing for potential mis-specifications on the adapted $M_{t+1}^*$ process. The idea is to run model simulations across a wide range of $\rho^M, \eta_M$ and $\bar{M}$ specifications nearby the calibrated one ($\rho^M = 0.710, \eta_M = 0.012$ and $\bar{M} = 0.949$) in Table I-3. We document such checks in Appendix A6; these checks show that our conclusion is robust in a wide neighboring region from the baseline specification.

D. Summary

This chapter sets out with the question of whether the approach of introducing risk-averse investors can resolve the low-spread anomaly in structural sovereign default models, and it answers the question with a No. Upon introducing a risk-averse pricing kernel in a way that does not allow arbitrage in this market, the model achieves very minimal success in reconciling its low-spread anomaly as compared with the data. To improve the model’s asset-pricing performance, we should look elsewhere for theoretical resolutions.
Chapter II.

The Home Bias of Sovereign Borrowing

Existing sovereign finance theories are missing a large piece of the jigsaw puzzle in that they ignore everything about domestic market debt.¹ Notably, domestic debt accounts for an astounding two-thirds of total sovereign borrowing (Reinhart and Rogoff, 2011a),² and yet existing theories remain completely agnostic on this and assume countries only borrow externally (e.g., Eaton and Gersovitz, 1981; Bulow and Rogoff, 1989).³ In this chapter, we aim to address this issue by proposing a novel

¹Domestic market debt is issued under home legal jurisdiction. In most countries, over most of their history, it has been denominated in the local currency and held mainly by residents. On the other hand, external market debt is issued under foreign jurisdictions. It has mainly been denominated in foreign currencies and held by foreign residents. Note that Reinhart and Rogoff (2011a) define domestic and external debts in the same way.

²Unearthing archives from the now-defunct League of Nations, Reinhart and Rogoff (2011a) find that “domestic debt averages almost two-thirds of total public debt” for 64 countries over 1910-2010.

³Earlier literature on sovereign debt and defaults almost all exclusively focus on external sovereign debt. See Eichengreen (1991) and Tomz and Wright (2013) for a quick survey of this research.
sovereign finance theory that incorporates both domestic and external debts.

Incorporating both domestic and external debts into a common framework provokes many interesting questions. What are the relevant trade-offs between domestic and external debts when a sovereign needs financing? How does the “home bias” arise? What is driving the cross-country heterogeneity in it? It is especially intriguing to think about the home bias from a risk-sharing perspective — domestic debt is much less useful than external debt for hedging macroeconomic income risks, and yet governments are borrowing nearly two-thirds of their debts domestically.

To answer these questions, chapter 2 develops a novel general equilibrium model, in which the benevolent government can strategically choose to borrow from domestic or external markets. Under reasonable assumptions and calibrations, the home bias of sovereign borrowing naturally emerges in this model as an equilibrium outcome through the government’s strategic financing behaviors.

We are the first to model a domestic market explicitly apart from an external market in sovereign debt models. To hedge its inter-temporal income risks, the government borrows from households and residing foreigners on the domestic market, whereas it only borrows from non-resident foreigners on the external market. More importantly, the government can choose to default on either market selectively. We base such a set-up on empirical observations, which we discuss more in the next section.

Given this set-up, the government tends to prioritize its borrowing from the do-

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4One implicit assumption here is that the sovereign is free to choose either domestic or external markets to finance its debts. Historically, however, a sovereign sometimes loses this freedom as a result of war resolutions. Analysis in this chapter would not apply in such situations.
mestic market, since the government finds it cheaper, *ceteris paribus*, to borrow domestically than externally. The government, if it had to, prefers an external default than a domestic default as it tries to avoid hurting households.\(^5\) In general equilibrium, all investors realize that and demand lower yields on domestic debt than external debt.

However, the government does not want to borrow *only* from the domestic market because only a limited amount of foreign capital is available for its hedging needs. Most of the domestic debt is borrowing from households, which is merely an internal transfer of wealth that does not improve the country-level budget constraint. If the government needs foreign capital beyond what is available on the domestic market, it accesses the external market for external debt.

By introducing a capital control constraint on foreign investments within the domestic market, the model implies that looser inflow capital controls for a country are associated with a stronger home bias in its sovereign borrowing. In the model, this happens because looser inflow capital controls allow more foreign capital into the domestic market, and hence the government has less need to supplement its hedging needs with external debt. Using a dataset that spans 58 countries over 1996-2010, chapter 2 runs a controlled long-run average regression and shows that this relationship is indeed borne out in the data.

This chapter organizes itself as follows. Section A discusses the empirical grounds

\(^5\)That is, however, not to say that domestic defaults never occur in precedence to external defaults in the model. In fact, under certain conditions, the government in the model would choose domestic defaults over external defaults. This observation is also in line with empirical recounts of historical sovereign defaults in the next section.
for building a theory of selective defaults between two separate debt markets. Section B presents a novel general equilibrium sovereign debt model with two markets and demonstrates how the home bias of sovereign borrowing could arise as an equilibrium outcome in this model. Section C documents empirical evidence supporting the model-implied relationship that looser inflow capital controls for a country are associated with a stronger home bias in its sovereign borrowing. Finally, section D concludes the chapter.

A. Empirical Grounds for A Theory of Selective Defaults

Selective defaults are only meaningful when the appropriate definition is used to define domestic and external market debts. Due to the legal nature of a post-default resolution process, we use the contractual markets of jurisdiction as our definition—that is where the bond contracts are issued and hence under what laws these contracts are governed should later disputes arise. Under this definition, selective

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6For instance, selective defaults are impossible under the citizenship of ownership definition—that is to say, it is practically impossible for the government to selectively default on debts held by foreigners while to repay on debts held by domestic households because foreigners could always sell defaulted bonds to domestic households to retrieve remaining values. Previous works such as Guembel and Sussman (2009), Broner, Martin, and Ventura (2010), Broner and Ventura (2011), and Perez (2015) have repeatedly emphasized this point.

7Besides the markets of jurisdiction definition, other definitions that have been used to distinguish domestic from external debts include currency denominations and citizenship of ownership. See Du and Schreger (2016ab) for examples using the currency denomination definition, and Arslanalp and Tsuda (2014ab) for examples using the ownership citizenship definition. Refer to Panizza (2008) for a discussion on similarities and differences for using different definitions.

8For instance, a U.S. dollar-denominated Argentine bond issued in New York under the U.S. law held by Argentine institutional investors would constitute external market debt for the Argentina
defaults are pragmatically feasible because domestic and external market debts are treated separately according to their respective legal jurisdictions in the case of a default.\(^9\)

Not only are they possible, selective defaults have in fact happened frequently over time. In Figure II-1 at its left panel, we plot summary statistics from a sample of all \textit{de jure} sovereign default episodes (i.e., outright non-payments and involuntary restructuring) across 70 countries over 210 years. 93\% of all sovereign default episodes

---

in the sample are selective (i.e., 14% of domestic only and 79% of external only).\footnote{We also plot summary statistics using a sub-sample over 1960-2010 at the right panel in Figure II-1; the message stays strikingly consistent no matter which time frame we look at within the sample.} Such a high probability is partially driven by improper accounting — we count it as a selective default when a country \textit{explicitly} defaults on its external debt and \textit{implicitly} defaults on its domestic debt via hyper-inflations. To account for \textit{de facto} defaults beyond the \textit{de jure} ones, we plot these summary statistics again in Appendix A7 with additional considerations for hyper-inflations. Despite some changes in numbers, the key idea that selective defaults are frequent phenomena remains compelling across different specifications.

Furthermore, Figure II-1 also shows that external defaults seem much more likely than domestic defaults. Over 1800-2010, 85% of the sovereign defaults involve external markets (i.e., 79% of external only and 6% of twin defaults) while only 20% involve domestic markets (i.e., 14% of domestic only and 6% of twin defaults). To ensure this is not just driven by a few outlier countries but more of a general phenomenon, we plot similar statistics at the country level in Appendix A8 and conclude that external defaults are indeed more likely than domestic defaults across countries. Overall, this suggests that any theory of selective defaults should be able to account for this phenomenon, and fortunately our model is able to achieve this as well.
B. A Sovereign Debt Model with Two Markets

In this section we outline a novel general equilibrium sovereign debt model, in which the benevolent government can strategically choose to borrow from domestic or external markets. We assume that the government borrows from both households and residing foreigners on its domestic market, whereas it borrows only from non-resident foreigners on its external market. The government cannot commit to repay its debts \textit{ex-post} on both markets per Eaton and Gersovitz (1981), but it can choose to selectively default on either market.

\textbf{Households} solve an inter-temporal consumption problem. Their representative agent receives a Markov stochastic stream of endowments \( y_t > 0 \) that follows a transition function \( f(y_{t+1}, y_t) \) and has compact support \( Y \). Its objective is to maximize its expected lifetime utility, and in doing so, it chooses its private goods consumption \( c_t \) in each period, taking public goods consumption \( g_t \) as given.

Formally, households

\[
\max_{\{c_t\}} \sum_{t=0}^{+\infty} \beta^t E_0 \left[ u(c_t, g_t) \right],
\]

subject to their inter-temporal budget constraint that takes shape after the government makes its borrowing and default decisions each period. \( \beta \in (0, 1) \) denotes the households’ subjective period discount factor. \( u(c_t, g_t) \) denotes the households’ period utility function. It takes a standard constant relative risk aversion (CRRA) utility functional form with a constant elasticity of substitution (CES) aggregator

\[
u(C_t) = \frac{C_t^{1-\sigma} - 1}{1 - \sigma} \text{ with } C_t = (s_c c_t^\rho + (1 - s_c) g_t^\rho)^{\frac{1}{\rho}},\]
in which $\sigma$ is the coefficient of risk aversion for households, $s_c$ is the share parameter, and $\rho$ governs the degree of substitutability between private and public goods consumption. $\rho < 1$ so that private and public goods are not perfect substitutes.\footnote{This is a reasonable assumption given the relevant empirical work on public and private consumption substitutability. See, for example, Kwan (2006).}

At the same time, households act as bond investors on the domestic market. They invest by purchasing one-period discount bonds issued by the government within the domestic market. If the government keeps honoring its domestic debt, households’ inter-temporal budget constraint is

$$c_t + q^d_t b^d_{t+1} = b^d_t + y_t (1 - \tau),$$

in which $\tau$ denotes the income tax rate, $b^d_t$ denotes the nominal value of previously purchased bonds households can redeem in period $t$, $b^d_{t+1}$ denotes the nominal value of bonds redeemable next period, and $q^d_t$ denotes the current-period price for each nominal unit of domestic bonds maturing next period.

If the government declares a default on its domestic market, prior domestic bonds are no longer honored, and the government is temporarily excluded from the domestic debt market. In this case, households follow a simple hand-to-mouth budget constraint

$$c_t = y^\text{def}_t (1 - \tau),$$

in which they consume everything from their post-tax endowment income $y^\text{def}_t (1 - \tau)$. $y^\text{def}_t$ denotes the period endowment income during a default; it is assumed to be a
depressed level of \( y_t \), depending on the exact default status on the two markets.

**Foreign investors** reside on both domestic and external markets so they invest on both domestic and external bonds. However, they are subject to a capital control constraint on the domestic market: only a limited entry of foreign investments is allowed into the domestic domain. Formally,

\[
b_{df}^{t+1} \leq \gamma b_{dh}^{t+1}, \forall t,
\]

in which \( b_{df}^{t+1} \) denotes the nominal value of domestic bonds purchased by foreign investors in period \( t \), and \( \gamma \in [0, +\infty) \) governs the degree of domestic capital controls. If \( \gamma = 0 \), the domestic market is completely shut off to foreign investors; if \( \gamma = +\infty \), the domestic market imposes no constraints over foreign investors.

Foreign investors are risk-neutral, and they are willing to borrow or lend as much as they need to, as long as they are compensated with an expected return of the constant international risk-free lending rate \( r_f > 0 \).

With perfect information on the debtor country income process, foreign investors price the defaultable bonds in a risk-neutral manner so that they break even in expected value in every bond contract. However, since domestic and external bonds have different default probabilities, this requires domestic bond prices \( q_t^d \) and external bond prices \( q_t^e \) to separately satisfy

\[
q_t^d \left( 1 + r_f \right) = 1 - \delta_{t+1}^d; \quad q_t^e \left( 1 + r_f \right) = 1 - \delta_{t+1}^e.
\]
in which $\delta_{t+1}^d, \delta_{t+1}^e$ respectively denote the expected probabilities of debtor country default in period $t+1$ on domestic and external markets.

The next-period default risks $\delta_{t+1}^d, \delta_{t+1}^e$ are endogenous to the model. They depend on the government’s incentives to default domestically or externally under different possible $y_{t+1}$ realizations. In equilibrium, they are sums of probabilities for $y_{t+1}$ realizations in the next period, in which the government finds it optimal to default on the respective market. Formally,

$$\delta_{t+1}^d = \int_{DD(b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e)} f(y_{t+1}, y_t) dy_{t+1}; \quad \delta_{t+1}^e = \int_{ED(b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e)} f(y_{t+1}, y_t) dy_{t+1},$$

in which $DD(b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e) \equiv \{y_{t+1} \in Y : \text{government chooses a domestic default}\}$, and $ED(b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e) \equiv \{y_{t+1} \in Y : \text{government chooses an external default}\}$.

The benevolent government solves a strategic borrowing and default problem in this economy. Entering each period, it receives its current-period tax income $\tau y_t$, provides public goods consumption $g_t$ for households, and decides whether to repay on its maturing domestic and external debts ($b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e$). If it does, it continues to borrow by selling bonds with face values ($b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e$) at unit prices of ($q_{t}^d, q_{t}^e$). If not, it declares a default on its domestic debt, or its external debt, or both. Maturing debts within the markets in default are ignored, but no new bonds could be issued in the respective markets. The general inter-temporal budget constraint for the government is $\tau y_t + q_{t}^d (b_{t+1}^{dh} + b_{t+1}^{df}) + q_{t}^e B_{t+1}^e = b_{t}^{dh} + b_{t}^{df} + B_{t}^e + g_t$.

Defaulting on either market has two consequences — temporary financial exclusion

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12 A formal introduction of $DD(b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e)$ and $ED(b_{t+1}^{dh}, b_{t+1}^{df}, B_{t+1}^e)$ are deferred until expositions on the government’s strategic default problem.
and direct output loss. The debtor country loses its access to the respective debt market and only regains access with exogenous probabilities \((\theta^d, \theta^e \in [0,1])\) during each subsequent period. For as long as the debtor country is in default of either market, its output remains at a depressed level \(y^{def}\). Depressed output level \(y^{def}_t\) is assumed to be a concave piecewise linear function with a kink at a variable threshold \(\hat{y}\), depending on specific default status of the debtor country. Formally,

\[
y^{def}_t = \min\{y_t, \hat{y}\},
\]

where

\[
\hat{y} = \begin{cases} 
\omega^e\bar{y}, & \text{if external default only} \\
\omega^d\bar{y}, & \text{if domestic default only} \\
\omega^e\omega^d\bar{y}, & \text{if twin default}
\end{cases}
\]

and \(\bar{y}\) denotes the long-run average of \(y_t\).

Formally, the government’s strategic borrowing and default problem is outlined below. (For brevity of notations, I drop all \(t\)-subscripts and replace \(t+1\) notations with ‘ variables.) Entering each period, the government is maximizing its welfare value function \(V^o(b^{dh}, b^{df}, B^e, y)\) by choosing among repaying all debts \(V^r(b^{dh}, b^{df}, B^e, y)\), defaulting domestically \(V^d(B^e, y)\), defaulting externally \(V^e(b^{dh}, b^{df}, y)\), and defaulting on both markets \(V^b(y)\),

\[
V^o(b^{dh}, b^{df}, B^e, y) = \max_{V^r, V^d, V^e, V^b} \{V^r(b^{dh}, b^{df}, B^e, y), V^d(B^e, y), V^e(b^{dh}, b^{df}, y), V^b(y)\}.
\]
Specifically, the value function of repaying all debts $V^r(b^{dh}, b^{df}, B^e, y)$ is

$$V^r(b^{dh}, b^{df}, B^e, y) = \max_{b^{dh'}, b^{df'}, B^e'} \left\{ u(C) + \beta \int_{y'} V^o(b^{dh'}, b^{df'}, B^e', y') f(y', y) dy' \right\}. $$

The value function of being in domestic default $V^d(B^e, y)$ is

$$V^d(B^e, y) = \max_{B^e'} \left\{ u(C) + \beta \int_{y'} \left[ \theta^d V^o(0, 0, B^e', y') 
+ (1 - \theta^d) \max_{V^d, V^b} \left\{ V^d(B^e', y'), V^b(y') \right\} \right] f(y', y) dy' \right\}. $$

The value function of being in external default $V^e(b^{dh}, b^{df}, y)$ is

$$V^e(b^{dh}, b^{df}, y) = \max_{b^{dh'}, b^{df'}} \left\{ u(C) + \beta \int_{y'} \left[ \theta^e V^o(b^{dh'}, b^{df'}, 0, y') 
+ (1 - \theta^e) \max_{V^e, V^b} \left\{ V^e(b^{dh'}, b^{df'}, y'), V^b(y') \right\} \right] f(y', y) dy' \right\}. $$

The value function of being in default on both markets $V^b(y)$ is

$$V^b(y) = u(C) + \beta \int_{y'} \left[ \theta^d \theta^e V^o(0, 0, 0, y') + \theta^d (1 - \theta^e) V^e(0, 0, y') 
+ (1 - \theta^d) \theta^e V^d(0, y') + (1 - \theta^d)(1 - \theta^e) V^b(y') \right] f(y', y) dy'. $$

The choices among $V^r, V^d, V^e, V^b$ constitute the government’s default policy sets for the domestic market ($DD(b^{dh}, b^{df}, B^e)$) and the external market ($ED(b^{dh}, b^{df}, B^e)$).

Formally,

$$DD(b^{dh}, b^{df}, B^e) \equiv \{ y \in Y : \max \{ V^r, V^d, V^e, V^b \} \in \{ V^d, V^b \} \}, $$
and
\[ ED(b^{dh}, b^{df}, B^e) \equiv \{ y \in Y : \max\{ V^r, V^d, V^e, V^b \} \in \{ V^e, V^b \} \}. \]

With the households, the foreign investors, and the government in place, we now define the recursive equilibrium in this economy.

**Definition.** The recursive equilibrium in this economy is formally defined as the policy functions/sets \( \{ c_t \}_{t=0}^{+\infty}, \{ g_t \}_{t=0}^{+\infty}, DD(b^{dh}, b^{df}, B^e), ED(b^{dh}, b^{df}, B^e), \{ b_{t+1}^{dh} \}_{t=0}^{+\infty}, \{ b_{t+1}^{df} \}_{t=0}^{+\infty}, \{ B_{t+1}^e \}_{t=0}^{+\infty} \), and market prices \( \{ q_t^d \}_{t=0}^{+\infty}, \{ q_t^e \}_{t=0}^{+\infty} \) such that

1. households maximize their expected lifetime utility subject to their budget constraint, taking as given the government default policies and public goods provisions;

2. the government default policies and borrowing choices satisfy its optimization problem, taking as given the endogenous prices for both domestic and external bonds issued;

3. endogenous bond prices reflect corresponding default probabilities in respective market, and are consistent with foreign investors’ expected zero profits condition;

4. domestic market bond holdings between households and residing foreigners satisfy the capital control constraint,

Taking as given the stochastic endowment process \( \{ y_t \}_{t=0}^{+\infty} \).

To demonstrate how a home bias of sovereign borrowing can arise as an equilibrium outcome in the model, we computationally solve for equilibrium solutions using a
counterfactual calibration. The goal of this calibration is not to match to any specific economy; instead, it is meant to show how the “home bias” of sovereign borrowing can occur in such a model under reasonable assumptions and calibrations to that of a “typical” emerging market economy.

Table II-1: Model Counterfactual Calibration Parameters

<table>
<thead>
<tr>
<th>Variables</th>
<th>Calibration</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta = 0.98$</td>
<td>assumption</td>
</tr>
<tr>
<td>HH risk aversion</td>
<td>$\sigma = 2$</td>
<td>assumption</td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td>$\rho = 0.6$</td>
<td>assumption</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>$r^{f} = 1.23%$</td>
<td>quarterly yield of 5% per annum</td>
</tr>
<tr>
<td>HH income tax rate</td>
<td>$\tau = 0.3$</td>
<td>assumption</td>
</tr>
<tr>
<td>Depressed output</td>
<td>$\omega^{e} = 0.97, \omega^{d} = 0.91$</td>
<td>Reinhart and Rogoff (2011b)</td>
</tr>
<tr>
<td>Prob. of re-entry</td>
<td>$\theta^{e} = 5%, \theta^{d} = 13%$</td>
<td>Reinhart and Rogoff (2011b)</td>
</tr>
<tr>
<td>Capital control tightness</td>
<td>$\gamma = 0.3$</td>
<td>assumption</td>
</tr>
<tr>
<td>Stochastic process for $y_t$</td>
<td>log AR(1)</td>
<td>Arellano (2008)</td>
</tr>
</tbody>
</table>

Table II-1 outlines all parameters for the counterfactual calibration. Using this set of calibration parameters, I computationally solve for the recursive equilibrium using standard value function iterations\(^{13}\) on discretized grids. In Figure II-2, we plot the numerical equilibrium solutions for discount bond prices on both markets at mean output level $\bar{y}$, while assuming debt levels on the other market are zero. Intuitively, this is shutting off one debt market while relying on the other so that we can compare domestic and external market debt in a ceteris paribus manner.

Figure II-2 demonstrates two desirable features of the model equilibrium in tandem. First, external defaults are more likely than domestic defaults at equilibrium, which is seen from $q^{e}$ “dipping” earlier than $q^{d}$ in the plot. At $B < 0.02$, $q^{d}$ and $q^{e}$

\(^{13}\)See Appendix A9 for details on the solution algorithm.
both plateau at $\frac{1}{1+r_f}$ since there is no perceivable default risk yet on both markets at such low levels of debt. However, at $0.02 < B < 0.028$, more debt is borrowed on both markets, and $q^e$ tanks to reflect the increased default risk while $q^d$ still plateaus at $\frac{1}{1+r_f}$. In fact, at any point within $0.02 < B < 0.045$, external default risk is always higher than domestic default risk for a given debt level. This corresponds well with earlier empirical observation in that external defaults are historically more likely than domestic defaults for a given country.

Second, domestic debt is always cheaper — if not equal — to borrow than external
debt when borrowing an *identical* amount of debt on either market. At all debt levels in the plot, $q^e$ has always been beneath — if not equal to — $q^d$, and this means the cost of borrowing for a given amount of debt is lower on the domestic market than the external market, *ceteris paribus*. As the government prioritizes domestic debt to lower its costs of financing, the model generates the observed “home bias” in sovereign borrowing.

### C. Relationship between Capital Control Measures and Home Bias of Sovereign Borrowing

The model implies a relationship between a country’s capital control measures and its home bias of sovereign borrowing through the constraint $b_{df}^{t+1} \leq \gamma b_{dh}^{t+1}$. In the model, a higher $\gamma$ allows more foreign capital $b_{df}^{t+1}$ on the domestic market, and hence the government has less need to supplement its hedging needs with external debt. As a result, the degree of home bias in sovereign borrowing is stronger. But empirically, is this borne out in the data?

To test out this relationship in the data, we compile a cross-country dataset that spans 58 countries over 1996-2010 and run a multivariate cross-sectional regression using long-run averages.\(^{14}\) We formally specify the regression below, and summarize

\(^{14}\)Alternatively we could have run a panel regression using this dataset. However, it would largely be the same as a cross-sectional regression using long-run averages. This is because capital control measures are rarely changing over years for most countries and the panel regression would have
its full results in Table II-2. As a quick preview, these results show that looser inflow capital control measures on the domestic market are indeed associated with a stronger home bias in the sovereign borrowing of a country.

**Specification** (Multivariate Cross-country Test using Long-run Averages).

\[
\overline{dShare_i} = \beta_0 + \beta_c \overline{netInflow_i} + X_i + \mu_i,
\]

in which \(i\) denotes a country, \(\overline{dShare_i}\) measures its degree of home bias in sovereign borrowing, \(\overline{netInflow_i}\) measures its degree of financial openness to net capital inflows on the domestic market, and \(X_i\) denotes all other controls including the rule of law index, the total sovereign debt to GDP ratio, the real gross domestic product, the real GDP per capita, the gross savings to GDP ratio, the annualized inflation rate, the current account balance to GDP ratio and the annualized average GDP growth.

We construct the degree of home bias \(\overline{dShare_i}\) using the sample average of annual domestic/total debt shares for country \(i\) over 1996-2010, adjusted into a common currency of US dollars. Formally,

\[
\overline{dShare_i} = \frac{1}{T} \sum_{t}^{T} \frac{\text{country } i\text{'s outstanding domestic debt in } \$\text{ at year } t}{\text{country } i\text{'s outstanding total debt in } \$\text{ at year } t}.
\]

To construct these domestic debt shares, we use data from Reinhart and Rogoff (2011a), cross checked and supplemented with data from Cowan et al (2006), Guscina and Jeanne (2006), and Panizza (2008).

almost no intra-country inter-temporal variations in its independent variable.
Table II-2: Regressions of Domestic Debt Shares on netInflow Openness

<table>
<thead>
<tr>
<th>Variables</th>
<th>domestic Debt/total Debt</th>
<th>netInflow</th>
<th>Rule Of Law</th>
<th>Constant</th>
<th>total Debt/GDP</th>
<th>GDP</th>
<th>GDP/capita</th>
<th>gross savings/GDP</th>
<th>inflation</th>
<th>current account/GDP</th>
<th>GDP growth</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>0.052**</td>
<td>0.164***</td>
<td>0.215</td>
<td>0.955</td>
<td>12.493</td>
<td>1.359</td>
<td>1.321***</td>
<td>−0.516</td>
<td>−1.334</td>
<td>−0.303</td>
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<td></td>
<td></td>
<td>(0.024)</td>
<td>(0.044)</td>
<td>(0.169)</td>
<td>(0.068)</td>
<td>(2.350)</td>
<td>(2.536)</td>
<td>(0.616)</td>
<td>(0.536)</td>
<td>(0.931)</td>
<td>(0.778)</td>
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<td></td>
<td></td>
<td>0.058***</td>
<td>0.208***</td>
<td>0.403***</td>
<td>2.496</td>
<td>24.96</td>
<td>9.244***</td>
<td>2.297***</td>
<td>−1.397**</td>
<td>−3.102***</td>
<td>−0.628</td>
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<td></td>
<td></td>
<td>(0.021)</td>
<td>(0.017)</td>
<td>(0.068)</td>
<td>(8.352)</td>
<td>(1.442)</td>
<td>(1.442)</td>
<td>(0.646)</td>
<td>(0.618)</td>
<td>(0.871)</td>
<td>(0.956)</td>
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<tr>
<td></td>
<td></td>
<td>0.059**</td>
<td>0.059**</td>
<td>−0.032</td>
<td>0.095</td>
<td></td>
<td>9.566***</td>
<td>2.126***</td>
<td>−1.038***</td>
<td>−2.956***</td>
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<td></td>
<td></td>
<td>(0.029)</td>
<td>(0.028)</td>
<td>(0.166)</td>
<td>(0.068)</td>
<td></td>
<td>(1.360)</td>
<td>(0.649)</td>
<td>(0.323)</td>
<td>(0.866)</td>
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<td></td>
<td></td>
<td>0.061**</td>
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<td>−0.029</td>
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<tr>
<td>$R^2$</td>
<td></td>
<td>0.727</td>
<td>0.691</td>
<td>0.647</td>
<td>0.644</td>
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<tr>
<td>$F$</td>
<td></td>
<td>24.11</td>
<td>62.27</td>
<td>19.16</td>
<td>25.47</td>
<td></td>
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<tr>
<td>Prob. &gt; $F$</td>
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<td>0.000</td>
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</table>

Notes: All ratios (including inflation and GDP growth) are in decimals. All variables for each country are inter-temporal averages over 1996-2010, in which inflation, GDP growth are computed using annualized averages while the rest are simple arithmetic means. All GDP data are deflated to 2010 US$, in which GDP are in quadrillions US$ while GDP/capita are in millions US$. Robust standard errors are reported in parentheses below the coefficient estimates; * is significant at 10%, ** is significant at 5% and *** is significant at 1%.

We construct the financial openness index $\text{netInflow}_i$ using more primitive restriction indices developed by FKRSU-2016 (Fernandez, Klein, Rebucci, Schindler & Uribe, 2016). To develop quantitative measures on capital control policies, they encode textual policy descriptions from IMF AREAER reports into numeric indices

15This paper has a few earlier editions in the same spirit including Schindler (2009), Klein (2012), and Fernandez, Klein & Uribe (2015).

16IMF AREAER (i.e., International Monetary Fund Annual Report on Exchange Arrangements and Exchange Restrictions) reports are frequently used as primary sources of capital control policies.
\[ \in [0,1] \text{ that measure capital control restriction intensities on both inflows and outflows of different cross-border transaction types. To construct } \overline{\text{netInflow}}_i, \text{ we use average financial openness for capital inflows less average financial openness for capital outflows, specifically on money market transactions, bond transactions, derivative investments transactions, and financial credit transactions.}^{17} \]

Formally,

\[ \overline{\text{netInflow}}_i = \frac{1}{T} \sum_T \text{inflow}_{i,t} - \frac{1}{T} \sum_T \text{outflow}_{i,t}, \]

in which \( i, t \) denotes a country-year, \( \text{inflow}_{i,t} = \frac{1}{4}[(1 - mmi_{i,t}) + (1 - boi_{i,t}) + (1 - dei_{i,t}) + (1 - fci_{i,t})], \)

\( \text{outflow}_{i,t} = \frac{1}{4}[(1 - mmo_{i,t}) + (1 - boo_{i,t}) + (1 - deo_{i,t}) + (1 - fco_{i,t})], \)

and \( mmi_{i,t}, mmo_{i,t}, boi_{i,t}, boo_{i,t}, dei_{i,t}, deo_{i,t}, fci_{i,t}, fco_{i,t} \) are primitive restriction indices on specific transaction type inflows/outflows taken from FKRSU-2016.\(^{18} \)

Among all other controls we include a rule of law index that is taken from the Worldwide Governance Indicators. It is included to control for heterogeneity in home bias of sovereign borrowing that arises directly from differences in legal environments between home and abroad. All macroeconomic controls are constructed using data from IMF WEO database.\(^{19} \) These are in place to account for cross-country differ-

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\(^{17}\)These transaction categories are specifically chosen so that they cover all potential methods of foreign investments on domestic sovereign bonds. This is because foreign investors residing domestically could potentially invest on domestic sovereign bonds through money market instruments, directly on bonds, indirectly through derivatives, or borrowing from banks to invest.

\(^{18}\)Specifically, \( mmi_{i,t}, mmo_{i,t} \) are on money market investment inflows/outflows, \( boi_{i,t}, boo_{i,t} \) are on bond investment inflows/outflows, \( dei_{i,t}, deo_{i,t} \) are on derivative investment inflows/outflows, and \( fci_{i,t}, fco_{i,t} \) are on financial credit inflows/outflows.

\(^{19}\)We use the October 2016 version of IMF WEO database (i.e., International Monetary Fund World Economic Outlook).
ences in macroeconomic conditions.

According to the model, we expect $\beta_c$ in the regression to be positive. Table II-2 display $\hat{\beta}_c$ estimates in bold at the first row from the top, and they are indeed positive and statistically significant. Across different columns in Table II-2, we also run slightly different specifications of the baseline regression. This is to sanity-check on robustness of the regression results conditioning on including different controls in the regressions. Overall, the relationship that looser inflow capital control measures are associated with stronger home biases remains present and statistically significant across different specifications.

D. Summary

This chapter sets out with the goal of incorporating domestic debt into sovereign finance theories. In doing so, it proposes a novel general equilibrium sovereign debt model, in which the benevolent government can strategically choose to borrow from the domestic or external markets. Under reasonable assumptions and calibrations, the observed home bias of sovereign borrowing naturally emerges in the model as an equilibrium outcome through the government’s strategic financing behaviors. Finally, this chapter also presents some cross-country evidence for the model-implied relationship that looser inflow capital control measures for a country are associated with a stronger home bias in its sovereign borrowing.
Chapter III.

The Financial Channel of

Economic Agglomeration

Economic activities tend to agglomerate in space.¹ For instance, nearly a third of all U.S. economic activities take place within merely 1% of total land area in the country.² How does economic agglomeration arise in those areas?³ An understanding of underlying economic forces is crucial because it can guide developments and growths elsewhere.

¹We map economic activities using locations of firms/establishments as in Ellison, Glaeser, and Kerr (2010). Others, such as Davis and Weinstein (2002) and Gabaix et al. (2011), have used the spatial distribution of the population.

²The 100 densest counties by the number of establishments per unit land area accounts for 32% of all establishments in the U.S. economy and 1% of total land area in the country. The U.S. Census Bureau defines an establishment as “a single physical location where business is conducted or where services or industrial operations are performed.” See Appendix A10 for a map of U.S. economic density at the county-level.

³While natural advantages and random chances partly contribute to the economic prosperity in those areas, they hardly represent the whole story (Ellison and Glaeser, 1997, 1999; Duranton and Oveman, 2005). In this case, “natural advantages” are defined broadly as in Ellison and Glaeser (1999). One example is the relatively low electricity prices in Washington as a “natural advantage” for economic productions.
Traditionally, urban economists interpret economic agglomeration as an outcome of firms choosing to locate near each other, because doing so begets increasing returns to scale in their productions.\textsuperscript{4} To explain economic agglomeration, these theories show that firms would endogenously choose to move near each other in a spatial equilibrium, when production factors (especially labor) are perfectly mobile (Glaeser and Gottlieb, 2009). However, sometimes moving costs, in reality, are likely so large that any mobility becomes impossible to achieve.\textsuperscript{5}

Alternatively, chapter 3 explores the possibility of explaining economic agglomeration from a novel financial perspective — the financial channel of economic agglomeration. The basic idea posits that firms would more likely emerge together near banks due to less stringent financial frictions in obtaining bank loans, and firms subsequently agglomerate in these areas as they grow over time.\textsuperscript{6}

\textsuperscript{4}Such increasing returns could come from savings in trade costs (e.g., Krugman, 1991b; Allen and Arkolakis, 2014), labor-market pooling (e.g., Krugman 1991a; Strange et al., 2006), or knowledge spillovers (e.g., Duranton and Puga, 2001; Davis and Dingles, 2019). The original ideas of savings in trade costs, labor-market pooling, and knowledge spillovers all date back to Marshall (1890, 1920), and all three theories have considerable empirical support (Ellison, Glaeser and Kerr, 2010). Other important earlier works about savings in trade costs include Fujita, Krugman and Venables (1999); works about labor-market pooling include Diamond and Simon (1990), Helsley and Strange (1990), Costa and Kahn (2000), Fallick, Fleischman and Rebitzer (2006), Freedman (2008); works about knowledge spillovers include Glaeser et al (1992), Audretsch and Feldman (1996), Glaeser and Mare (2001), Lucas (2001), Berliant, Peng and Wang (2002), Henderson (2003), Helsley and Strange (2004), Moretti (2004), Berliant, Reed III and Wang (2006), and Freedman (2008). See Glaeser and Gottlieb (2009) for a quick tour of the intellectual lineage, and Duranton and Puga (2004), Moretti (2011) for more surveys of the related literature.

\textsuperscript{5}Rauch (1993) has theoretically demonstrated how strategic complementarity could create a first-mover disadvantage that prevents any relocation of firms. A recent strand of empirical literature (Bryan, Chowdhury and Mobarak, 2014; Chetty, Hendren and Katz, 2016; Munshi and Rosenzweig, 2016; Nakamura and Steinsson, 2018; Bryan and Morten, forthcoming) looks at economic consequences of moving for people and concludes that moving costs — arising from informational, cultural, legal, and economic barriers — of labor must be so substantial that people are often “stuck” in locations that do not fully realize their economic potentials.

\textsuperscript{6}Duranton and Kerr (2015) are the first to discuss financial frictions being potentially important for understanding economic agglomeration.
Such a channel is theoretically feasible, given what we have learned from existing research. First, firms could indeed more likely emerge due to less stringent financial frictions because entrepreneurship requires external financing, and the ability to borrow is vital for firm formations (Evans and Jovanovic, 1989). Second, financial frictions could be less stringent near banks because a shorter borrower-lender distance does improve lending terms in bank loans (Mian, 2006; Bolton et al, 2016). And third, frictions in obtaining bank loans could really matter because the average U.S. firm heavily relies on bank loans for external financing (Peterson and Rajan, 2002).

However, whether such a channel exists in the data is a difficult empirical question. Merely observing more firms locate near banks in the cross-section is insufficient for at least two reasons. First, there could be omitted variable biases in that firms and banks can collocate for reasons unrelated to borrowing and lending (Fujita and Mori, 1996; Ellison and Glaeser, 1999; Davis and Weinstein, 2002). Second, there could be reverse causality in that banks posteriorly locate themselves in places where firms already agglomerate.

To show that a bank can indeed cause firms to agglomerate in its proximity by easing their financial frictions, chapter 3 designs a natural experiment by exploiting

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7The distance effects could come from a variety of microeconomic mechanisms, such as less costly monitoring (Rajan, 1992; Von Thadden, 1995), better information acquisition (Agarwal and Hauswald, 2010; Puri et al., 2010), and less severe principal-agent problem (Stein, 2002).

8See Appendix A10 for a cross-sectional plot observing more firms locate near banks.

9Historical narratives have also emphasized the importance of inherent natural advantages in the rise of well-known metropolises such as New York City, Chicago, and Pittsburgh. See Albion (1938) and Cronon (1991) for more details.

10Anecdotal evidence suggests that banks indeed relocate themselves to “chase the crowd.” See, for example, “Bank of Commerce Holdings Announces Relocation of Headquarters” (Globe Newswire, 2017a) and “First U.S. Bancshares, Inc. Announces Relocation of Headquarters to Birmingham” (Globe Newswire, 2017b).
the sudden location change on the target bank after each banking merger — in that the target bank suddenly “relocates” (through merging) to the acquiring bank. The intuition is to see what a quasi-exogenous relocation of a bank closer to a region does to the region’s total loan supplies and subsequent establishment growths. A standard difference-in-difference (Diff-in-Diff) approach shows that relocation of a bank closer to a region indeed causes more supply of bank loans in that region, and subsequently causes more firm establishments to emerge and agglomerate within the same area.11

Two major identifying assumptions have to hold for this strategy to be successful. First, absent the treatment, outcomes at the “treated” regions would evolve similarly as those of the “control” regions, and one necessary condition for this assumption to hold is the so-called “parallel pre-trend” — trends in outcome variables between the two groups are parallel at least before the treatment. We can validate this condition using our data. Second, no other shocks are happening at the same time of treatment that could potentially affect the outcome variables. To alleviate this concern, we include additional controls to proxy for such shocks in our regression specifications.

This chapter organizes itself as follows. Section A discusses the identification strategy in detail. Section B briefly outlines the data sources we use as well as the sample construction process. Section C formally spells out the Diff-in-Diff specification. Section D validates the parallel pre-trend condition. Section E presents the full set of regression results. Finally, section F concludes the chapter.

11 Guiso, Sapienza, and Zingales (2004) study how having nearby banks could help local economic growth through promoting entrepreneurship in Italy. In some way, this chapter studies an analog of that question in the context of the U.S.
A. Identification Strategy

To identify if a bank can indeed cause firms to agglomerate within its proximity by easing their financial frictions in obtaining loans, we design a natural experiment that resembles a hypothetical randomized controlled trial. In such a trial, we would first want to exogenously move a bank closer to or away from its lending areas while controlling for other factors, and then examine consequences on total loan supplies and subsequent firm/establishment growths within the same areas.

Correspondingly, the natural experiment generates a quasi-exogenous bank relocation, by exploiting the sudden location change of the target bank after a banking merger. As the target bank suddenly “relocates” (through merging) to the acquiring bank, we examine loan and firm/establishment outcome changes within the target bank lending areas, which can become closer to or farther away from the bank after the merger. To maximally control for other factors during this process, we develop a procedure that carefully isolates the “relocation shock” from other things happening at the same time as the merger. To do so, we proceed in three steps.

First, we compile a list of large-scale banking mergers over 1998-2015 as events generating the relocation shocks, in which each merger gives us one natural experiment.\textsuperscript{12} In this case, large-scale banking mergers are those with individual pre-merger total assets above $1 billion from both merging banks. We only look at these mergers to reduce concerns of reverse causality — since it is unlikely that local loan and firm/establishment outcome changes are driving merger decisions in deals of such

\textsuperscript{12}We perform repeated natural experiments using a pooled sample, as in Greenstone, Hornbeck, and Moretti (2010).
sizes. This tactic has been used by Nguyen (2019) to alleviate reverse causality concerns.

Second, we sample all de novo counties associated with each merger and use each county as a controlled environment, in which we later examine outcomes of different ZIP-code areas. We define de novo counties as counties in which only the target bank (out of the merging banks) had full-service deposit-taking branches before the merger.\(^{13}\) In these counties, the merger does not create market structure changes in the local banking markets.\(^{14}\) Furthermore, regulations keep existing target bank branches intact after the merger. These features help us maximally control for other things happening at the same time as the merger within the natural experiment.\(^{15}\)

Finally, within each de novo county from the sample, we examine total bank loan originations and firm/establishment growths across different ZIP-code areas. We use a Census-defined ZIP Code Tabulation Area (ZCTA) as a unit of observation for ZIP-code areas,\(^{16}\) and we coarsely define a ZCTA as a lending area for a bank if the bank has full-service deposit-taking branches within the ZCTA. Following these definitions, we consider the target bank lending ZCTAs within each de novo county.

\(^{13}\)We name these counties as “de novo” from the perspective of the acquirer because it is through a particular merger the acquiring bank first enters these counties. In Appendix A11, we illustrate the concept of de novo counties using an example.

\(^{14}\)In local banking markets within these counties, no consolidation occurs as the acquiring bank takes the place of the target bank after the merger. In other counties where both the target and the acquiring banks were present before the merger, consolidation occurs, and the acquiring bank has a much higher market power after the merger.

\(^{15}\)U.S. regulations require that all merging banks commit to maintain existing services at communities which the non-surviving bank has previously provided. In de novo counties, the acquiring bank typically maintains the target bank’s existing branches together with all their prior services and local banking relationships. In other counties, branch closures frequently occur after the merger if the acquiring bank already has incumbent branches before the merger.

\(^{16}\)A ZIP Code Tabulation Area (ZCTA) is a collection of contiguous Census blocks that consolidate nearby areas of similar ZIP codes.
as the “treated” areas and all other ZCTAs as the “control” areas in the natural experiment.

Using a standard difference-in-difference (Diff-in-Diff) approach to compare outcomes across “treated” and “control” ZCTAs before and after each merger, we can then identify if a quasi-exogenous relocation of a bank indeed affects total loan supplies and firm/establishment growths within its lending area. We use strong fixed effects to ensure we only compare across ZCTAs within each de novo county from a particular merger. We discuss the formal regression specification in a later section.

B. Data Sources and Sample Construction

To carry out the identification strategy outlined above, we need several sources of information on the U.S., including data on banking mergers, data on bank branch spatial networks, disaggregate data on total bank loan originations by region, and disaggregate data on establishment growths by region.

Information on U.S. banking mergers is available from the Mergers and Acquisitions dataset by the Federal Reserve Bank of Chicago (FRB Chicago) through the National Information Center (NIC). Per U.S. banking regulations, all mergers have to be reported to and approved by the Federal Reserve System. As such, this dataset contains information “that can be used to identify all bank and bank holding company (BHC) acquisitions and mergers that have occurred since 1976” (FRB Chicago). Merging it with the standard Call Reports at the bank-level, we can then shortlist all U.S. banking mergers from 1998 - 2015 that have pre-merger individual total assets
above $1 billion. We start from 1998 in our sample because the Riegle-Neal Act that enables complete inter-state banking mergers only went into effect in June 1997.

Geospatial information on bank-branch networks comes from the Summary of Deposits (SOD) dataset compiled by the Federal Deposit Insurance Corporation (FDIC). The SOD is, per the FDIC websites, “[a required] annual survey of branch office deposits as of June 30 for all FDIC-insured institutions, including insured U.S. branches of foreign banks.” In other words, we can use it to locate all full-service deposit-taking branches of any commercial bank to the ZIP-code level. This information is crucial for sampling de novo counties as well as designating “treated” and “control” ZCTAs within each county.

Disaggregate data on total bank loan originations by region are available at the Federal Financial Institutions Examination Council (FFIEC) through the Community Reinvestment Act (CRA) enacted in 1977. Per CRA regulatory requirements, all U.S. commercial banks above a threshold in total assets are required to report their annual business loan originations to FFIEC for compliance assessments.\footnote{This threshold is approximately $1 billion and it is slightly adjusted every year to account for general inflations. In 2010, “the asset size threshold that triggers data collection and reporting for all agencies is $1.098 billion as of December 31 of each of the prior two calendar years” (FFIEC).} Aggregating this information across banks, the FFIEC creates a dataset at the Census-tract level, and it contains annual total bank loan originations (in both quantities and dollar amounts) to all firms having less than $1 million annual revenues within a Census-tract.

Disaggregate data on establishment growths by region are from the County Business Patterns (CBP) dataset developed from the Longitudinal Business Data (LBD) database by the U.S. Census Bureau. It contains establishment-level information on
employment counts, payroll amounts, industry classification, and ZIP codes.

In our regression specification, we also include other controls on natural geographies (i.e., local weather and land cover information) and demographic characteristics (i.e., population size, urban ratio, household income level, labor force participation ratio, and housing vacancy ratio). These controls are in place so that we can eliminate regional heterogeneities in total bank loan supplies and subsequent establishment growths that are coming from natural advantages.

Data on natural geographies are from the National Land Cover Database (NLCD) and the PRISM Climate Database (PRISM CD). The NLCD provides a Census-tract level land area together with a characterizing vector of proportions for different land cover types (e.g., open water and grassland) once every five years (i.e., 2001, 2006, and 2011). The PRISM CD provides a county-level mean and standard deviation of year-round precipitations and temperatures once every year. Data on demographic characteristics are from the decennial U.S. Census of 1990, 2000, and 2010, and they contain information on essential demographics at the ZIP-code level.

While merging different datasets outlined above, we have to deal with different geographic units and time frequencies frequently. We use the 2010 Reference Files published by the U.S. Census Bureau to map across different geographic units (e.g., from Census-tracts to ZCTAs, and vice versa). To match across different time frequencies (e.g., matching decennial Census data to annual establishment counts data), we use the last updated observation from datasets with lower time frequencies to fill gaps in datasets with higher time frequencies until the next available value — for example, we use 2000 Census observation for 2000-2009 and use 2010 Census obser-
vation for 2010 and above in our constructed sample.

<table>
<thead>
<tr>
<th>Table III-1: Sample Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of States</td>
</tr>
<tr>
<td>No. of Counties</td>
</tr>
<tr>
<td>%. of Treated ZCTAs</td>
</tr>
<tr>
<td>No. of Mergers</td>
</tr>
<tr>
<td>No. of ZCTA-Year Observations</td>
</tr>
</tbody>
</table>

Upon merging different datasets, we obtain a pooled cross-sectional sample of de novo counties together with their respective “treated” and “control” ZCTAs from 1998-2015. Table III-1 presents the sample summary statistics. The sample seems reasonably representative of the U.S. economic landscape as it spans a wide range of geographic locations in the country.

C. Diff-in-Diff Regression Specification

We employ a continuous treatment Diff-in-Diff regression specification using the “relocation distance” \(\Delta \text{distance}_i\) as the treatment intensity for a “treated” ZCTA \(i\). Formally,

\[
\Delta \text{distance}_i = \text{distance}(ZCTA \ i, \text{acquiring bank}) - \text{distance}(ZCTA \ i, \text{target bank}),
\]

in which \(\text{distance}(A, B)\) denotes the great-circle distance between locations of A and B. Intuitively, \(\Delta \text{distance}_i > 0\) means the target bank has “relocated” farther away
from its lending ZCTA \( i \) after the merger. For “control” ZCTAs within each de novo county, \( \Delta distance_i \equiv 0 \).

Also, we include a “size shock” (\( \Delta size_i \)) as an additional control in the specification, because the target bank has not only “relocated” but also become much bigger in size due to the merger. Intuitively, this is to control for any “size” effects on lending that are not directly coming from \( \Delta distance_i \). Formally, \( \Delta size_i \) denotes the increase in total assets on the target bank associated with the “treated” ZCTA \( i \). Again, for “control” ZCTAs, \( \Delta size_i \equiv 0 \).

We run regressions of total bank loan originations (in $) and log(establishment counts) in turn using the following specification. Formally,

\[
y_{i,t} = \pi_0 + \pi_1 \cdot Post_t + \pi_2 \cdot \Delta distance_i \\
+ \beta \cdot \Delta distance_i \times Post_t + \pi_3 \cdot \Delta size_i + \pi_4 \cdot \Delta size_i \times Post_t \\
+ \Pi_c \times X_{i,t} + \Gamma + e_{i,t},
\]

in which \( y_{i,t} \) denotes the outcome variables of interest, \( Post_t \) denotes a dummy variable that equals 1 if the observation is post-merger and 0 if it is pre-merger, \( X_{i,t} \) denotes controls on natural geographies and demographic characteristics, and \( \Gamma \) denotes Merger \( \times \) County fixed effects. The key coefficient of interest is \( \beta \). In light of the financial channel of economic agglomeration, we expect its estimate to be negative.

In this specification, \( X_{i,t} \) and \( \Gamma \) tremendously alleviate concerns from other factors that could potentially bias our estimates of \( \beta \). \( X_{i,t} \) include both natural ge-
ographies (i.e., total land area, land cover types, mean and standard deviation of year-round temperatures and precipitations) and demographic characteristics (i.e., \(\ln(population)\), urban ratio, household income levels, labor force ratio, and housing vacancy ratio). In addition, the fixed effects \(\Gamma\) can soak up all unobserved heterogeneities across different merger-county pairs. Intuitively, this means the variation this regression uses only comes from within-merger within-county comparisons across differentially affected ZCTAs.

D. Identifying Assumption — The Parallel Pre-trend

We check if the “parallel pre-trend” condition holds in our sample using two approaches. In the first approach, we perform a visual check by plotting simple cross-sectional averages of total bank loan originations and establishment count growths over time between the “control” group and the “treated” group with \(\Delta distance_i > 0\). In the second approach, we run a lead-lag version of the discrete treatment Diff-in-Diff regression using all observations with \(\Delta distance_i > 0\) as the treated group, and then examine coefficient estimates before the lead and lag dummies.

Both approaches require long time series data. Since such data are not available for the entire sample, we construct a constant sub-sample of observations with at

\(^{18}\text{Recall that it is possible for the target bank to “relocate” closer to its lending ZCTA, and hence it is possible to have } \Delta distance_i < 0. \text{ For the purpose of checking the “parallel pre-trend”, we drop observations with } \Delta distance_i < 0, \text{ and they only represent about 3% of the entire sample.}\)
Figure III-1: Parallel Pre-Trend in Bank Loan Originations

Pre-Trend Analysis in Loan Originations
(using constant sub-sample with at least 10 years' data)

Lead & Lag Diff-in-Diff in Loan Originations
Figure III-2: Parallel Pre-Trend in Establishment Count Growth

Pre-Trend Analysis in Establishments’ Growth
(Using constant sub-sample with at least 10 years' data)

Lead & Lag Diff-in-Diff in Establishments’ Growth

53
least 10 years of data (i.e., 7 years before the merger and 3 years after the merger). Using the constant sub-sample, we perform the parallel pre-trend analyses using the two approaches outlined above.

We plot the analysis results for total bank loan originations and establishment count growths in Figure III-1 and III-2. In top panels of the figures, we do the visual check of group averages by normalizing the “control” to match against the “treated” as a counterfactual benchmark of comparison. There is a clear parallel pre-trend between “treated” and “control” groups before the treatment year, which is defined as $t = 0$. In bottom panels of the two figures, we present $\beta$ estimates together with their 95% confidence interval bands from the lead-lag regressions (using -2 as the base year). These estimates show that there are no significant differences between the two groups before treatment, and it is only after $t = 0$ we then start to see significant differences between the two groups.

Overall, there is a clear parallel pre-trend in our sample. This tremendously boosts our confidence in our identified effects being truly causal.

E. Spatial Causal Effects of A Bank Relocation on Its Lending Regions

We run the Diff-in-Diff regressions on both total bank loan originations (in $) and log(estabishment counts) in turn. Table III-2 and III-3 summarize the results below.
<table>
<thead>
<tr>
<th></th>
<th>(1) Loans (in $M)</th>
<th>(2) Loans (in $M)</th>
<th>(3) Loans (in $M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post x Δ distance</td>
<td>-0.0328***</td>
<td>-0.0328***</td>
<td>-0.0483***</td>
</tr>
<tr>
<td></td>
<td>(0.00462)</td>
<td>(0.00465)</td>
<td>(0.00431)</td>
</tr>
<tr>
<td>Post</td>
<td>-0.0604*</td>
<td>-0.0604*</td>
<td>-0.163***</td>
</tr>
<tr>
<td></td>
<td>(0.0327)</td>
<td>(0.0329)</td>
<td>(0.0362)</td>
</tr>
<tr>
<td>Δ distance (in 100 miles)</td>
<td>0.0230***</td>
<td>0.0267***</td>
<td>0.0283***</td>
</tr>
<tr>
<td></td>
<td>(0.00560)</td>
<td>(0.00475)</td>
<td>(0.00457)</td>
</tr>
<tr>
<td>Post x Δ size</td>
<td>0.000111</td>
<td>0.000111</td>
<td>0.000430***</td>
</tr>
<tr>
<td></td>
<td>(0.000101)</td>
<td>(0.000101)</td>
<td>(0.0000953)</td>
</tr>
<tr>
<td>Δ size (in $ billions)</td>
<td>0.000806***</td>
<td>0.000607***</td>
<td>0.000272***</td>
</tr>
<tr>
<td></td>
<td>(0.000181)</td>
<td>(0.000130)</td>
<td>(0.000102)</td>
</tr>
</tbody>
</table>

Demographic Controls | No | No | Yes |
Weather Controls     | No | No | Yes |
Land Cover Controls  | No | No | Yes |
FE: Merger x County  | No | Yes | Yes |

Adjusted $R^2$         | 0.017 | 0.163 | 0.276 |
N                        | 78,298 | 78,298 | 69,928 |
Number of Clusters       | 797 | 797 | 738 |

Robust standard errors in parentheses are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Estimates for the key coefficient of interest $\beta$ are tabulated in the first row in both tables. These estimates are negative and statistically significant at 1% level, even with robust standard errors clustered at the county level. We run 3 slight variations of the same regression by including/excluding additional controls and fixed effects, and document their respective results in columns (1)-(3). Across different columns, the estimates for $\beta$ stay largely constant and they always remain statistically significant.

According to column (3) in both tables, after controlling for the “size shock”,
Table III-3: Diff-in-Diff Regression Results on Establishment Growth

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ln(Est. Counts)</td>
<td>ln(Est. Counts)</td>
<td>ln(Est. Counts)</td>
</tr>
<tr>
<td>Post x Δ distance</td>
<td>-0.00202***</td>
<td>-0.00202***</td>
<td>-0.00198***</td>
</tr>
<tr>
<td></td>
<td>(0.000225)</td>
<td>(0.000229)</td>
<td>(0.000321)</td>
</tr>
<tr>
<td>Post</td>
<td>0.00236</td>
<td>0.00236</td>
<td>0.00458*</td>
</tr>
<tr>
<td></td>
<td>(0.00280)</td>
<td>(0.00285)</td>
<td>(0.00264)</td>
</tr>
<tr>
<td>Δ distance (in 100 miles)</td>
<td>0.00101***</td>
<td>0.00101***</td>
<td>0.000973***</td>
</tr>
<tr>
<td></td>
<td>(0.000112)</td>
<td>(0.000114)</td>
<td>(0.000161)</td>
</tr>
<tr>
<td>Post x Δ size</td>
<td>0.0000272***</td>
<td>0.0000272***</td>
<td>0.0000195***</td>
</tr>
<tr>
<td></td>
<td>(0.00000669)</td>
<td>(0.00000681)</td>
<td>(0.00000736)</td>
</tr>
<tr>
<td>Δ size (in $ billions)</td>
<td>-0.0000136***</td>
<td>-0.0000136***</td>
<td>-0.00000990***</td>
</tr>
<tr>
<td></td>
<td>(0.00000334)</td>
<td>(0.00000341)</td>
<td>(0.00000371)</td>
</tr>
<tr>
<td>Demographic Controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Weather Controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Land Cover Controls</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>FE: Merger x County</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.016</td>
<td>0.163</td>
<td>0.269</td>
</tr>
<tr>
<td>N</td>
<td>34,652</td>
<td>34,652</td>
<td>14,212</td>
</tr>
<tr>
<td>Number of Clusters</td>
<td>842</td>
<td>842</td>
<td>697</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses are clustered at the county level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

heterogeneities arising from demographic and natural geographic differences, and
merger-county fixed effects, if we hypothetically move a bank away from its lending
ZCTAs, total bank loan originations in these areas decrease by $48,300 on average for
every 100 miles the bank moves. Subsequently, establishment count growths in these
ZCTAs drop by 0.2% on average. Relatively speaking, this is a large drop in growth
rate, given that the average pre-shock annual establishment count growth across all
ZCTAs is only at about 1%.
Overall, these regression results support the financial channel of economic agglomeration in that firms/establishments could indeed more likely emerge together near banks due to less stringent financial frictions in obtaining loans. These results also suggest the importance of credit availabilities for regional economic growths.

F. Summary

This chapter revisits the classic question of how economic agglomeration arises from a novel financial perspective. It presents evidence that alternatively explains economic agglomeration as a result of firms more likely emerging together near banks due to distance-related frictions in obtaining loans. It does so by designing careful natural experiments that exploit sudden location changes on banks after banking mergers. A standard difference-in-difference approach shows that a quasi-exogenous relocation of a bank closer to a region indeed causes more supply of bank loans to the region, and subsequently causes more firm establishments to emerge and agglomerate within the same area.
Bibliography


Appendix

A1. Solution Algorithm for Benchmark Model

To computationally solve for equilibrium solutions in the benchmark model, we follow closely the algorithm in Arellano (2008). It is a standard value function iteration algorithm on discretized grids of debt levels $B$ and income levels $y$. Formally,

1. Start with some guess for the parameters to be calibrated: $\beta$, $\theta$, $\hat{y}$, and a discretized state space for debt levels consisting of a grid of 200 points equally spaced.

2. Start with a guess for the bond price schedule such that $q^0(B, y) = \frac{1}{1+r_f}$ for all $B'$ and $y$.

3. Given the bond price schedule, solve the optimal policy functions for consumption $c(B, y)$, debt levels $B'(B, y)$, repayment sets $A(B)$, and default sets $D(B)$ via value function iteration. For each iteration of the value function, we need to compute the value of default which is endogenous because it depends on the value of the contract at $B = 0$. We iterate on the value function until convergence for a given $q^0$.

4. Using default sets and repayment sets, compute new bond price schedule $q^1(B, y)$ such that lenders break even and compare it to bond price schedule of the previous iteration: $q^0(B, y)$. If a convergence criterion is met, $\max\{q^0(B, y) - q^1(B, y)\} < \epsilon$, then move to the next step. Otherwise, update the price using a Gauss-Seidel algorithm and go back to step 3.

5. Compute default probabilities from 100 samples of model simulations containing a default. If the model predictions match the data we stop; otherwise we adjust parameters and grid, and go to step 2.
A2. Numerical Equilibrium Solutions for Benchmark Model

In Figure A-1, we plot the equilibrium solutions at two given income levels that are respectively 5% above and below trend (i.e., \( y^{\text{high}} \) and \( y^{\text{low}} \)).

Figure A-1: Benchmark Model Numerical Solutions
A3. Notations for Cochrane-Piazzesi Regressions

The Cochrane-Piazzesi regressions start from log bond prices,

\[ p_t^{(n)} \equiv \log \text{price of } n\text{-year discount bond at time } t, \]

in which they use parenthesized superscripts to distinguish maturity from exponentiation.

On the one hand, denoting the log yield as

\[ y_t^{(n)} \equiv -\frac{1}{n} p_t^{(n)}, \]

and the log holding period return from buying an \( n \)-year bond at time \( t \) and selling it as an \( n-1 \) year bond at time \( t+1 \) as

\[ r_{t+1}^{(n)} \equiv p_{t+1}^{(n-1)} - p_t^{(n)}, \]

the excess log returns are therefore

\[ r_{x_{t+1}}^{(n)} \equiv r_{t+1}^{(n)} - y_t^{(1)}. \]

On the other hand, they write the log forward rate at time \( t \) for loans between time \( t + n - 1 \) and \( t + n \) as

\[ f_t^{(n)} \equiv p_t^{(n-1)} - p_t^{(n)}. \]
A4. $M^*_t$ Frequency and Pricing Horizon Adjustments

We start expositions of these adjustments by first specifying the following notations. In this section, subscripts $-tm$ denotes a month and $-tq$ denotes a quarter, whereas superscripts $-a$ denotes an annual pricing horizon and $-q$ denotes a quarterly pricing horizon. Using these notations, the $M^*_t$ process can be denoted as $M^a_{tm+1}$ before adjustments, and $M^q_{tq+1}$ after adjustments.

We first transform the time series from monthly to quarterly frequencies by taking the quarterly average over constituent monthly values. Formally,

$$M^a_{tq+1} \equiv \frac{1}{3} \sum_{tm \in tq} M^a_{tm+1}.$$ 

For instance, if we have pre-adjustment values of 1998Jan to 1998Mar to be 1, 2 and 3, the 1998Q1 value is then $\frac{1}{3}(1 + 2 + 3) = 2$.

We then shift the pricing horizon of the time series from a year to a quarter by modifying the SDF so that it approximately “de-annualizes” an annual risk-free rate into a quarterly yield. Formally,

$$M^q_{tq+1} \equiv \frac{1}{\exp\left(\ln\left(\frac{1}{M^a_{tq+1}}\right)\right)}.$$ 

so that we could derive $1 \approx \mathbb{E}_t[(1 + r^{f,a}_{tq})M^q_{tq+1}]$ from $1 = \mathbb{E}_t[(1 + r^{f,a}_{tq})M^a_{tq+1}]$, and $1 + r^{f,a}_{tq} = (1 + r^{f,q}_{tq})^4$. 


A5. Sanity Check on $M^*_t$ Before and After Adjustments

In Figure A-2, we plot the $M^*_t$ process before and after these adjustments for quick sanity checks. Overall, these ad-hoc adjustments decently preserve the time series dynamics of the stochastic process.

Figure A-2: $M^*_t$ Process Before and After Adjustments
A6. Robustness Simulations in Neighboring Regions of $\rho^M = 0.710, \eta_M = 0.012$ and $\bar{M} = 0.949$

In Figure A-3, we plot results from robustness simulations. Although we always target a 3% default probability across all our simulations, each time the actual model simulated probability is slightly different (e.g., 2.9% vs. 3.1%) due to the numerical nature of computational solutions. To account for such discrepancies in comparing results across different simulations, we use the mean-spread-default-probability differential, defined as simulated average credit spread less the simulated default probability, as a sufficient statistic.

Notably, the highest mean-spread-default-probability differential in all these robustness simulations is less than 1.4%. That means, the highest simulated credit spread is approximately 4.4%, which is still way below the 10.25% in the data.

Figure A-3: Robustness Simulations in Neighboring Specifications
A7. Historical Default Episodes with Hyper-Inflations

In Figure A-4, we re-plot Figure II-1 using alternative default criteria that account for *de facto* defaults through hyper-inflations. Notably, 400% inflation rate is defaulting on approximately 80% of outstanding domestic bonds that are largely issued in domestic currencies, and 100% inflation rate loosely corresponds to an implicit default on 50% of existing domestic bonds.

**Figure A-4: Historical Default Episodes with Hyper-Inflations**
A8. Historical Default Episodes at Country-Level

In Figure A-5, we plot summary statistics of historical default episodes for countries that are among the top 15 most frequent defaulters within the sample. Notably, external defaults are universally more common than domestic defaults for every single one in the list.

Figure A-5: Top Serial Defaulters
A9. Solution Algorithm

To computationally solve for the equilibrium solutions, we follow a standard value function iteration procedure formally outlined as below.

1. Guess initial equilibrium discount bond prices \( q^d_0 \) and \( q^e_0 \).

2. Guess initial value functions \( V^o_0, V^d_0, V^e_0 \), and \( V^b_0 \).

3. Compute optimal policies in \( B^e, b^{dh}, \) and \( b^{df} \) for the case of repaying both domestic and external debts, taking bond discount prices \( q^d_0 \) and \( q^e_0 \) and initial guess of continuation value \( V^o_0 \) as given.

4. Compute next-iteration \( V^r_1 \), taking optimal policies in \( B^e, b^{dh}, \) and \( b^{df} \) and continuation value \( V^o_0 \) as given.

5. Repeat steps 3 and 4 to compute next-iteration \( V^e_1 \) and \( V^d_1 \), as well as their respective optimal default policies \( DD_0(b^{dh}, b^{df}, B^e) \) and \( ED_0(b^{dh}, b^{df}, B^e) \), and their respective optimal policies in \( B^e, b^{dh}, \) and \( b^{df} \).

6. Compute next-iteration \( V^b_1 \), taking \( V^e_1, V^d_1 \), and \( V^o_0 \) as given.

7. Compute next-iteration \( V^o_1 \), and optimal default policies \( DD_1(b^{dh}, b^{df}, B^e) \) and \( ED_1(b^{dh}, b^{df}, B^e) \), taking \( V^b_1, V^e_1, V^d_1 \) and \( V^r_1 \) as given.

8. Replace \( V^o_0 \) with the newly computed \( V^o_1 \), and repeat steps 3–7 until convergence in \( V^o \).

9. Compute new discount bond prices \( q^d_{101} \) and \( q^e_{101} \), taking optimal default policies \( DD(b^{dh}, b^{df}, B^e) \) and \( ED(b^{dh}, b^{df}, B^e) \) as given.

10. Update discount bond prices \( q^d_1 = \mu q^d_0 + (1 - \mu) q^d_{101} \), and \( q^e_1 = \mu q^e_0 + (1 - \mu) q^e_{101} \).

11. Repeat steps 3–10 until convergence in prices \( q^d \) and \( q^e \).
A10. U.S. Economic Landscape

In Figure A-6, we categorize all U.S. counties from the 48 contiguous states into ten deciles by the number of establishments per unit land area. In Figure A-7, we plot locations of bank headquarters for all commercial banks with total assets ≥ $1 billion as of 2010 on top of Figure A-6.
A11. An Example of *de novo* Counties

To illustrate the concept of *de novo* counties using an example, we start from *BB&T Corporation*’s acquisition of *First Virginia Banks* completed on July 2, 2003. In Figure A-8, we plot a map of county-level footprints for the two merging banks right before the merger. Green counties denote those in which there were deposit-taking *BB&T Corporation* branches, yellow counties denote those in which there were deposit-taking *First Virginia Banks* branches, and the red-shaded counties denote those with an overlap. In this case, we sample all yellow counties as our *de novo* counties. Intuitively, these are the counties *BB&T Corporation* first enters into through the merger.

![Figure A-8: Map of County-Level Bank Footprints](image-url)