Three Essays on the U.S. Banking Industry Evolution

Shen Jin
jin.m.shen@gmail.com

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ABSTRACT

There has been a dramatic consolidation process in the U.S. banking industry. Most related literatures are reduced form analyze. There are very few structural model literatures in this field, and the study focus is on branch level analysis, for example branch networks, or consumer’s discrete choice model on local banks. However, the consolidation process, which is driven by both bank exit and bank merger, happens at the firm level. My dissertation attempts to examine the banking industry dynamics. Specifically, I estimate the underlying real exit primitive for the industry to characterize the current industry structure observed in the data in the first chapter. As the banking industry is highly regulated in almost all countries, I examine a series of regulation environments using Monte Carlo experiments to quantify the effects of regulation changes on the corresponding stay rate and producer surplus in the U.S. banking industry in chapter two based on the structural model recovered in the previous chapter. Chapter three examines the
characteristics that affect the bank stay and different exit decisions using Extended Cox Model with time-dependent covariates. By separating all merger types to construct a full set of competing risks, we can at least provide more event-specific estimates comparing to categorizing all mergers as a lump sum risk set.
Three Essays on the U.S. Banking Industry Evolution

Shen Jin

B.S., Financial Management, Huazhong University of Science and Technology, China, 2005

A Dissertation
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Three Essays on the U.S. Banking Industry Evolution

Presented by
Shen Jin, B.S. Financial Management

Major Advisor

Stephen L. Ross

Associate Advisor

Yonghong Ah

Associate Advisor

Ling Huang

University of Connecticut
2013
To my parents. Without my parents' unconditional love and support, this would not have been possible.
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I am deeply indebted to my major advisor Professor Stephen L. Ross for his guidance, understanding, and patience. This thesis would have been impossible without his support and monitoring.

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Introduction

1.1 Introduction

There has been a dramatic consolidation process in the U.S. banking industry. Most related literatures are reduced form analyze. There are very few structural model literatures in this field, and the study focus is on branch level analysis, for example branch networks, or consumer’s discrete choice model on local banks. However, the consolidation process, which is driven by both bank exit and bank merger, happens on firm level. My dissertation attempts to examine the banking industry dynamics. Specifically, I estimate the underlying real exit primitive for the industry to characterize the current industry structure observed in the data in the first chapter. As the banking industry is highly regulated in almost all countries, I conduct a series of regulation environments using Monte Carlo experiments to quantify the effects of regulation changes on the corresponding stay rate and producer surplus in the U.S. banking industry in chapter two based on the structural model recovered in the previous chapter. Chapter three examines the characteristics that affect the bank stay and different exit decisions using Extended Cox Model with time-dependent covariates. By separating all merger types to construct a full set of competing risks, we can at least provide estimates that are more specific.
1.2 Chapter One: A Dynamic Structural Model for the U.S. Banking Industry

There has been a dramatic consolidation in the U.S. banking industry. The number of institutions continues to decrease, which is driven by both bank exit and bank merger. In this paper, I estimate the underlying real exit primitive for the industry to characterize the current industry structure observed in the data. I specify and estimate a dynamic structural model of the banking industry evolution following a method proposed by Bajari, Benkard and Levin (2007) and the oblivious equilibrium concept by Weintraub, Benkard and Van Roy (2008). Loans count for 60% of total assets. Thus, banks are modeled to operate in loan markets to maximize net interest income from loans, and earn net noninterest income from many other on-and-off-balance sheet activities. The sum of net interest income and net noninterest income after corporate tax payments is treated as per period profit. If a bank exits, the scrap value is a portion of equity, which is estimated. Within the model, rational forward-looking agents will compare the value of continuation and the scrap value. All previous literature in a structural setting focuses on the network or branch level of the banking industry. I estimate a model of the firm level using a rich data set from the Consolidated Report of Condition and Income from 2000 to 2010. Per period profit parameters, law of motions for state variables’ transitions, and real exit policy function are estimated in the first stage, dynamic scrap parameters are estimated by simulated minimum distance, which is applied by adding a disturbance to the recovered real exit policy function and optimizing over the minimum violation condition.
1.3 Chapter Two: Monte Carlo Experiments of Consolidation and Welfare Impact

Banks in all countries are highly regulated. Chapter Two quantifies the effects of policy changes on the corresponding stay rate and producer surplus in the U.S. banking industry using the estimated structural parameter from Chapter One. I design the following experiments: increase the scrap parameter in order to capture an increase in the level of bank regulation; limit the size of loan portfolio in order to capture more active intervention of regulator in bank portfolio risk; apply the same shocks to segments of the industry: top 1-10 banks and 51-60 banks respectively, in order to quantify the effect of shocks on different banks to the whole industry; control the interest rate to consider another possible alternative for regulation. The simulation results indicate that as the scrap parameter becomes sharper, the stay rate in the banking industry will decrease and the producer surplus will increase corresponding to a more concentrated market. Negative shocks on the top banks are more significant for the whole industry in both scale and sensitivity. Finally, a 10% increase (decrease) on the earning spread ratio between the loan rate and the deposit rate is equivalent to a 2.2% decrease (a 2.8% increase) on the corporation tax rate.

1.4 Chapter Three: Identify Consolidation in Banking: Separating the Role of Exits and Mergers

Chapter Three uses a reduced form survival analysis to identify bank-level factors that affect the stay and different exit decisions. The model first uses acquisition and failed or closed bank
exit as two possible actions in the choice set to compare with formal reference papers’ results, then I extend the choice set to be a full set of possible actions by breaking down different acquisitions to derive more specific estimates.
Chapter One

A Dynamic Structural Model for the U.S. Banking Industry

2.1 Introduction

In the U.S. banking industry, we have observed a dramatic consolidation process. Formal research on the fundamental causes of consolidation usually concludes that there is no single reason for consolidation. Possible causes include technology innovation, financial globalization process, and deregulation.¹ Financial globalization not only enables larger banks to establish foreign offices, but also comes with technology improvements. Electronic funds transfer has greatly reduced transaction times. Introduction of ATM and internet banking reduces operational costs. All of these improvements put inefficient banks up in an even less competitive position.

The most important deregulation act in the U.S. banking industry is Riegle-Neal Interstate Banking and Branching Efficiency Act, which repeals the interstate banking constraint. Permissible banking activities were relaxed dramatically after that. Innovations are introduced in more complicated macroeconomic environments. For example, financial derivatives have been introduced to protect producers from possible sharp price changes on raw materials. The updating and learning processes during innovations put more requirements on skilled employees, which is also a problem for some small banks.

Consolidation can occur through exit by merger, or exit by failure or closure. In this paper, I study the exit by failure or closure problem. It is an important and direct source for the banking

¹See Berger, Kashyap and Scalise (1995); Berger, Demsetz and Strahan (1999); Shull and Hanweck (2001).
industry evolution—we observe the number of bank keeps decreasing, there were 8778 commercial banks in 2000, and 6898 commercial banks in 2010. The banking industry is highly regulated in all perspectives of normal operation, capital structure, exit, and entry decisions. Exit actions are combinations of firm decision in part based on regulatory burdens, which might increase in the financial distress, and the regulator’s decision to close the institution. Regardless, both the firm and regulator’s decision are influenced by the financial health, capital position, and industry environment. Industry evolution and corresponding producer surplus highly depend on exit decision underlying primitive applied in the industry.

In this paper, we are interested in what is the underlying model that generates the current banking industry structure. Our strategy to answer this question proceeds in two steps. First, we pose a theoretical model of the banking industry. Bank makes optimal decisions over providing loans for profit given its own state, the industry structure, and facing a variable penalty cost on capital structure. Decision makers make optimal exit decisions. Second, using a unique micro panel data reported by each bank to the FDIC, named Consolidated Report of Condition and Income (CALL), we recover parameters, which are consistent with the underlying model.

Among structural models in the banking industry, Ackerberg and Gowrisankaran (2006) analyzed banks’ adoptions of the automated clearinghouse electronic payment system. They separated banks into mutually exclusive networks, and limited the sample to banks in small markets (national banks are excluded). Aguirregabiria, Clark, and Wang (2012) also introduced a network model, which focused on bank expansion after the Riegle-Neal Act. Dick (2002) and Zhou (2007) both introduced a market level analysis, by matching the observed bank market share to the simulated bank market share in the model. With assumption of Type I extreme value distribution on unobserved error term, these papers have a closed form solution for the market
share. So existing structural models either focus on bank expansion or market level analysis. My paper is the first one to build a structural model to analyze banking industry consolidation, driven by bank exit, at the firm level.

The backbone of this paper builds on a fully dynamic model introduced by Ericson and Pakes (1995). Existing papers that apply this model share a common feature: there is a stochastic process determining the firms’ state variable, therefore, production and profit that are based on the state variable will change over time respectively. Production and profit are the key components that lead to the stay or exit decision, and then the overall industry structure is determined. In our model, decision makers are forward-looking agents. In the exit decision process, they will compare the value of continuation to the benefit or loss of exit to see whether to stay or not. The forward-looking property is driven by a dynamic setting. Bank’s size of loan without additional cost is constrained by a capital threshold. This threshold can be understood as for a given capital level, the bank cannot issue too many loans without additional cost. So the additional regulatory cost term together with the threshold will provide an internal solution on loan quantity.

We assume each bank will optimize profit conditional on current own state and the sum of the state variable across the industry. This equilibrium definition is introduced by Weintraub, Benkard, and Van Roy (2008) as “Oblivious Equilibrium” (henceforth OE)\(^2\), which is applied in Markov perfect industry with many firms. In OE, each firm is assumed to make decision on own state and the average industry state, and ignores current information on competitors. This method can avoid solving a large number of simultaneous equations in each period as firms compete

with each other. Weintraub, Benkard, and Van Roy (2008) proved that when there are a large number of firms within the industry, OE closely approximates Markov Perfect Equilibrium. In our example, in the panel data from 2000 to 2010, there are around 7000 incumbents per year. Oblivious equilibrium will dramatically overcome the computation burden in this dynamic game.

The method used in estimation is Bajari, Benkard, and Levin (2007) two-stage estimation. The intuition is straightforward. Ryan (2012) summarizes it as “the econometrician lets the agents in the model solve the dynamic program” in the first stage, and “finds parameters of the underlying model such that their behavior is optimal” in the second stage. More specifically, in our model the static per period profit, reduced form policy function, and the stochastic process law of motions for state variables are recovered in the first stage; in the second stage, the dynamic exit scrap parameter is recovered by simulation for minimal violation.

In fact, the same question can be addressed in different countries. When exit decisions in different countries are recovered, we can compare these underline primitives across counties. The purpose of Basel is not to harmonize supervisory process in member and non-member countries. Instead, it just provides guidelines and applicable approaches, which include on-site inspections, off-site review, requirements for policy statements on risk management issues, discussion with bank management, etc. Facing new financial environment and development in the banking industry, Basel itself is continually updated. Therefore, it is rational to expect different countries to have different exit policies. We focus our study on the U.S. given the availability of data, the largest number of institutions in the banking industry in the world, and its importance in the world financial system.
The remaining of the paper is as follows: Section 2.2 provides a brief description of the industry. Section 2.3 presents the model. Section 2.4 presents the data used. Section 2.5 provides the empirical strategy and estimation results. Section 2.6 concludes.

### 2.2 Description of the Industry

A bank, exchangeable with a firm in the paper, is a financial institution that accepts deposits from fund suppliers and provides funds to demanders. This channel function between borrowing and lending activities also classifies banks as one type of financial intermediary. There are two main sources of banks profit: the spread the between interest rate on saving account provided to fund supplier and the loan rate charged on fund demander; and transaction fees and financial services revenues associated with many on-and-off-balance sheet activities. The fractional reserve operation enables bank to hold only a small portion of the deposits and lend out the rest for profit.

The banking industry in almost all countries is highly regulated based on this fractional operation. At the same time, if a large portion of banks fails in a short period, it is a bad signal for a country’s economical environment. In the U.S., there are three insured institution types: insured branch of foreign bank, insured commercial bank, and insured savings institution. This paper will analyze a panel set of the U.S. commercial banks from 2000 to 2010. Savings institutions, including savings and loan association, or called thrift, and savings bank are not in our sample. Thrifts, by law, can have no more than 20 percent of lending in commercial loans during sample periods. Savings banks are primarily established for accepting saving deposits. The establishment of thrift and savings bank is not totally the same as commercial bank. Besides
that, their chartering agency is the office of thrift supervision. While for national commercial banks, the chartering agency is the Comptroller of the Currency.

Table 1 shows important financial data for the banking industry. For the structure of the whole industry, the number of incumbents keeps decreasing from 1990 to 2010. Before the financial crisis from 2007, industry total equity, total asset and total loan kept increasing. The loan to asset ratio moves around 0.6 but never falls below one half.

The mean of loans to total assets ratio from 1990 to 2010 is 0.588, loans form the biggest assets composition in the bank portfolio. Earnings from loans is one source of bank income; the other source is from fee-based products, including on-and-off-balance sheet activities. Diversification in these two types of operations has reduced risk. I separate bank income into two types: net interest income (earnings on the spread between the loan rate and the interest rate) and net noninterest income (on other alternatives). This setting up also follows the CALL report format: total taxable income is the summation of net interest income and net noninterest income, when banks provide their income statements. Examples of noninterest activities include interest rate futures and forward contracts, interest rate written option contracts, foreign exchange purchased option contracts, contracts on other commodities and equities futures and options, standby Letters of Credit, etc. Most of these are off-balance sheet activities. Net noninterest income is introduced as a mapping from the state variable equity. Having a structural form for net interest income in the first step of profit function, and then adding net noninterest income in the second step provides an attempt to make the model at least close to the real world, by recognizing that loans are only a portion in the bank asset portfolio.
### Table 1: Summary Statistics for Important Financial Variables

<table>
<thead>
<tr>
<th>Year</th>
<th>Equity</th>
<th>Loans</th>
<th>Assets</th>
<th>Loans/Assets Ratio</th>
<th>Number of Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>324448345</td>
<td>3140641709</td>
<td>5006872413</td>
<td>0.6273</td>
<td>12752</td>
</tr>
<tr>
<td>1991</td>
<td>330137163</td>
<td>2938151926</td>
<td>4874935180</td>
<td>0.6027</td>
<td>12320</td>
</tr>
<tr>
<td>1992</td>
<td>367047290</td>
<td>2833968645</td>
<td>4861213412</td>
<td>0.5830</td>
<td>11940</td>
</tr>
<tr>
<td>1993</td>
<td>404374848</td>
<td>2925757355</td>
<td>5021363721</td>
<td>0.5827</td>
<td>11525</td>
</tr>
<tr>
<td>1994</td>
<td>417456615</td>
<td>3132025081</td>
<td>5309072593</td>
<td>0.5899</td>
<td>11033</td>
</tr>
<tr>
<td>1995</td>
<td>457411631</td>
<td>3378140611</td>
<td>5595083638</td>
<td>0.6038</td>
<td>10505</td>
</tr>
<tr>
<td>1996</td>
<td>481367713</td>
<td>3576344223</td>
<td>5814707174</td>
<td>0.6151</td>
<td>10089</td>
</tr>
<tr>
<td>1997</td>
<td>521817218</td>
<td>3697187964</td>
<td>6215806450</td>
<td>0.5948</td>
<td>9667</td>
</tr>
<tr>
<td>1998</td>
<td>570685124</td>
<td>3977565052</td>
<td>6671204718</td>
<td>0.5962</td>
<td>9264</td>
</tr>
<tr>
<td>1999</td>
<td>582927219</td>
<td>4224784862</td>
<td>6926973874</td>
<td>0.6099</td>
<td>9063</td>
</tr>
<tr>
<td>2000</td>
<td>627694565</td>
<td>4510268770</td>
<td>7351128948</td>
<td>0.6135</td>
<td>8778</td>
</tr>
<tr>
<td>2001</td>
<td>700299508</td>
<td>4510207324</td>
<td>7578822559</td>
<td>0.5951</td>
<td>8540</td>
</tr>
<tr>
<td>2002</td>
<td>753076385</td>
<td>4728272159</td>
<td>8046061157</td>
<td>0.5877</td>
<td>8325</td>
</tr>
<tr>
<td>2003</td>
<td>786470639</td>
<td>4942340554</td>
<td>8459234210</td>
<td>0.5843</td>
<td>8197</td>
</tr>
<tr>
<td>2004</td>
<td>932873056</td>
<td>5282646693</td>
<td>9039258606</td>
<td>0.5844</td>
<td>8040</td>
</tr>
<tr>
<td>2005</td>
<td>960365275</td>
<td>5585919201</td>
<td>9355627577</td>
<td>0.5971</td>
<td>7921</td>
</tr>
<tr>
<td>2006</td>
<td>1043403028</td>
<td>5983646642</td>
<td>10061778096</td>
<td>0.5947</td>
<td>7793</td>
</tr>
<tr>
<td>2007</td>
<td>1120785037</td>
<td>6422872090</td>
<td>10800297123</td>
<td>0.5947</td>
<td>7666</td>
</tr>
<tr>
<td>2008</td>
<td>1105484472</td>
<td>6482713667</td>
<td>11606127804</td>
<td>0.5586</td>
<td>7456</td>
</tr>
<tr>
<td>2009</td>
<td>1221203182</td>
<td>6104305572</td>
<td>11058490958</td>
<td>0.5520</td>
<td>7214</td>
</tr>
<tr>
<td>2010</td>
<td>1260098399</td>
<td>6129613529</td>
<td>11153103672</td>
<td>0.5496</td>
<td>6898</td>
</tr>
</tbody>
</table>

Note: Column two to four present important bank financial variables from 1990-2010. Data reported are the real value chained to 2005 GDP; unit is one thousand dollars. Column six presents the number of banks from 1990-2010, which indicates the consolidation process in the U.S. banking industry.

Entry into the industry occurs when a firm obtains approval for the establishment, and a charter is issued by the corresponding regulator. The banking industry is not a free entry industry by this entering requirement. In 2010, the number of entrants was 9. In addition, looking at the number of incumbents in the industry, exit apparently dominates entry. We assume that there is only one entrant per period given the industry trend, and lack of a free entry condition to check in computation.
Exit in the banking industry is a little complicated. Once an incumbent bank becomes inactive, there are two possibilities: real exit\(^3\) and merger exit. When banks no longer provide the CALL report and disappear from the data, it does not necessary mean that they disappear from the “real business.” If they are merged with other banks, in this case, they do not really leave. Others could just recapture them, in that the acquirer would continue to operate the branch locations, and exploit existing networks, etc. The acquirer files the merger report to the corresponding regulators, and will become the new equity holder, once it is approved. This case is not a real exit for my purposes. Real exit occurs when the firm no longer operates in the market. In our paper, I focus on real exit. In terms of merger exit, TDeYoung (2009) provides a clear literature review in the paper “mergers and acquisitions of financial institutions: a review of the post-2000 literature”, so I will not repeat them here. To my best knowledge, these references mentioned are either in static setting, or in reduced form, which is just an approximation to try identifying particular relationships between variables, instead of constructing the model that generates the observed data. So reduced form analysis cannot handle policy experiments, which are considered in my dissertation chapter two.

In this paper, I will address a dynamic model for the bank real exit problem. The merger problem is not addressed here for two reasons. First, even if banks are merged under acquirers’ name, they may still continue in operation after consolidation. Second, in order to model merger, I need assumptions on the timing and nature of the merger for computation. For example, the largest bank decides to merger or not on value-maximization objective first; if it chooses not to merger, the decision passes to the second largest bank, etc. However, in the real world, the

\(^3\) Real exit includes failed and closed exit in this paper.
merger decision can arise from multiple motivations: manager’s self-serving\(^4\), or desire to get the “too-big-to-fail” status\(^5\). Therefore, the merger policy should be a convolution of different functions corresponding to each objective, and it is consistent with neither. Non-value maximization motivations are easy to handle in reduced form analysis by just choosing appropriate dependent and independent variables, but it is hard in a dynamic structural model. The assumptions posed for model computation with merger might be inconsistent with the real data, which makes the estimated primitives inconsistent.

2.3 Model

2.3.1 Sequence of Actions

Time is discrete and indexed by \( t = 1, 2, 3 \ldots \). The firm within the industry is indexed by \( i = 1, 2, 3 \ldots \). Firms discount the future at the rate \( \beta = 0.925 \). In each period \( t \), the state of bank \( i \) can be described by a set of state variables: bank capital (or called equity) \( X_{it} \), industry level loan rate faced in that time period \( ir_t \), and total factor productivity in the net noninterest process \( \theta_{it} \). \( \theta_{it} \) includes all factors besides the state variable equity and loan rate, for example, human capital, and more efficient computers in financial derivative pricing, etc. It maps equity to net noninterest income, \( NNI_{it} \), which is the difference between noninterest income (including income from fiduciary activities, venture capital revenues, and servicing fee, etc) and noninterest expense (including salaries and employee benefits, and goodwill adjustment, etc). By introducing this mapping, we can write

\[ NNI_{it} = \theta_{it} X_{it} \]  

We use notation \( S_{it} = (X_{it}, \theta_{it}, ir_t) \) to describe the set of state variables for bank \( i \) at time \( t \), \( S_t = (S_{1t}, S_{2t}, \ldots, S_{nt}) = \{(X_{1t}, \theta_{1t}, ir_t), (X_{2t}, \theta_{2t}, ir_t), \ldots, (X_{nt}, \theta_{nt}, ir_t)\} \) is the industry state variable as the collection of all banks at time \( t \). A bank also has net interest income \( NII_{it} \) from the spread between the cost of funds and the revenue from funds. The summation of \( NII_{it} \) and \( NNI_{it} \) is used as the corporation income tax base, after tax payment the net income attributed to a bank in that period is \( NIA_{it} \). We choose notation \( \pi_{it} \) to represent \( NIA_{it} \) in the remaining of this paper, because \( \pi_{it} \) is the final per period profit earned, which is also consistent with the general notation used in dynamic game papers.

At the beginning of each period, the incumbent provides loans \( Q_{it} \) to earn net interest income \( NII_{it} \) on the spot market. The decision makers make exit decisions based on idiosyncratic scrap parameter \( \phi \), which is iid across firms and time. If a bank decides to exit, \( \chi_{it} = 1 \); it will get profit \( \pi_{it} \) in that period and scrap value \( \phi X_{it} \), which is a portion of the owner’s equity depending on the remaining term after liabilities are paid off. If a bank decides to stay, it gets profit \( \pi_{it} \) and \( \chi_{it} = 0 \). Then the bank state will evolve from \( X_{it} \) to \( X_{i,t+1} \).

In each period, there is one entrant with charter into the industry. The entrant draws the initial state from the empirical distribution of real entrants’ initial equity data. The preparation for entry and exit takes one period. Then, incumbents with \( \chi_{it} = 1 \) exit and new entrant enters the industry to realize the decisions.
In the model, each decision period is one year. To put the timing of actions in order, it is as follows:

1. Incumbents operate on loan market to maximize the interest profit over the size of loans they provide, and operate on-and-off-balance sheet activities to earn noninterest income. After corporate tax payment, they earn net profit.

2. Incumbents privately observe a scrap parameter to make the exit and stay decisions. If exit happens, they take the period profit and the scrap value.

3. Entrant observes current industry state \( S_t = (S_{1t}, S_{2t}, S_{3t}, \ldots) \) and prepares for entering.

4. Exit and entry happen, industry state vector updates to \( S_{t+1} \).

### 2.3.2 Static Production

Banks obtain net interest income from lending and borrowing activities. The net interest income of bank \( i \) in period \( t \) is:

\[
NII_{it} = \alpha_1 \exp \left( \sum_{j \in X} \left[ \beta j \right] Q_{ij} + \alpha_2 I(\beta j < \beta j_{-1})X_{it} - \alpha_3 I(Q_{ij} > TX_{it}) \left( \frac{Q_{ij}}{X_{it}} - T \right)^2 X_{it} \right)
\]

where \( \beta j \) is loan rate, \( Q \) is amount of loans, \( X \) is equity (capital), \( I(\bullet) \) is the indicator function in this paper, \( T \) is the threshold of loan to equity ratio at which cost binds.\(^6\) There are three parts of the

---

\(^6\) I built profit function on intuition of Ryan (2012), who studied cement industry with assumptions of constant marginal cost, no fixed cost, and increasing variable cost as the “hockey stick” part to capture the idea when production passed the capability constraint there will be corresponding additional cost. My equation to the banking industry differs in the way that instead of constant marginal cost, I directly construct the earning-ratio of loans revenues. This idea is driven by the fact that different banks may have different marginal cost given different operation efficiency. Introducing the earning-ratio together with another term to capture the market power, can provide different marginal revenue for each bank. Besides modification on modeling cost, there is another
profit function introduced in order: the first term is the main loan earnings part, the second term is revenue adjustment, and the last is cost adjustment. The spread between the deposit and the loan rate is the main source of interest income. \( \alpha \) is the coefficient representing the earning spread ratio of fund. A bank’s competitive position is defined as the relative magnitude of own state variable, \( X_i \) to the industry state, which is modeled as \( \exp(X_i / \sum_{j=1}^{n} X_j) \). Larger bank equity share represents more market power. By introducing the earning spread ratio, marginal revenue depends on the market power exponential term; therefore, I can avoid the troublesome constant marginal cost assumption in the banking industry. Maturity and interest rate of loans are different case by case, and customers would pay their interest and loans based on the contract. When the loan rate decreased, early issued long-term loans with a higher contract rate will contribute some extra income to the bank if the loan revenue is computed with current low rate.

Suppose a 5-year loan is issued in 2000, it should pay interest on the contract rate at sign-up time 2000. If in 2003 the loan rate is lower than 2000, this loan will pay interest higher than the result from computation with 2003 loan rate. This correction of loan return approximation is modeled as the second term in equation (2.2). The fact of decreasing loan rate is the first indicator function in equation (2.2). Loan is a decision variable in equation (2.2) depending on states. Therefore, we directly map the extra revenue to equity \( X \). This is an approximation to handle the loan- maturity problem, and it is lag in order one in order to be consistent with the definition of the Markov. The last term is the cost adjustment. Given fixed equity amount if a bank issues more loans, the assets to equity ratio will increase. When loans to equity ratio passes a threshold \( T \), there is an additional regulatory cost. As loans pass the loan to equity threshold more in

---

7 Constant marginal cost may be a trouble assumption in the banking industry. D.C. Wheelock and P. W. Wilson (2000) had construct Data Envelop Analysis on banks cost inefficiency.
magnitude, the additional marginal regulatory cost will arise. The third term in equation (2.2) can be interpreted as an ongoing regulatory cost, depending on the loan issuance during bank operation. The last term in (2.2) gives a “hockey stick” shape cost function associated with regulatory burden between loan and equity. To apply this shape of cost function is common in industries, like electricity generation industry and cement industry, with increasing cost when production is near maximum capability. To interpret application of this cost form intuitively in the banking industry, loans are similar to production and threshold times equity is the maximum capability. If a bank issues too many loans and passes a threshold, it means that the bank does not have adequate capital for the risk it has exposed itself to through lending and investment practices. When the bank reaches a certain threshold, it will suffer additional variable regulatory costs, $\alpha_3$ is the cost parameter for the binding threshold on leveraged equity to loans. For convenience, I approximate this non-linear ongoing regulatory cost as the square of the magnitude of passing the threshold and mapping it directly to the state variable equity.

In the model, I impose the assumption that fixed costs are zero. Unless we can observe the shutting down of operation in some period, the fixed costs cannot be identified. In our data sample, we rarely can observe that. In the banking industry, fixed costs are not a fundamental problem of interest. Banks do not hold many physical capitals because they do not have physical production.

---

8 Gregory Elliehausen (1998) introduced regulatory cost consists of opportunity and operating cost that arise from activities required by the regulation. More loans contribute a higher asset level, given the same amount of equity; this higher leverage leads to non-linear increasing cost. The worst case is that when loan to equity ratio is high enough to drive the assets to equity ratio to break the capital requirement, the bank needs capital injection before reopen.

9 This specification is consistent with the Basel II requirement of additional regulatory scrutiny based on the ratio of the volume of risk-weighted assets to equity as capital requirement. While this paper does not consider asset risk, the model captures the relationship between the volume of lending activity and regulatory actions implied by Basel II.

Equation (2.2) defines the net interest income process for each bank from loan activities. In the second step, we add net noninterest income and tax process. Thus per period payoff is:

\[
\pi_{it} = (1-\text{tax}) \cdot I(NII_{it} + \text{NNI}_{it} > 0) \cdot (NII_{it} + \text{NNI}_{it}) + I(NII_{it} + \text{NNI}_{it} \leq 0) \cdot (NII_{it} + \text{NNI}_{it}) = (1-\text{tax}) \cdot I(NII_{it} + \theta_{it}X_{it} > 0) \cdot (NII_{it} + \theta_{it}X_{it}) + I(NII_{it} + \theta_{it}X_{it} \leq 0) \cdot (NII_{it} + \theta_{it}X_{it})
\] (2.3)

Summation of net interest income and net noninterest income is the tax base. If it is a positive number, banks need to pay the corporate income tax; otherwise, it is a net loss case, and there is no tax payment.

From (2.3), \(\theta_{it}\) can be constructed as

\[
\theta_{it} = I(\pi_{it} > 0) \cdot \frac{\pi_{it}}{1-\text{tax}} - NII_{it} \cdot \frac{1}{X_{it}} + I(\pi_{it} \leq 0) \cdot (\pi_{it} - NII_{it}) \cdot \frac{1}{X_{it}}
\] (2.4)

\(\theta_{it}\) is total factor productivity in net noninterest process, which follows a unique AR(1) process for each bank. This assumption indicates that each bank’s capability to earn net noninterest income has its own pattern. Interest income is relatively more standardized in operation; therefore it follows a common function (2.2). However, net noninterest income is modeled quite differently as a combination of many on-and-off balance sheet activities. We assume \(\theta\) follows its own AR(1) process, and parameters can be estimated from bank level historical data. This can be one reasonable way to handle the difficulties in the profit function given varieties of bank on-and-off-balance sheet activities, while some of them are short term cleared and hard to capture in an annual structural model analysis.

\[\text{Assuming }\text{AR}(1)\text{ process for state variable transition is common and standard in dynamic empirical Industrial Organization papers: price state variable }\text{AR}(1)\text{ process as in Ling Huang at al. (2011), Yizao Liu (2010); demand state variable }\text{AR} (1)\text{ process as in Myrto Kalouptsidi (2012).}\]
In fact, the process to get \( \theta \) from real data is very close to the macro paper’s treatment on total factor productivity. After calibration of capital share and labor share in Cobb-Douglas production function, we can compute total factor productivity. After the above process of constructing the total factor productivity from the data, there are papers just assume an AR(1) process\(^{12}\) as in (2.6), or add time trend in the AR(1) process\(^{13}\) as in (2.6.1).

### 2.3.3 Transition of States

The state vector \( S_t \) is composed of three variables \( X, \theta \) and \( i_r \) for all incumbents. \( X \) and \( \theta \) are bank specific variables. \( i_r \) is the industry level variable, following an exogenous growth process as described in (2.5).

\[
i_{r,t+1} = c^1 + a^1 i_{r,t} + \zeta_t
\]  

(2.5)

Total factor productivity in noninterest income process \( \theta \) for each bank follows its own AR(1) process as described in (2.6).

\[
\theta_{i,t+1} = c^2 + a^2 \theta_{i,t} + \nu_{i,t}
\]  

(2.6)

This process is only a function of itself. Total factor productivity excludes equity by definition, and \( i_r \) is for the interest income process. Therefore, \( \theta \) is independent of equity and interest rate.

Evolution on equity depends on lags of loan rate \( i_r \), total factor productivity in noninterest income process \( \theta \), and itself.

---

\(^{12}\) See José-Víctor Ríos-Rull, Raul Santaeulalia-Llopis (2010) for detail.

\(^{13}\) See Paul Gomme and Peter Rupert (2007) for detail.
\[ X_{t,i+1} = c_i^3 + a_i^3X_{t,i} + b_i^3i + d_i^3\theta_{t,i} + \eta_{t,i} \quad (2.7) \]

Equity is an accumulation process. A higher last period loan interest rate and \( \theta \) can contribute to a higher \( \pi \). Excluding dividend payments, higher profit will lead to an accumulation of owner equity.

When each bank has its own specific \( X \) and \( \theta \) processes, it could be true that some of these processes are non-stationary: \( |a_i^3| > 1 \) or \( |a_i^3| > 1 \) in (2.6) and (2.7). To handle the possible non-stationary problem, we further extend (2.6) and (2.7) to be:

\[ \theta_{t,i+1} = c_i^3 + a_i^3\theta_{t,i} + b_i^3t + \nu_{t,i}, \text{and} \quad \theta_{t,i+1} \in (-2|\max(\theta_i)|, 2|\max(\theta_i)|) \quad (2.6.1) \]
\[ \theta_{t,i+1} = c_i^3 + a_i^3\theta_{t,i} + \nu_{t,i}, \text{and} \quad \theta_{t,i+1} \in (-2|\max(\theta_i)|, 2|\max(\theta_i)|) \quad (2.6.2) \]

\[ X_{t,i+1} = c_i^3 + a_i^3X_{t,i} + b_i^3i + d_i^3\theta_{t,i} + e_i^3t + \eta_{t,i}, \text{ and} \quad X_{t,i+1} \in (-2|\max(X_i)|, 2|\max(X_i)|) \quad (2.7.1) \]
\[ X_{t,i+1} = c_i^3 + a_i^3X_{t,i} + b_i^3i + d_i^3\theta_{t,i} + \eta_{t,i}, \text{ and} \quad X_{t,i+1} \in (-2|\max(X_i)|, 2|\max(X_i)|) \quad (2.7.2) \]

(2.7.1) adds a time trend into the Law of Motion for equity \( X \). We also put an upper bound and a lower bound as double of the corresponding absolute value of maximum state variable we ever observed in the historical data. Intuitively, the bound for the state variable indicates the fact that regulators will not allow banks to behave ‘wildly’. Theoretically, it is consistent with the equilibrium existence assumptions in Doraszelski and Satterthwaute (2010) that profits are bounded. Profit is driven by state variables; therefore, we directly bound the state variables. This assumption further modifies the equity transition with time trend to be equation (2.7.1). If it is still non-stationary with time trend: \( |a_i^3| > 1 \) in (2.7.1). We will use (2.7.2). This treatment of non-stationary problem applies for \( \theta \) too, as listed in (2.6.1) and (2.6.2). The number of LOM applied in each case is reported in the next section.
We need the number of time series data to be no smaller than the number of coefficients to identify the regression. So we use data from 1990-2010 to estimate all Laws of Motion. For the case of not enough data for identification, we report those banks in a not enough data case, and variable evolution in this case will be the mean value plus a random term.

2.3.4 Incumbent’s Problem

Each firm’s stay or exit strategy \( \sigma_i(S_i, \epsilon_i) \) is a mapping from the state vector and shock to the action decision:

\[
\sigma_i : (S_i, \epsilon_i) \rightarrow \chi_i
\]  

(2.8)

\( \chi_i = 1 \), it decides to exit; if \( \chi_i = 0 \), it decides to stay. In this paper, we use \( \sigma_i(S_i) \) to represent the exit policy function of bank exit behavior as a function of the present state variables.

Give the knowledge of profit function, and state evolution, the incumbent’s Bellman equation can be written as:

\[
V(X_i; \sigma_i(S_i), \sigma_{-i}, \alpha, \epsilon_i) = \pi(X_i; \sigma_i, \alpha) + E_{\phi} \{ \max(\phi X_{it}, \beta V(X_{i,t+1}; \sigma_i(S_{i,t+1}), \sigma_{-i,t+1}, \alpha, \epsilon_i)) \}
\]  

(2.9)

\( \epsilon_i \) represents firm level private information about all state variable evolution and the scrap parameter, \( \alpha \) is the vector of payoff relevant parameters. If the incumbent exits, it can get a portion of equity \( \phi X_{it} \) plus profit. The exit decision is made based on the scrap value \( \phi X_{it} \) and the value of continuation, which equals

\[
VC = E[V(X_{i,t+1}; \sigma_i(S_{i,t+1}), \sigma_{-i,t+1}, \alpha, \epsilon_i)]
\]  

(2.10)
2.3.5 Equilibrium Concept

Following Ericson and Pakes (1995), defining the value function \( \bar{V}(X;X_-,\sigma,\sigma,\varepsilon) \) as the expected discounted payoffs of a firm facing competitors \( X_- \) playing strategy \( \sigma_- \). Markov Perfect Equilibrium requires:

\[
\bar{V}(X;X_-,\sigma,\sigma,\varepsilon) > \bar{V}(X;X_-,\check{\sigma},\sigma,\varepsilon)
\]  \tag{2.11}

to hold for all alternative \( \check{\sigma} \neq \sigma \).

However, MPE requires solving the problem based on the interactions between each incumbent in each period. In the banking industry, there are around 7000 banks each year during the sample period. It is infeasible and computationally intractable to apply this equilibrium concept. Therefore, we define the value function and equilibrium definition in OE. With some abuse of notation, the value function \( V(X;S,\sigma,\sigma,\varepsilon) \) is the expected discounted payoffs of a firm facing the industry level \( S \), which is the summation of all bank equities \( X \). OE requires:

\[
\bar{V}(X;S,\sigma,\sigma,\varepsilon) > \bar{V}(X;S,\check{\sigma},\sigma,\varepsilon)
\]  \tag{2.12}

to hold for all alternative \( \check{\sigma} \neq \sigma \).

In the OE setting, each bank tracks the industry state every period, together with knowledge on own state in order to make near optimal decision. Weintraub, Benkard and Van Roy (2008) have proved that when the number of firms in an industry is large and a light-tail condition holds, OE can closely approximate MPE.
2.3.6 Estimation Strategy

The main problem for estimating a dynamic game is the computational burden. We use Bajari, Benkard and Levin (2007) two stage estimation. The intuition of the BBL method is straightforward. We recover as many static parameters as possible in the first stage, in this paper they are profit function, exit policy function and laws of motion for the state variables. In the second stage, the remaining structural parameter $\phi$ is estimated using the optimality condition for equilibrium. If $\sigma_i$ is the optimal strategy for firm $i$, and $\sigma_{-i}$ denote competitors’ strategy, equilibrium conditions requires (2.12) to hold. We use a simulation-based minimum distance estimator method in the second stage. By adding disturbances to the policy function recovered in the first stage, we search for the value of $\phi$ which gives the minimum violation.

Doraszelski and Sattherthwaite (2010) have proved the existence of equilibrium in a close related form. We will assume the existence of equilibrium.

2.4 Data

In the U.S., every national bank, state member and insured non-member bank is required to file and submit a call report to the FDIC. After the FDIC collects, corrects, updates these files, it puts these files onto a public information website. The first dataset used in this paper is the CALL report. The CALL report contains a large set of bank financial data. Schedule RI contains the income statement, Schedule RC collects the balance sheet, and Schedule RC-L includes derivatives and off-balance sheet activities. We get all data used in our first stage estimation: including total equity (RCFD G105 or the summation of RCFD 3000 and RCFD 3210), total
asset (RCFD 2170), total loan (RCFD 2122), net interest income (RIAD 4074), net income attributes to bank (RIAD 4340), from this dataset.

Loan rate may be different across loans. It is not feasible to allow interest to vary across loans. Therefore, I use the mean value of prime loan rate from the FED and 30-year mortgage rate from Freddie Mac as an approximation of loan rate.14

The second dataset used is the archive FDIC certificate number of insured commercial banks. We separate commercial banks from other institutions like saving banks, which also need to provide the CALL reports.

The last dataset is the Merger Decision Annual Report to Congress by the FDIC, which is used to separate real exit and merger exit. Exit in the banking industry is a little complicated. Unlike other industries, there are two types of exits. We cannot just pool all bank exits to define as the real exit. The merger report provides applicant institution and target institution’s FDIC certificate numbers, and action approved time. From the sample of banks that disappear from the dataset, we pick out the merger cases, and the remaining exits are real exits. The merger decision annual report to Congress is only available from 2000. This report separates mergers into four categories: regular mergers, interim mergers, corporate reorganization mergers, and failed or closed bank mergers. Table 2 provides a brief mergers statistic:

---

14 Real Estate loan is 56.33% of total loans from 2000 to 2010 in the banking industry, so we approximate 50% of loan interest rate associated with mortgage interest rate and 50% associate with prime loan rate.
Table 2: Summary Statistic for Mergers

<table>
<thead>
<tr>
<th>Mergers</th>
<th>Number of Merger Cases Reported</th>
<th>Number of Institutions Merged</th>
<th>Number of Commercial Banks Merged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Mergers</td>
<td>1432</td>
<td>1141</td>
<td>860</td>
</tr>
<tr>
<td>Corporate Reorganization Mergers</td>
<td>1163</td>
<td>1113</td>
<td>817</td>
</tr>
<tr>
<td>Interim Mergers</td>
<td>211</td>
<td>209</td>
<td>180</td>
</tr>
<tr>
<td>Failed or Closed Bank Mergers</td>
<td>191</td>
<td>190</td>
<td>161</td>
</tr>
</tbody>
</table>

Note: The data source is the Merger Decision Annual Report to Congress by the FDIC from 2000-2010.

Some mergers take several steps in approval, for example: Citizens Bank, VIENNA, GA has been merged 2 offices in 06/27/2000 and 3 offices in 9/18/2000. These were two cases involving one institution. Therefore, the number of merger case reports is different from number of institutions acquired. Merger reports also contains saving institutions and thrifts. We separate the commercial bank from the merger report using the Archive FDIC certificate number of insured commercial banks. The final data on commercial bank mergers is in the last column.

The number of real exit is 1433, which is similar in magnitude to total bank mergers in the last column of Table 2, and so represents an important under studied question on bank consolidation. We can do robust check by adding failed or closed bank mergers to the real exit case, given the similarities between these two cases.

In order to get a better estimation for Laws of Motion for the state variables’ transitions, we use data from 1990 to 2010. Other than recovering the state transitions, the data analysis is conducted using the panel from 2000 to 2010.
2.5 Empirical Estimation and Results

The goal of estimation is to recover model primitives: per period payoff, laws of motion for all state variables, and exit scrap parameter \( \phi \). After all model primitives are recovered, we can conduct counterfactual experiments. The empirical estimation strategy is listed as follows:

1. Estimate the first stage net interest income profit function (2.2).
2. Use net interest income \( NII \) and bank’s per period payoff, net income attributes to bank \( \pi \), according to equation (2.4) to construct \( \theta \) in the second stage of profit function.
3. Estimate state variables’ transition for each bank in (2.6) and (2.7), and industry level state variable loan rate in (2.5).
4. Estimate real exit policy function.
5. Do forward simulation to estimate dynamic scrap parameter \( \phi \).

Estimation results are reported in each following subsections.

2.5.1 Profit Function First Step: Net Interest Income

The first step profit function in the spread earnings from borrowing and lending activities follows specification (2.2). \( NII \) is net interest income (RIAD4074). Loan rate is approximated as the average value between business prime loan rate from the FED and 30-year mortgage rate from Freddie Mac. \( Q \) is the size of loan (RCFD 2122). \( X \) is the equity (RCFD G105 or the summation of RCFD 3000 and RCFD 3210). Even if we could observe all data, equation (2.2) cannot be estimated directly by OLS. Loan volume is a decision variable that depends on the state vector equity. OLS result will not be consistent. When the incumbent bank chooses loan
quantity for profit optimization, we solve (2.2) to get the first order condition as the optimization decision. The solution of loans is

\[
Q_a = \begin{cases} 
\frac{x_t}{2\alpha_3} & \text{if } Q_a > TX_a \\
TX_a & \text{if } Q_a \leq TX_a 
\end{cases}
\]  

(2.13)

Then plugging (2.13) into (2.2), we can rewrite (2.2) as

\[
NII_a = \frac{\alpha_1^2}{4\alpha_3} I(Q_a > TX_a)(e^{\delta_1}\delta_2 X_a + \delta_3 \delta_4 I(ir_t < ir_{t-1})X_a \\
= \delta_1 I(Q_a > TX_a)(e^{\delta_1}\delta_2 X_a + \delta_3 \delta_4 I(ir_t < ir_{t-1})X_a
\]  

(2.14)

To estimate (2.14), we set \(T\) for a wide range of value from 1 to 20, and estimate by OLS for each given \(T\) value. The estimation result is from regression given the minimum summation of difference between real \(NII\) and estimated \(NII\). Table 3 is the result for (2.14) and (2.2). Standard errors are reported in parentheses.

<table>
<thead>
<tr>
<th>(\delta_1)</th>
<th>(\alpha_1)</th>
<th>(\delta_2)</th>
<th>(\alpha_2)</th>
<th>(\delta_3)</th>
<th>(\alpha_3)</th>
<th>Threshold (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.6065</td>
<td>0.4246</td>
<td>0.4246</td>
<td>0.1191</td>
<td>0.1191</td>
<td>0.0019</td>
<td>6.9</td>
</tr>
<tr>
<td>(4.8181)***</td>
<td>(0.0239)***</td>
<td>(0.0155)***</td>
<td>(0.0019)***</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Profit Function Estimation Results

Note: Number of observations = 82.267. *** indicates significance at 0.01 level. Estimators are from OLS result. Standard errors (in parentheses) are estimated by random sample with replacement with 5000 bootstraps.

The left panel reports parameters in (2.14), which are all significant at 0.01 level. R-square is 0.9234, which is a good overall fit. The results to transform coefficients in (2.14) to coefficients...
in (2.2) are on the right panel. There are two sources of bank heterogeneity in the net interest income process. The first is the efficiency level in the earning spread ratio of funds, small banks get near $\alpha_1$, while larger banks get more than $\alpha_1$. 0.424620 on average seems a reasonable value. Corbae and D’Erasmo (2011) provide cost of fund in terms of loan return. Their ratio (1-cost of funds) is close to the earning spread ratio $\alpha_i$ in our estimation. In an extreme case that one bank takes half of the market, $\alpha_i \exp(X_{\mu_i} / \sum_{j=1}^{n_i} X_{\mu_j})$ equals 0.7001. Under the market with extremely high market concentration, this spread ratio seems to be still reasonable. In a more normal case, if a bank takes one tenth of the market, $\alpha_i \exp(X_{\mu_i} / \sum_{j=1}^{n_i} X_{\mu_j})$ equals 0.4693. Comparing to small banks with 0.4246, the difference is acceptable given the loans process is standardized.

The second source of heterogeneity is the bank’s decision in each period concerning whether regulatory threshold is binding or not. The threshold $T$ here is different from the capital requirement, which is the ratio between assets and equity, instead of loans. So $T$ should be smaller than the inverse of the capital requirement. When the total capital requirement ratio is 10%, the inverse is 10. Given the loan to asset ratio with mean value 0.588, a 6.9 threshold is a reasonable value. The signs of the coefficients are all consistent with intuitive expectations.

### 2.5.2 Profit Function Second Step: Net Noninterest Income

Net noninterest income is the difference between noninterest income and noninterest expense. Noninterest income activities include many on-and-off-balance sheet activities, which are infeasible to be modeled by just simple persuasive equations. The idea behind the approximation
of $NII = \theta X$ is to build the model on the state variable, and the state variable can link both on- and-off-balance sheet activities. When the bank operates with assets, parts of the assets are devoted to the loan activity and majority of the remaining part is allocated to various on-and-off- balance sheet activities. The asset is a variable depending on the capital ratio and equity from leveraged property in the banking industry. Loan volume is a decision variable depending on the state variables too as described in the earlier section. Therefore, the asset allocated to noninterest activities, as well as the income derived, can be introduced by as a link to the state variable equity. The major part of noninterest expense is salaries and employee benefits, which depend on asset size and finally leads expense term to link with equity.

In state vector $S = \{(X_{t}, \theta_{t}, ir_{t}), (X_{2t}, \theta_{2t}, ir_{t}), \ldots, (X_{nt}, \theta_{nt}, ir_{t})\}$, $X_{t}$ and $ir_{t}$ can be directly observed, $\theta_{t}$ is calculated from equation (2.4) by observing $\pi_{t}, NII_{t}, X_{t}$ and tax rate. The corporation income tax brackets and tax rate is stable from 1993 to 2010. Rate for first $50,000 is 15%; $75,000-$75,000 is 25%; $75,000-$100,000 is 34%; $100,000-$335,000 is 39%; $335,000-$10,000,000 is 34%; $10,000,000-$15,000,000 is 35%; $15,000,000-$18,333,333 is 38%; over $18,333,333 is 35%. The rates for taxable income brackets below $335,000 are the same between 1988-1992 and 1993-2010. The only difference is from 1988-1992; the rate over $335,000 is constant 34%. We use the mean values of 25%, 34%, 39%, 34% as an approximation for the tax rate.
2.5.3 State Transitions

The state vector $S_t$ is composed of three variables $X, \theta$, and $ir$. $X$ and $\theta$ are bank special variables. $ir$ is industry level variable, following AR(1) process as described in (2.5). Estimation result is in Table 4.

<table>
<thead>
<tr>
<th>Constant $c^1$</th>
<th>0.0101</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.0104)</td>
</tr>
<tr>
<td>Lag interest rate $a^1$</td>
<td>0.8178</td>
</tr>
<tr>
<td></td>
<td>(0.1805)</td>
</tr>
</tbody>
</table>

Note: Standard errors (in parentheses) are estimated on 500 bootstrapping samples.\(^\text{15}\)

The loan interest rate shows high persistence, with $a^1 = 0.8178$ at annual level. It is also stationary as $|a^1| < 1$.

For firm level variables: $\theta$ for each bank follows it own AR(1) process as exhibits in (2.6). The process is only a function of itself, because bank’s capability in operation to transfer equity to net noninterest income is an independent process from equity and loan rate. To handle the non-stationary problem, we set an upper bound and a lower bound for each bank as described in the early section. Banks can grow, but not infinitely.

Given the large number of banks, we will not report all coefficients, and just show the number of banks belonging to each type in Table 5 and the graph for the coefficients distribution in Figure 1.

\(^{15}\) See Appendix A.1. for bootstrapping detail in AR(1) process.
Table 5: $\theta$ Transition Summary

<table>
<thead>
<tr>
<th>(2.6)</th>
<th>Stationary</th>
<th>8112</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2.6.1) Stationary with time trend</td>
<td>193</td>
<td></td>
</tr>
<tr>
<td>(2.6.2) Non-stationary</td>
<td>437</td>
<td></td>
</tr>
<tr>
<td>Not enough data</td>
<td>707</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 shows the distribution of coefficient $a_i^2$ in (2.6.1) in the upper figure and (2.6) in the bottom figure. The distributions are skewed. It has a heavy weight in the positive direction indicating higher persistence. Equity evolution includes the returns from both interest income activities and noninterest income activities, and last period stock value. Therefore, $\theta_{t-1}$, $ir_{t-1}$ and $X_{t-1}$ enter into the equity Laws of Motion. The treatment of non-stationary process is the same as $\theta$ variable. Table 6 and Figure 2 reports the result.

Table 6: Equity State Transition Summary

<table>
<thead>
<tr>
<th>(2.7)</th>
<th>Stationary</th>
<th>5957</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2.7.1) Stationary with time trend</td>
<td>2021</td>
<td></td>
</tr>
<tr>
<td>(2.7.2) Non-stationary</td>
<td>764</td>
<td></td>
</tr>
<tr>
<td>Not enough data</td>
<td>707</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: $\theta$ Law of Motion

- Top graph: Distribution of persistence coefficients with a time trend.
- Bottom graph: Distribution of persistence coefficients without a time trend.
Figure 2: Equity Law of Motion

equity persistence coefficients distribution-stationary with time trend

equity persistence coefficients distribution-stationary without time trend
Figure 2 shows the distribution of coefficient $a_i^3$ in (2.7.1) in the upper figure and (2.7) in the bottom figure. The distribution of equity is also skewed toward a high level of persistence. Figure 3 is the comparison between distribution of theta processes that pools (2.6), (2.6.1) together to be shown on the upper figure, and distribution of equity processes that pools (2.7), (2.7.1) together to be shown on the bottom figure.

We can see the process of equity is more persistent than $\theta$. This is consistent with model state transitions: $\theta$ is only a process of itself, which may be more volatile; while equity is a process of three variables in combination, and it shows higher persistence.

### 2.5.4 Exit Policy Function

As exit is the main feature of the model of banking industry evolution and it is not a free entry industry, we assume there is only one entrant per period. The initial entry state variables are draw from the entry distribution observed in the data. Therefore, the only policy we need to recover is exit policy.

I characterize the probability of real exit using a Probit regression:

$$Pr(\chi_i = 1; X_0 > 0, S_i) = \Phi(\gamma_0 + \gamma_1 X_{i,t} + \gamma_2 \sum_{j \neq i} X_{j,t} + \gamma_3 X_{i,t} \sum_{j \neq i} X_{j,t})$$  \hspace{1cm} (2.15)

The explanatory variables include own equity, competitors’ equity, and cross term of equities. When a bank exits by merger, we will drop the remaining observations at the time of merger exit from our regression as it is not a real exit case. There are 401 cases of merger and stay. We do not have data to track partial mergers. At the same time, these banks do not meet the common
definition of “stay” in the model. Therefore, we also drop these banks from regression after the partial merger. After excluding all merger exits, we have a panel of 69976 bank-year observations. The regression results are reported in Table 7.

Table 7: Exit Policy Result

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient 1</th>
<th>Standard Error</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant γ₀</td>
<td>-1.6799</td>
<td>(0.0486)***</td>
<td>-34.88</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Own Equity γ₁</td>
<td>4.1212E-07</td>
<td>(7.5508E-08)***</td>
<td>544.95</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Competitors’ Equity γ₂</td>
<td>-4.1882E-10</td>
<td>(5.4325E-11)***</td>
<td>-78.04</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Own equity* Competitors’ Equity γ₃</td>
<td>-3.5614E-16</td>
<td>(7.9368E-17)***</td>
<td>-452.61</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-6958.05</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All merger cases are excludes from exit in this specification. Number of observation = 69976, *** indicates significance at 0.01 level.¹⁶

All regressors are significant. The effect of own equity depends on the sign of \( γ₁ + γ₃ \sum_{j \neq i} X_{j,t} \).

Competitor’s equity \( \sum_{j \neq i} X_{j,t} \) for each bank at each time period is different. We evaluate the sign of effect on own equity, and find that both \( γ₁ + γ₃ \min(\sum_{j \neq i} X_{j,t}) < 0 \), and \( γ₁ + γ₃ \max(\sum_{j \neq i} X_{j,t}) < 0 \). Therefore, the effect of own equity with respect to the exit probability is negative. Banks with low levels of capital are more likely to exit. For the effect of competitors’ equity, the sign of \( γ₂ + γ₃ X_{j,t} \) is negative; but competitors’ equity effect is much smaller compared to own equity.

¹⁶ Robust report by treating failed or closed bank mergers as real exit is in Appendix A.2.
Figure 3: Theta and Equity Law of Motion

theta peresistence coefficients distribution-stationary

number

theta peresistence coefficients

-1  -0.5  0   0.5  1

equity peresistence coefficients distribution-stationary

number

equity peresistence coefficients

-1  -0.5  0   0.5  1
2.5.5 Dynamic Scrap Parameter: $\phi$

In the first stage, we have recovered the profit function, state transitions, and real exit policy function. The remaining question is to find the dynamic scrap parameter $\phi$ that will most closely match the data we observe. We use the simulation-based minimum distance estimator proposed by BBL.

The per period profit function after integrating out the private shocks is:

$$\tilde{\pi}_i(X_i; \sigma_i(S_i), \sigma_{-i}, \alpha, \phi) = \pi_i(X_i; \sigma_{-i}, \alpha) + \sigma_i(S_i) \cdot \phi \cdot X_i$$  \hspace{1cm} (2.16)

$\sigma(S)$ is real exit policy function.

To rewrite (2.16), we get

$$\tilde{\pi}_i(X_i; \sigma_i(S_i), \sigma_{-i}, \alpha, \phi) = [\pi_i(X_i; \sigma_{-i}, \alpha) \cdot \sigma_i(S_i) \cdot X_i] [1 \cdot \phi]$$  \hspace{1cm} (2.17)

Following BBL’s notation, we define

$$W_i(X_i; \sigma_i(S_i), \sigma_{-i}, \alpha) = E_{\sigma_i(S_i)} \sum_{t=0}^{\infty} \beta^t [\pi_{i,t+i} \cdot \sigma_i(S_{i,t+i}) X_{i,t+i}]$$  \hspace{1cm} (2.18)

Then the value function is:

$$V_i(X_i; \sigma_i(S_i), \sigma_{-i}, \alpha, \phi) = W_i(X_i; \sigma_i(S_i), \sigma_{-i}, \alpha) [1 \cdot \phi]$$  \hspace{1cm} (2.19)

The definition of equilibrium condition requires for all alternative policies $\tilde{\sigma}_i$, the following inequality holds:

---

17 The estimation equation is built on Bajari et al. (2007). I differ from them in that they only assumed scrap value, given the size distribution in the banking industry is skewed. I introduce the scrap value as the scrap parameter multiply bank equity. Therefore, it is the portion of equity recoverable when exiting.
\[V_i(X_j; \sigma_j, \sigma_{-j}, \alpha, \phi) > V_i(X_j; \tilde{\sigma}_j, \sigma_{-j}, \alpha, \phi)\]
\[W_i(X_i; \sigma_i, \sigma_{-i}, \alpha) > W_i(X_i; \tilde{\sigma}_i, \sigma_{-i}, \alpha)\cdot [1 - \phi]\]  \hspace{1cm} (2.20)

If there is any violation, we define the violation term as:
\[g(X, \phi) = V_i(X_j; \tilde{\sigma}_j, \sigma_{-j}, \alpha, \phi) - V_i(X_j; \sigma_j, \sigma_{-j}, \alpha, \phi)\]
\[= W_i(X_i; \tilde{\sigma}_i, \sigma_{-i}, \alpha)\cdot [1 - \phi] - W_i(X_i; \sigma_i, \sigma_{-i}, \alpha)\cdot [1 - \phi]\]  \hspace{1cm} (2.21)

To implement the estimation, we add a disturbance term to the Probit exit policy on the drawn bank as the first term in (2.21), the second term is without disturbance term. The simulation-based minimum distance estimator method searches the parameter that gives the minimum violation on equation (2.21). I use bootstrapping in \( \phi \) estimation. I draw 500 alternative policies in each run, when \( g(S, \phi) > 0 \), it is a violation. The objective function for the search is
\[
\min_{\phi} Q(\phi) = \frac{1}{n} \sum_{j=1}^{n} I(g > 0) g^2
\]  \hspace{1cm} (2.22)

I repeat the run 1000 times. The standard error is estimated by random subsampling without replacement as in Politis and Romano (1994). I randomly draw subsamples of 5000 complete bank histories 20 times in each run.

I will provide some intuitive possible range of the dynamic scrap parameter before presenting the results. Banks need to satisfy the simple accounting identity. \( A = L + X \), \( A \) is asset, \( L \) is liability, \( X \) is equity. Suppose now one bank operates with 10% capital ratio, and the risk-free interest rate is 3\%, then \( A = 10X \), \( L = 9X \). After one year, if the bank operates well, total assets increases from \( A \) to 1.1\( A \), equity will be 1.1*10X – 9X *1.03 = 1.73X , which is a 73\% increase in equity that year, then it steps into next year. If the bank operates badly, there is a negative shock to the total assets which cut it to 0.9\( A \), in this case 0.9*10A < 9X *1.03. Bank assets is unable
to cover the liability; if the bank exits, the FDIC deposit insurance will make up the difference.\textsuperscript{18} This is a net loss case. Decision makers may maintain the bank if the value of continuation can cover the net loss. Therefore, we can give a reasonable initial guess of $\phi$: it is smaller than 1, and could take on a small negative value. Table 8 reports the estimation result.

<table>
<thead>
<tr>
<th>Exit Scrap Parameter $\phi$</th>
<th>Mean</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.4123</td>
<td>0.2129</td>
<td></td>
</tr>
</tbody>
</table>

Leland and Toft (1996) has derived an equilibrium bankruptcy-triggering asset value by a smooth-pasting condition. They found that for firms with long-term debt structure, the endogenous bankruptcy-triggering asset value is typically less than the principal value of debt. Therefore, the firm may continue to operate despite having negative net worth with limited liability to debt holders. In fact, the equity is a call option on bank value; hence, there is option value for bank equity. Harding, Liang and Ross (2009) had extended Leland’s model to the banking industry with deposit insurance, and obtained a similar result.

### 2.6 Conclusion

This paper develops and estimates a dynamic structural model for the U.S. banking industry evolution from 2000-2010. Banks issue loans to earn net interest income. Together with net noninterest income, banks’ per period profit is constructed. Entry is an exogenous process given the fact that the banking industry is not a free entry industry. The exit decision is endogenous and

\textsuperscript{18} It is not required for state-charter bank to have deposit insurance; now according to the data released by FDIC almost all banks have deposit insurance.
dynamic, as the decision makers are forward-looking. After exit scrap parameter is recovered, we find that it is consistent with Leland and Toft’s (1996) finding that firms (banks in this paper) will operate even with negative net worth.
Appendix A:

A.1.

The panel is short in time, which leads to inaccurate computation of standard errors. We use a parametric bootstrap as instead to get more accurate standard errors. The step proceeds as follows:

Suppose we have a sample $X_t, t=1,2,\ldots,T$ from AR(1) process

$$X_t = \hat{a}_0 + \hat{a}_1 X_{t-1} + \varepsilon_t$$  \hspace{1cm} (2.23)

1. Estimate the parameters $\hat{a}_0, \hat{a}_1$ and the residuals $\hat{\varepsilon}_t$.

2. Generate $R$ bootstrap samples for $X_t$ for a long series using $\hat{a}_0$ and $\hat{a}_1$, draw residuals with replacement from $\hat{\varepsilon}_t$.

3. Retain only the last $T$ observations.

4. Refit the model using simulated data.

5. Compute standard error and confidence interval using $R$ samples.

A.2.

Regulators can deal with the failed or closed bank in several ways. One way is the payoff method. The other is the assumption method. Failed or closed exit by payoff, or being acquired should follow the principle of which method yields the “minimum cost.” Overall, failed or closed merger is a small portion of all mergers. Table 9 provides a robustness check by adding failed or closed mergers to real exit.
Table 9: Exit Policy Result (robustness check)

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.8255</td>
<td>(0.0474)***</td>
<td></td>
</tr>
<tr>
<td>Own Equity</td>
<td>4.2808E-07</td>
<td>(7.5978E-08)***</td>
<td></td>
</tr>
<tr>
<td>Competitors’ Equity</td>
<td>-2.1449E-10</td>
<td>(5.2117E-11)***</td>
<td></td>
</tr>
<tr>
<td>Own equity* Competitors’ Equity</td>
<td>-3.7663E-16</td>
<td>(8.0078E-17)***</td>
<td></td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-7543.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Failed or closed bank merger is counted as exit case in this Probit exit policy function specification. Number of observation = 70137, *** indicates significance at 0.01 level.

The dynamic scrap parameter under robustness check policy function is -0.4047, which stays in the confidence interval.
Chapter Two

Monte Carlo Experiments of Consolidation and Welfare Impact

3.1 Introduction

Among structural models regarding the banking industry, Ackerberg and Gowrisankaran (2006) analyzed banks’ adoption of the automated clearinghouse electronic payment system. They separated banks into mutually exclusive networks, and a limited sample of banks in small markets (national banks are excluded). Aguirregabiria, Clark, and Wang (2012) also introduced a network model, which focused on Bank Expansion after the Riegle-Neal Act. Dick (2002) and Zhou (2007) both introduced a market level analysis, by matching the observed bank market share to the simulated bank market share in the model. With assumption of Type I extreme value distribution on unobserved error term, these papers have a closed form solution for the market share. So existing structural models either focus on bank expansion or market level analysis. This dissertation is the first one to build a structural model to analyze banking industry consolidation, driven by bank exit, at the firm level. Therefore, we can quantify the industry stay rate, given the structural model is at the firm level; and industry producer surplus, given the profit function setting in the model.

There are three principal findings. First, as the value of the continuation threshold becomes sharper, the stay rate in the banking industry will decrease and the producer surplus will increase corresponding to a more concentrated market. Second, negative shocks on the top banks are
more significant for the whole industry in both scale and sensitivity. For the same level of negative shocks, top 10 banks contributes to a decrease in producer surplus of at least $4537M and the industry equity elasticity of producer surplus is 0.8504, 51 to 60 banks contributes the decrease in the producer surplus by at least $1098M and the elasticity is only 0.5770. Finally, a 10% increase (decrease) on the earning spread between the loan rate and the deposit rate is equivalent to a 2.2% decrease (a 2.8% increase) on the corporation tax rate.

### 3.2 Monte Carlo Experiments

The benefit of a structural model is once model primitives are recovered, we can construct counterfactual experiments. We have placed structure on the profit function, which is required in order to examine producer surplus and firm behavior in counterfactual experiments. Therefore, in this paper we quantify the impact of regulatory environmental changes over different values of the continuation threshold $\phi$ on producer surplus and stay rate in the banking system. To achieve this, we compute the equilibrium with different sets of parameters designed by corresponding experiments.

The steps to compute the equilibrium are:

1. To start with an industry state $S_t$.
2. Update exit using recovered exit rule.
3. New entrant enters.
4. Update industry state using recovered state transition, entry and exit decisions to $S_{t+1}$, get the number of exitors, and then go back to 1.
The equilibrium is reached when the number of exitors is not changing. All results are the mean values of 500 runs, number of periods simulated is 200 years, and the initial starting environment in all experiments is the U.S. banking industry structure in year 2000.

3.2.1 Value of Continuation Threshold

Decision makers compare the value of continuation and scrap value. When \( VC_t > \phi X_t \), bank will stay to continue; otherwise, it will exit. The previous section estimated \( \phi \) in the second stage. We take the recovered value as the benchmark, and construct other different sets of parameters \( \phi = 0, 1 \). As \( \phi \) takes larger value, the exit pressure becomes tighter. I also compute industry producer surplus and stay rate at three sets of \( \phi \) values.

Another setting to consider is whether the regulator allows loan volume to exceed the loan to equity threshold as captured by the last cost adjustment term in equation (2.2), e.g. a loan volume where the hockey stick regulatory costs apply. In model estimation, we observe the data on loan volume, and we know whether it binds or not given the parameter. In the policy simulation, however, we need to decide whether the regulatory threshold is binding or not. With the ability to exceed the regulatory threshold, banks choose the quantity of loans for optimization, which provides an interior solution based on facing the additional increasing regulatory cost term. While for the binding case with the threshold acting as a cap, banks will choose a corner solution leading up to the maximum level of loans allowed, e.g. up to the threshold. Therefore, we consider two circumstances: the regulator allows all banks to exceed the threshold; or no bank is allowed to exceed the threshold. We compute the stay rate and producer surplus in the model
given a set of value of continuation threshold parameters under these two circumstances. Results are reported in Table 10.

Table 10: Value of Continuation Counterfactual

<table>
<thead>
<tr>
<th></th>
<th>$Q &gt; TX$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\phi$</td>
<td>$\phi = 0$</td>
<td>$\phi = 1$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.1.1</td>
<td>6.1.2</td>
<td>6.1.3</td>
<td></td>
</tr>
<tr>
<td>Stay Rate</td>
<td>89.93%</td>
<td>73.69%</td>
<td>47.31%</td>
<td></td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>1.2027E+09</td>
<td>1.5488E+09</td>
<td>1.8694E+09</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$Q \leq TX$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\phi$</td>
<td>$\phi = 0$</td>
<td>$\phi = 1$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.1.4</td>
<td>6.1.5</td>
<td>6.1.6</td>
<td></td>
</tr>
<tr>
<td>Stay Rate</td>
<td>71.03%</td>
<td>53.52%</td>
<td>32.37%</td>
<td></td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>3.8749E+08</td>
<td>6.5002E+08</td>
<td>1.0808E+09</td>
<td></td>
</tr>
</tbody>
</table>

Note: Stay rate equals (1-real exit rate), which is the exit excludes all merger cases. Both stay rate and producer surplus are industry level variables for all tables in chapter two. The first column reports the simulation results when $\phi = -0.4123$ as the benchmark model. The second column reports the simulation results when there is no value of continuation. The third column reports the result when bank equity owners can just recover their equity at the time of exiting.

The upper panel reports the results when all banks are allowed to pass the 6.9 loan to equity threshold. As the value of the continuation threshold $\phi$ becomes sharper from 6.1.1 to 6.1.3, it is more difficult for incumbents to stay in the industry. Therefore, the industry becomes more concentrated, and the industry producer surplus increases with market power due to the concentration of industry. 6.1.1 to 6.1.3 for the upper panel represent results in order of $\phi$ from low to high, while loan volume is not controlled. This result also holds for the lower panel, where loan volume is restricted. In each column of Table 10, the $Q > TX$ environment will provide a higher industry level producer surplus and stay rate, comparing to the $Q \leq TX$ sceneries. Controlling the loan size leads to a smaller per period profit, this will reduce the value function and the value of continuation. Therefore, exit is more likely to happen, exit rate
increases, and stay rate decreases. The stay rate wedge on whether loan volume is controlled or not seems to decrease when facing higher $\phi$ value. Under sharper regulatory environment, loan control may become a less determinant factor for the stay or exit decision. Less competitive banks under sharper regulation will leave anyway, which makes the wedge between stay rates for the two circumstances to coverage. Ratios of producer surplus under 6.1.4 to 6.1.1, 6.1.5 to 6.1.2, and 6.1.6 to 6.1.3 are 0.3221, 0.4197, and 0.5781 respectively. The ratio is increasing. This indicates that the better competitive position $\exp(X_i/\sum X)$ in a more concentrated market, which results from the higher $\phi$ value and lower stay rate, would compensate the loss associated with holding loans to the threshold in the operation.

### 3.2.2 Loan Control Policy

From 6.1.1 to 6.1.3, we have conducted experiments allowing all banks to pass the threshold; and not allowing any bank to pass the threshold from 6.1.4 to 6.1.6. In this section, we design another experiment that controls loan volume conditional on bank’s equity: the regulator only allows the top 10 banks to pass the threshold. When we extend the loan size for one bank, assets will increase, which is financed by debt in this model as equity evolution has its own process. Therefore, the capital structure of that bank will change. The setting of this experiment is close to the case of only allowing top banks to deleverage. It gives us an elementary analysis on how different capital structures conditional on bank state will affect the whole industry.
The pattern of stay rate decreasing and producer surplus increasing with $\phi$ is retained from 6.2.1 to 6.2.3. The stay rates do not change much, comparing 6.2.1 vs. 6.1.4, 6.2.2 vs. 6.1.5, and 6.2.3 vs. 6.1.6. The ratios of producer surplus under above two environments are 1.9328, 1.6263, and 1.3258 respectively. When exit pressure is low, the ratio is high, and passing the loan threshold contributes a lot to the industry producer surplus. When exit pressure is sharp, the ratio is low, with overall low stay rate only relatively large banks can survive, and the resulting market concentration dilute the effect of unfair competition on midsized banks. The remaining experiments in this chapter assume $Q \geq TX$ sceneries for simplification.

### 3.2.3 Shocks and Regulator Intervention

The purpose of this experiment is to explore the effect of negative shocks over the whole industry. By comparing different negative shocks, we can deduce the importance of regulator intervention during periods of financial instability. We first construct the following environments: a 50% negative shock to top 10 banks each period on their equities. When this happens, there are two options to choose from: first, to have capital injection, therefore the banks maintain the top status in size; second, to adjust operation activities according to the new lower equity levels. In our paper, we do not have the process of recapitalization; hence banks need to make adjustments.
on operations including loan size in net interest income process and equity based net noninterest income process without government intervention. Results are reported in Table 12.

Table 12: Shock Counterfactual 1: top 1-10 banks

<table>
<thead>
<tr>
<th></th>
<th>$\phi$</th>
<th>$\phi = 0$</th>
<th>$\phi = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Rate</td>
<td>90.32%</td>
<td>80.81%</td>
<td>47.23%</td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>7.7099E+08</td>
<td>7.9839E+08</td>
<td>1.2398E+09</td>
</tr>
</tbody>
</table>

Comparing the results to 6.1.1-6.1.3, average stay rate for all banks is a little higher generally. This result is by the fact that larger banks’ market power is decreased by negative shocks; hence, small banks are more profitable in the income process and more likely to stay. Producer surplus decreases by the negative shocks as the intuitive expectation.

Next, we assume there are same levels of negative shocks on rank 51 to 60 banks.

Table 13: Shock Counterfactual 2: 51-60 banks

<table>
<thead>
<tr>
<th></th>
<th>$\phi$</th>
<th>$\phi = 0$</th>
<th>$\phi = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Rate</td>
<td>90.61%</td>
<td>74.96%</td>
<td>45.26%</td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>1.0939E+09</td>
<td>1.4088E+09</td>
<td>1.8212E+09</td>
</tr>
</tbody>
</table>

The effect of negative shocks to the 51 to 60 banks is much smaller than top 10 banks in scale. We also compute the industry equity elasticity of producer surplus in the benchmark model. When the shocks are on top banks, the elasticity is 0.8504; while for the 51 to 60 banks, it is 0.5770. The impact with the shocks is substantially smaller when shocks are on the 50 to 60 banks, even after controlling for the scale of the experiment.

This experiment can explain the “too-big-to-fail” phenomenon. The social influence on big banks’ failure will be much larger than small and medium banks in both scale and sensitivity. As
a regulator, the failure of larger banks is more than an industry issue. There is also a social pressure to be more prudent. The small bank’s failure will not attract the same level of attention, nor has the same impact on the market.

### 3.2.4 Interest Rate Control

Due to late 1970s high inflation rates, the price ceiling on interest rates has been removed to allow commercial banks and saving institutions to compete with money market mutual funds. In fact, the price ceiling on interest rate is an alternative way to control risk-taking behavior under normal inflation circumstances. For example, Hellman, Murdock, Stiglitz (2000) proved that large capital requirement can generate Pareto inefficient equilibrium, and they also find deposit rate controls together with capital requirement can Pareto dominate regulation based only on a capital requirement.

In this section, we design an experiment with regulation on the interest rate with a deposit price ceiling. First, we assume the regulator has lowered the price ceiling on the saving interest rate; therefore the earning spread ratio has increased by 10%. In the model, this design is equivalent to increasing the recovered benchmark $\alpha_i$ by 10%, which is $new\alpha_i = 1.1\alpha_i$.\(^{19}\) Then, we assume that the regulator increases the price ceiling on the saving interest rate, earning spread ratio decrease by 10%, which is $new\alpha_i = 0.9\alpha_i$. The results are present in Table 14.

\(^{19}\) This experiment is also equal to increase the loan interest rate by 10%.
With a higher earning spread ratio experiments in the upper panel, banks can make more profit, hence stay rate and producer surplus increase. For a lower earning spread ratio experiments in the lower panel, both terms will decrease for all $\phi$ values. These results are intuitive. Then we compare the effects of the earning spread ratio changes to the change in corporation tax rate. Table 15 reports the result.

### Table 14: Profit Spread Control Counterfactual

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>$\phi = 0$</th>
<th>$\phi = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4.1</td>
<td>6.4.2</td>
<td>6.4.3</td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>1.3194E+09</td>
<td>1.8354E+09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>$\phi = 0$</th>
<th>$\phi = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.4.4</td>
<td>6.4.5</td>
<td>6.4.6</td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>8.2045E+08</td>
<td>1.1768E+09</td>
</tr>
</tbody>
</table>

### Table 15: Calibration Result

<table>
<thead>
<tr>
<th>$\text{newTax} = % \text{old Tax}$</th>
<th>Calibration Result</th>
<th>$\text{newTax} = % \text{old Tax}$</th>
<th>Calibration Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Rate</td>
<td>0.978</td>
<td>to 6.4.1</td>
<td>1.028</td>
</tr>
<tr>
<td>Producer Surplus</td>
<td>96.19%</td>
<td>1.3293E+09</td>
<td>82.94%</td>
</tr>
</tbody>
</table>

If there is an increase of 10% on the earning spread ratio, it is equivalent to a decrease in the tax rate to 0.978 of the original value, which is a 2.2% decrease. If there is a decrease of 10% on the earning spread ratio, it is equivalent to increase tax rate to 1.028 of the original value, which is a 2.8% increase. To compensate for the change in the spread, the government can apply a substantially smoother regulation in the corporation tax rate.
3.3 Conclusion

After recovering all underlying model primitives in chapter one, we simulate the model to calculate the expected industry stay rate and producer surplus in different environments. We find that when banks face higher exit pressure as the scrap parameter becomes larger, industry stay rate will decrease, and industry producer surplus increases due to a more concentrated market. If there are negative shocks in the industry, both scale and sensitivity of the shocks are more dramatic for top banks. As top banks are more important in status, it is consistent with the “too-big-to-fail” in the real word. If there are controls on the earning spread ratio, e.g. through the deposit rate price ceiling, a 10% increase (decrease) in earning spread ratio is equivalent to decrease (increase) tax rate by 2.2% (2.8%).
Chapter Three

Identify Consolidation in Banking: Separating the Role of Exits and Mergers

4.1 Introduction

We have observed a great consolidation in the U.S. banking industry over the last few decades. In 2000, the number of commercial banks was 8778. While in 2010, the number was 6898. The consolidation process in the banking industry takes the form of either exit by merger or exit by failure or closure.

Merger in financial markets is more complicated than merger in other industries. According to the Annual Merger Report to Congress by the FDIC, there are four types of mergers: regular merger; interim merger; corporation reorganization merger; and the failed or closed bank merger. Interim merger is a merger between an operating institution and a newly formed institution that exists solely for the purpose of facilitating the merger. Therefore, there is no impact on competition, and a report of competitive factors to the Department of Justice is not required. Corporation reorganization merger is a merger between an institution and one or more of its affiliates, and again the firm also does not need to report to the Department of Justice. Besides the merger types, in the real world the merger decision may arise from multiple motivations: manager’s self-serving, desire to obtain the “too-big-to-fail” status, or value maximization.

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20 See Bliss and Rosen (2001) for detail.
Combining different merger types and various possible motivations, with the assumption of one underlying merger primitive in a structural model is not creditable. In fact, a more reasonable assumption on the merger underlying primitive is that merger policy function is a convolution of the policy functions corresponding to different objectives, but it is consistent with neither. Given the complexity of the banking industry, I examine the determinants of the various forms of bank exit using a reduced form analysis in this paper.

The method used in this paper is to apply a reduced form competing risks survival analysis to identify bank-level performances that might affect the possible action decisions. Each bank will have one of the following possible actions according to their operation: exit by failure or closure, exit by regular merger, exit by interim merger, exit by corporation reorganization merger, exit by failed or closed merger, and stay. In this paper, I seek to identify bank characteristics that affect these competing choices using an Extended Cox model. To my best knowledge, this paper is the first one to separate the competing merger choices into a full set of possible outcomes.

---

22 Value maximization is the only appropriate objective function for a dynamic structural model formwork, Gautam Gowrisankaran (1999) “A Dynamic Model of Endogenous Horizontal Mergers”.

23 In a dynamic structural model, it is very difficult to include the merger process. Usually, merger comes into the model in the simulation section, instead of in the dynamic estimation. One example is Benkard, Bodoh-Creed and John Lazarev’s working paper “Simulating the Dynamic Effects of Horizontal Mergers: U.S. Airlines”. After model estimation, they do the merger simulation, for example if AA and UA merge what would be the response of the post-merger airline market. Therefore, the model provides a good reference on the merger decision making process for the Department of Justice. Another example is Zhou (2007) “Estimation of the Impact of Mergers in the Banking Industry,” which estimates the utility function of consumers choosing certain banks. The back bone of this paper is built on a discrete choice model to estimate market demand and supply, and analyze within-market merger in the simulation process after recovering all parameters. In terms of dynamic estimation with merger in the model, to my best knowledge, Gowrisankaran (1999) is the only paper developing a dynamic model of endogenous horizontal mergers. The model imposes some important assumptions and design restrictions on the merger process. First, the objective function in dynamic models with merger is the value function (or utility function). Second, the order for the merger process is assumed that if one firm is on the merger list, the largest incumbent makes the decision first, if the value function with merger is better than without merger, merger happens; otherwise, the merger decision passes to the second largest incumbent, or possibly the third largest incumbent and so on. These rules make the dynamic game tractable. However, this approach is very computational intensive, especially when there are many incumbents in the model.
To study bank consolidation, some of the empirical literature focuses only on the merger problem. Hadlock at al. (1999) examine the effect of management incentives, corporate governance, and performance on the likelihood that a bank is acquired on a sample of banks that have at least $300 million in assets from 1982-1992. They find a negative relationship between levels of management ownership and the likelihood to be acquired, and little evidence on other incentives. Amel at al. (1989) include firm, market, and regulatory characteristics as covariates to test the merger likelihood using data from 1978-1983. They find weak evidence that banks with low profits and growth are more likely to be acquired. Hannan at al. (1987) use a multinomial logit model to estimate the relationship between the likelihood of acquisition and independent variables: return on asset, return on equity, relative return on asset, relative return on equity, capital ratio, market share, market deposit growth, bank’s deposit growth, lag of bank asset, loan to asset ratio, SMSA dummy, three-firm concentration ratio, and time fixed effect, using a large sample of Texas banks from 1971 -1982. They find a positive relationship between market share and the likelihood of being acquired, and negative relationship for capital ratio, and for the SMSA dummy. There are no significant effects of profits and growth.

Besides studies on acquisition likelihood, there is another strand of the literature that conducts reduced form analysis on improvements in operational efficiency (including cost efficiency and profit efficiency) and accounting ratios pre- and post-merger.24 Additional papers focus on event-studies of stock and bond market reaction after merger.25 There are also event-study papers regressed a set of independent variables, which includes the merger decision, against non-stockholder value maximization variables as dependent variables to identify other possible

24 See Akhigbe et al. (2004), Ashton JK at al. (2007), Berger at al. (1998).
incentives for merger.\textsuperscript{26} All these studies use merger as a covariant to examine the effect of merger.

Another strand of empirical papers on bank consolidation studies bank failure only. Whalen (1991) studies the relationship between important bank financial variables on the failure hazard using data from 1987-1990. For all different versions of model specification, he finds that the share of commercial real estate loans is always insignificant. Cole at al. (1995) estimate the same relationship using a split-population model from 1986-1992. However, there is no clear distinction between failure and merger in these papers. Thomson’s (1992) two-step model of the closure decision extends the bank failure literature by explicitly separating economic insolvency from the closure rule. Wheelock at al. (1995) estimated a hazard model only on failure for a panel of Kansas banks, and merger in their paper is treated as censored.

In papers that examine both merger and failed or closed exit with a clear distinction between these two types, Wheelock at al. (2000) studies this problem in a sample of banks with at least $50 million of assets in 1984, and Robert DeYoung (2003) analyzes a smaller sample of 1664 new commercial banks chartered in the U.S. between 1980 and 1985.

In this paper, I introduce an Extended Cox model to identify the characteristics affecting bank exit decisions first following Wheelock (2000) without separating different merger types to check the robustness of the estimation results using a broad sample with all commercial banks in the U.S. banking industry from 2000-2010. I further extend the model by breaking down the competing risks into a full set of all possible exit decisions to correct estimation results. I also include debt composition variables, as they are also important financial factors.

\textsuperscript{26} See Anderson C at al. (2004), Bliss at al. (2001), Hughes at al. (2003), Gupta at al. (2007) for example.
I find that the well-capitalized banks are less likely to fall into failed or closed merger and failed or closed exit, and that capital ratio is not important to strategic or developmental associated mergers, such as regular merger and corporation reorganization merger. Asset structure is important for all general exit decisions. Failed or closed merger and failed or closed exit shares many similarities such as positive relationship on construction & land development loans and subordinated debt to the corresponding risk, and negative relationship on capital ratio and age to the corresponding risk. There is no robust result on the asset growth.

The remainder of the paper is organized as follows: section 4.2 introduces the methods used. Section 4.3 presents data used. Section 4.4 presents estimation results without breaking down merger types. Section 4.5 extends the model to include a full set of competing risks and provides the estimation results. Section 4.6 concludes.

### 4.2 Methodology

The method I am using is a Competing Risks Extended Cox Model with time-dependent covariates. Using $x$ to represent time-dependent covariates, the cause-specific hazard rate, which represents the risk of event $j$, is:

$$
\lambda_j(t, x) = \lim_{dt \to 0} \frac{\Pr\{t \leq T < t + dt, J = j | T \geq t, x\}}{dt}
$$

(4.1)

The overall hazard is

$$
\lambda(t, x) = \lim_{dt \to 0} \frac{\Pr\{t \leq T < t + dt | T \geq t, x\}}{dt}
$$

(4.2)
A bank that exits the market selects one leaving choice from the possible set of causes:

\[ R = \{ \text{regular merger; interim merger; corporation reorganization merger; failed or closed merger; failed or closed exit} \} \]

Therefore, we have

\[ \lambda(t, x) = \sum_{j=1}^{m} \lambda_j(t, x) \]  

(4.3)

To construct the general form of the likelihood function, the cause-specific density of failure is

\[ f_j(t, x) = \lim_{dt \to \infty} \frac{\Pr\{t \leq T < t + dt \mid x\}}{dt} = \lambda_j(t, x)S(t, x) \]

(4.4)

The likelihood function for cause \( j \) is

\[ L_j = \prod_{i=1}^{n} \lambda_{j_i}(t_i, x_i)^{d_i} S(t_i, x_i) \]  

(4.5)

Where \( i \) represents an observation in the risk set, \( d_i \) is the indicator for \( i \) died of \( j \).

The standard Cox model is

\[ \lambda(t \mid x) = \lambda_0(t) \exp(x \beta) \]  

(4.6)

Where \( \lambda_0(\cdot) \) is the baseline hazard function. The Cox hazard model is a semi-parametric model such that the focus of estimation is on the effect of change in the control variables on the change in the hazard. The baseline hazard is not identifiable, and no additional assumptions are
required for estimation. According to the partial-likelihood method suggested by Cox (1975), we can write the partial-likelihood function for competing risk as

\[
L = \prod_{j=1}^{m} \prod_{i=1}^{k_j} \frac{\exp(x_{ji} \beta_j)}{\sum_{k \in R(t_{ji})} \exp(x_{jk} \beta_j)}
\]  

(4.7)

Where \( k_j \) is the number of death due to cause \( j \), \( R(t_{ji}) \) is the risk set at time \( t_{ji} \). The partial-likelihood function is the joint function of all causes, and for each particular cause \( j \), all other causes of exit are treated as censored.

4.3 Data

The sample includes all commercial banks in the U.S. from 2000-2010. There are two main sources of data used in this chapter. The primary source is the CALL report collected by the FDIC. The other source is the Annual Merger Report to Congress again issued by the FDIC, which is used to separate merger types and mergers from failed or closed exits.

In this paper, I first estimate models using a simple cause set of \{ acquisition, failed or closed exit \}, which is the closest to Wheelock et al. (2000) in order to check the time robustness of the results using data from 2000-2010 for comparison to earlier models. The empirical model contains the covariates from the following information in bank operation to specify the exponential term in equation (4.6):

- Capital structure: total equity/total assets.
Assets composition: real estate loans/total assets, commercial & industry loans/total assets, agricultural loans/total assets, loans to individuals/total assets, construction & land development loans/total assets, and a lump sum residual assets variable defined as- other assets/total assets.

Debt composition: transaction deposits/total liabilities, time & saving deposits/total liabilities, subordinated debt/total liabilities, and a lump sum residual liabilities variable defined as- other liabilities/total liabilities.

Bank specific variables: bank age, log(total assets).

Earnings: net income/total assets.

Liquidity: (federal funds purchased – fed funds sold)/total asset.

In the bank financial report, debt composition variables mapping to total liabilities add up to one, which also holds on asset composition variables. Therefore, for both bank level asset and debt composition variables, the following identities hold:

\[ \sum_{i=1}^{n} A_i = 1, \text{ and } \sum_{i=1}^{m} L_i = 1 \]

Where \( A_i \) and \( L_i \) is each component in assets and liabilities respectively, and \( n = 6 \), \( m = 4 \) by the covariates construction in this paper. Recent papers have ignored the other assets and other liabilities. However, the coefficients on the categories are meaningful only in comparison to the omitted category. Effectively early papers estimate coefficients relative to these catchall categories as the reference benchmarks. An alternative is to choose a more homogeneous and relevant category as the benchmark. In this paper, I select real estate loans/total assets and time & saving deposits/total liabilities as the omitted categories. Real estate loans and time & saving
deposits are very standard in the operation and characteristic, which serve as better reference variables.

The numbers of mergers are shown in Figure 4, and important volume variables are reported in Table 16. It is obvious that regular merger and corporate reorganization merger are the two main merger types. There are relatively few failed or closed bank mergers before the 2007 financial crisis. The principle the FDIC used in failed or closed bank mergers is the “minimum cost approach”, which compares the cost of closing the bank to being taken over by an acquirer. Usually the acquirer requires compensation from the FDIC for taking over the banks liabilities. Interim merger has happened much less frequently, and there was no occurrence for commercial banks in this type after 2008. There were only 34 cases for the interim merger in the sample period, and given the number of covariates in the regression, the estimation result is not meaningful. Hence, I withdraw this merger type from alternative competing risk set. So there is no report on estimation results for this merger type.
Figure 4: Bank Merger Cases from 2000-2010

Note: m1 is the number of regular merger case; m2 is the number of corporate reorganization merger case; m3 is the number of interim merger case; m4 is the number of failed or closed bank merger case.

Table 16: Descriptive Statistics for Bank Merger Sample

<table>
<thead>
<tr>
<th></th>
<th>Total Assets</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Merger</td>
<td>5.9811E+08</td>
<td>1.1614E+06</td>
<td>1.0196E+07</td>
</tr>
<tr>
<td>Corporate Reorganization Merger</td>
<td>4.6396E+08</td>
<td>6.7732E+05</td>
<td>4.2686E+06</td>
</tr>
<tr>
<td>Interim Merger</td>
<td>7.3877E+06</td>
<td>2.1729E+05</td>
<td>1.9809E+05</td>
</tr>
<tr>
<td>Failed or Closed Bank Merger</td>
<td>9.8169E+07</td>
<td>6.9624E+05</td>
<td>3.2564E+06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Equity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1734E+08</td>
<td>2.2785E+05</td>
<td>2.5325E+06</td>
</tr>
<tr>
<td>4.6890E+07</td>
<td>6.8452E+04</td>
<td>4.7246E+05</td>
</tr>
<tr>
<td>7.4256E+05</td>
<td>2.1840E+04</td>
<td>2.0688E+04</td>
</tr>
<tr>
<td>1.0210E+07</td>
<td>7.2414E+04</td>
<td>3.2734E+05</td>
</tr>
</tbody>
</table>

Note: All data are real value chained to 2005 GDP; unit is one thousand dollars. The upper panel for the second and third column presents the means and standard deviations for total assets in the each merger subsample. The lower panel for the second and third column presents the means and standard deviations for the total equity in the each merger subsample in the same order.

Beyond the number of events, regular merger and corporate reorganization merger also represent the largest volume of merger activities in terms of both total equity and total assets.
involved. Failed or closed bank mergers happen less frequently, but are an important type of merger in terms of volume.

Descriptive statistics for independent variables are presented in Table 17. Commercial & industry loans, agricultural loans, loans to individuals, construction & land development loans, and subordinated debt have larger standard deviations relative to their mean values. Real estate loans are the primary source of a bank’s asset portfolio, and this loan share exhibits much less variation relative to other assets compositions. Time & saving deposits is the primary source in bank’s debt structure in general, which also shows less variation than other components of debt except transaction deposits.
Table 17: Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Regular Merger</th>
<th>Corporation Reorganization</th>
<th>Failed or Closed Bank Merger</th>
<th>Failed or Closed Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Capital Ratio</td>
<td>0.1151</td>
<td>0.0807</td>
<td>0.1130</td>
<td>0.0803</td>
<td>0.1053</td>
</tr>
<tr>
<td>Real Estate Loans/Total Assets</td>
<td>0.4157</td>
<td>0.1798</td>
<td>0.4096</td>
<td>0.1797</td>
<td>0.4518</td>
</tr>
<tr>
<td>C&amp;I Loans/Total Assets</td>
<td>0.0108</td>
<td>0.0414</td>
<td>0.0211</td>
<td>0.0576</td>
<td>0.0211</td>
</tr>
<tr>
<td>Agricultural Loans/Total Assets</td>
<td>0.0481</td>
<td>0.0817</td>
<td>0.0381</td>
<td>0.0776</td>
<td>0.0425</td>
</tr>
<tr>
<td>Loans to Individuals/Total Assets</td>
<td>0.0583</td>
<td>0.0746</td>
<td>0.0546</td>
<td>0.0617</td>
<td>0.0583</td>
</tr>
<tr>
<td>Construction &amp; Land Development Loans/Total Assets</td>
<td>0.0553</td>
<td>0.0744</td>
<td>0.0666</td>
<td>0.0877</td>
<td>0.0740</td>
</tr>
<tr>
<td>Other Assets/Total Assets</td>
<td>0.4117</td>
<td>0.2000</td>
<td>0.4101</td>
<td>0.2183</td>
<td>0.3522</td>
</tr>
<tr>
<td>log(Assets)</td>
<td>11.6903</td>
<td>1.2626</td>
<td>11.8402</td>
<td>1.6914</td>
<td>11.5732</td>
</tr>
<tr>
<td>Liquidity</td>
<td>-0.0068</td>
<td>0.0437</td>
<td>-0.0135</td>
<td>0.0585</td>
<td>-0.0088</td>
</tr>
<tr>
<td>Transaction Deposits/Total Liabilities</td>
<td>0.2497</td>
<td>0.1264</td>
<td>0.2439</td>
<td>0.1286</td>
<td>0.2401</td>
</tr>
<tr>
<td>Savings &amp; Time Deposits/Total Liabilities</td>
<td>0.4807</td>
<td>0.3945</td>
<td>0.2914</td>
<td>0.3840</td>
<td>0.3035</td>
</tr>
<tr>
<td>Subordinated debt/Total Liabilities</td>
<td>0.0005</td>
<td>0.0047</td>
<td>0.0010</td>
<td>0.0048</td>
<td>0.0004</td>
</tr>
<tr>
<td>Other Liabilities/Total Liabilities</td>
<td>0.2690</td>
<td>0.4006</td>
<td>0.4634</td>
<td>0.3962</td>
<td>0.4560</td>
</tr>
<tr>
<td>Net Income/Total Assets</td>
<td>0.0083</td>
<td>0.1007</td>
<td>0.0072</td>
<td>0.0651</td>
<td>0.0079</td>
</tr>
<tr>
<td>Age</td>
<td>63.7406</td>
<td>44.4126</td>
<td>54.1262</td>
<td>43.8132</td>
<td>57.3942</td>
</tr>
<tr>
<td># of observation</td>
<td>77358</td>
<td>2646</td>
<td>3466</td>
<td>1082</td>
<td>32.8369</td>
</tr>
</tbody>
</table>

Note: The first column presents the means and standard deviations for independent variables in the full sample including all commercial banks. The second to five column presents means and standard deviations for the independent variables in each merger case subsample.
4.4 Failed or Closed Bank Exit Hazard and Acquisition Hazard Estimation

Results

Wheelock and Wilson (2000) examine the hazard of bank exit due to either acquisition or failure with at least $50 million of assets from 1984-1993. They find that banks with lower capitalization, higher ratio of loans to asset, evidence of poor-quality loan portfolio, and lower earnings are at greater risks of failure. Banks in states with branching permitted allowing for risk diversification are also less likely to exit through failure. The results for the risk of acquisition in terms of capitalization and earnings are consistent with the results for the risk of failure. Branching opportunity increases the hazard for acquisition. The hazard for acquisition also declines with cost inefficiency.

In this paper, in addition to the asset composition variables chosen, I also include debt composition variables. The remaining of this section will first provide an intuitive expectation of each covariate’s effect. Then I will report the results. Bank capital ratio is included in the regression with the expectation of a negative correlation with the general hazard of exit. Capital behaves as a cushion for the risk that banks face, so a higher capital ratio could represent a positive signal for bank safety. I include the interaction term of capital ratio and bank size, as my data set contains all commercial banks in the industry and so has much more size heterogeneity than earlier studies. The same capital ratio may have different effects on large and small banks. Large banks have more diversification in scale and scope of operation, which would more actively reduce risk, and may prefer a different ratio of equity or debt financing given their risk control processes. Loans are usually illiquid and risky given long maturities. Banks with a relative higher portion of low risk loan type, for example agricultural loans, are more likely to
stay, and vice versa. Debt has a higher priority than equity in repayment; therefore, debt usually requires a lower rate of return than equity. In terms of debt compositions, it is reasonable to expect that a relatively higher portion of stable debt has a negative effect on general hazard of exit, and a relatively higher portion of risky debt such as subordinated debt has a positive effect. A higher portion of transaction deposits to total liabilities is a good signal for more active checking account business; therefore, it is likely to be negatively correlated with the general hazard of exit. The coefficient on the earnings ratio should also be negative. Age, as an approximation to a combination of unobservable variables, which could include accumulation of human capital, training programs, and firm culture, etc, should also have a negative sign on exit. I do not include state branch restrictions in the model, because interstate restrictions were repealed by the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994, which is prior to my sample period 2000-2010. After the brief intuitive expectations of effects, Table 18 shows the regression results.

---

27 Wheelock and Wilson (2000) have introduced branching dummy, given their sample is from 1984-1993. Interstate restriction was in the banking industry at that time.
Table 18: Acquisition and Failed or Closed Exit Hazard

<table>
<thead>
<tr>
<th></th>
<th>Acquisition Hazard</th>
<th>Failed or Closed Exit Hazard</th>
<th>Failed or Closed Exit Hazard</th>
<th>Failed or Closed Exit Hazard</th>
<th>Failed or Closed Exit Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>P-value</td>
<td>Coef.</td>
<td>P-value</td>
<td>Coef.</td>
</tr>
<tr>
<td>Capital Ratio</td>
<td>12.3300</td>
<td>0.0000</td>
<td>***</td>
<td></td>
<td>3.0270</td>
</tr>
<tr>
<td>C&amp;I Loans/Total Assets</td>
<td>0.1162</td>
<td>0.9036</td>
<td></td>
<td></td>
<td>0.3400</td>
</tr>
<tr>
<td>Agricultural Loans/Total Assets</td>
<td>-1.2410</td>
<td>0.0062</td>
<td>**</td>
<td></td>
<td>-3.0220</td>
</tr>
<tr>
<td>Loans to Individuals/Total Assets</td>
<td>-2.3840</td>
<td>0.0001</td>
<td>***</td>
<td></td>
<td>-0.0195</td>
</tr>
<tr>
<td>Construction &amp; Land Development</td>
<td>2.8770</td>
<td>0.0000</td>
<td>***</td>
<td></td>
<td>1.2810</td>
</tr>
<tr>
<td>Other Assets/Total Assets</td>
<td>0.2750</td>
<td>0.1893</td>
<td></td>
<td></td>
<td>0.3636</td>
</tr>
<tr>
<td>log(Assets)</td>
<td>0.0720</td>
<td>0.0438</td>
<td>*</td>
<td></td>
<td>0.2159</td>
</tr>
<tr>
<td>Liquidity</td>
<td>-0.5332</td>
<td>0.3725</td>
<td></td>
<td></td>
<td>-0.6130</td>
</tr>
<tr>
<td>Transaction Deposits/Total Liabilities</td>
<td>-1.3120</td>
<td>0.0004</td>
<td>***</td>
<td></td>
<td>-1.4500</td>
</tr>
<tr>
<td>Subordinated debt/Total Liabilities</td>
<td>13.8200</td>
<td>0.0000</td>
<td>***</td>
<td></td>
<td>4.7570</td>
</tr>
<tr>
<td>Other Liabilities/Total Liabilities</td>
<td>-0.3343</td>
<td>0.3339</td>
<td></td>
<td></td>
<td>0.3289</td>
</tr>
<tr>
<td>Net Income/Total Assets</td>
<td>-0.8694</td>
<td>0.0023</td>
<td>**</td>
<td></td>
<td>0.0241</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0016</td>
<td>0.0228</td>
<td>*</td>
<td></td>
<td>-0.0020</td>
</tr>
<tr>
<td>Capital Ratio*Log(Asset)</td>
<td>-1.4810</td>
<td>0.0000</td>
<td>***</td>
<td></td>
<td>-0.2446</td>
</tr>
<tr>
<td># of observation</td>
<td>77358</td>
<td></td>
<td>77358</td>
<td></td>
<td>76060</td>
</tr>
<tr>
<td># of events</td>
<td>1374</td>
<td></td>
<td>1433</td>
<td></td>
<td>1417</td>
</tr>
</tbody>
</table>

Note: The first column reports the regression estimators, p-value, and significance result without separating merger types. The second column presents the result for failed or closed exit. The third column presents the results using lag 1 period capital ratio to replace current capital ratio to handle endogeneity between capital ratio and the failed or closed exit hazard. The third column presents the results using lag 2 period capital ratio to replace current capital ratio to handle endogeneity between capital ratio and the failed or closed exit hazard. The third column presents the results using lag 3 period capital ratio to replace current capital ratio to handle endogeneity between capital ratio and the failed or closed exit hazard. *indicates significance at 0.1 level; *indicates significance at 0.05 level; **indicates significance at 0.01 level; ***indicates significance at 0.001 level.
4.4.1 Time to Acquisition

Besides commercial & industry loans/total assets, liquidity, and control variables such as other assets/total assets and other liabilities/total liabilities, all other covariates are significant. The insignificance of commercial & industry loans/total assets is consistent with Wheelock et al. (2000). In fact, federal funds as an approximation for liquidity do not provide much information; the insignificance might be due to the poor approximation.

The effect of capital ratio is significant, and the effect depends on the sign of $12.3300 - 1.4680 \log(\text{asset})$. I evaluate it at the mean value $12.1800 - 1.4680 \times 11.6903 = -4.9814$, which is negative as expected. On average, higher capital ratio reduces the acquisition hazard. The magnitude of this effect also depends on bank assets; it is more economically significant for large banks than small banks. For the same level of capital ratio improvement, the acquisition hazard for large banks decreases more relative to small banks.

Three out of the four assets composition covariates are significant. Shares of agricultural loans and individual loans have negative effects on the acquisition hazard using real estate loans as reference. A bank’s agricultural loans and individual loans are less risky than real estate loans to lead to the acquisition decision. The agriculture industry is usually relatively stable due to subsidies from government in many countries including the U.S. On the other hand; real estate loans usually have the longest maturity, which is associated with more uncertainty. Therefore, acquirer may be less likely to take over banks with a higher level of uncertainty in its asset portfolio if it has other options. While the share of construction & land development loans is the

---

28 Other assets/total assets is interpretable as a control variable. Therefore, I do not take it into asset composition covariates count.
29 The United State pays to farmers in direct subsidies as “farm income stabilization” in the following commodities: feed grain (mostly corn), upland cotton, wheat, rice, soybean, dairy, peanuts, sugar, minor oilseeds, tobacco, wool and mohair, vegetable oil products, honey, and other crops.
most risky loan type in asset portfolio, it has a positive effect on the acquisition hazard. To order
the preference of asset composition that leads to the acquisition decision: the first tier is
construction & land development loans, the second tier is real estate loans, and the last tier is
agricultural loans and individual loans.

The effect on control variable $\log(\text{asset})$ depends on the sign of $0.0720 - 1.4610 \times \text{capital ratio}$, which is a negative value even given the minimum capital requirement as 10%. Asset growth, which happens when $\log(\text{asset})$ is increasing, reduces the acquisition hazard. Given the same asset growth rate, acquisition is less likely to happen for banks with a higher capital ratio.

All debt composition covariates are significant.\textsuperscript{30} It is not surprising to have the same expected effects on transaction deposits and subordinated debt. To order the preference of debt composition that leads to the acquisition decision: the first tier is subordinated debt, the second tier is time & saving deposits, and the last tier is transaction deposits. Earnings ratio is negatively correlated to the acquisition hazard. Higher earnings lead the acquisition risk to decrease by a good income stream in bank profitability performance. Age, as an approximation of a collection of bank level unmeasurable variables is significantly negative related to the acquisition hazard as expected.

### 4.4.2 Time to Failed or Closed Bank Exit

Some covariates have the same effects on both time to acquisition hazard and time to failed or closed exit hazard. For example, the negative relationship to failed or closed exit hazard on agricultural loans, transaction deposits, and age; and positive relationship on construction & land

\textsuperscript{30} Other liabilities/total liabilities is interpretable as a control variable. Therefore, I do not take it into debt composition covariates count.
development loans and subordinated debt. The preference follows the same order as in acquisition hazard results.

The cross term of capital ratio and \( \log(\text{asset}) \) is not significant. Therefore, it is not reliable to derive effects on capital ratio and \( \log(\text{asset}) \) in this model specification. Current capital ratio is a potentially endogenous variable to the current exit decision, which might lead to the reported insignificant estimation result in the second column in Table 18. To handle this endogeneity, I further run the same model by replacing capital ratio with its values from a one-year to three-year lag, and present the results in column 3-5 in Table 18. In lag capital ratio model specifications, capital ratios with different lag period are all significantly negative, which indicates higher capital ratio history reduces the future failed or closed exit hazard on average. The effects on \( \log(\text{asset}) \) in all three lagged capital ratio models are positive, which contradicts the result for the acquisition hazard. Hence, I do not observe a consistent effect of asset growth on the general hazard of exit. Only capital ratio or lag value of capital ratio is consistently negatively correlated with the general hazard of exit.

Failed or closed exit hazard is more consistently affected by the debt composition variables; all of them are highly significant.\(^3\) In terms of asset composition, agriculture loans and construction & land development loans are significant. The cluster of impacts on the debt side and equity ratio to the failed or closed bank exit may be a signal that the bank’s evolution of corporate financing is more important to failed or closed exit risk. Especially, since at the same time only two variables out of four in asset composition is significant together with insignificant net income. Beyond debt side variables, longer age reduces the hazard of failed or closed exit, which is the same as in the acquisition case.

\(^3\) Other liabilities/total liabilities is treated as control variable.
4.5 Competing Risks within Acquisition Hazard Estimation Results

The Annual Merger Report to Congress can further extend the acquisition decision into four categories according to the classification. Therefore, given the availability of data, I will break the acquisition hazard into each subset of competing risks. The estimates for failed or closed exit hazard result will not change, as the estimation routine treat other cause-specific events as censored. Therefore, breaking down the acquisition into specific categories will not affect the failed or closed exit hazard results.

The purpose of this section is to compare the effects of bank-level variables on the risk of various types of acquisition. It is obvious that regular mergers and failed or closed mergers are very different given the motivation and regulatory process. To treat the combination of these two events as one event may produce noisy estimates because the numbers of these two events are different and the weight in estimation may drive the results closer to the event that is more frequent. The estimates will be improved in the model with a complete competing risks choice set. The regression result is reported in Table 19.  

\[ \text{32 I do not report the estimators for the interim mergers due to model specification. There are only 34 events in this type of merger and there are 14 parameters to estimate. Therefore, interim mergers are treated as being from truncated.} \]
### Table 19: Merger Hazards

<table>
<thead>
<tr>
<th></th>
<th>Regular Merger Hazard</th>
<th>Corporation Reorganization Merger Hazard</th>
<th>Failed or Closed Bank Merger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>P-value</td>
<td>Coef.</td>
</tr>
<tr>
<td>Capital Ratio</td>
<td>3.5482</td>
<td>0.3067</td>
<td>-1.8540</td>
</tr>
<tr>
<td>C&amp;I Loans/Total Assets</td>
<td>1.1805</td>
<td>0.4206</td>
<td>-1.0960</td>
</tr>
<tr>
<td>Agricultural Loans/Total Assets</td>
<td>-1.7644</td>
<td>0.0252</td>
<td>*</td>
</tr>
<tr>
<td>Loans to Individuals/Total Assets</td>
<td>-3.3695</td>
<td>0.0014</td>
<td>**</td>
</tr>
<tr>
<td>Construction &amp; Land Development Loans/Total Assets</td>
<td>2.4723</td>
<td>0.0033</td>
<td>**</td>
</tr>
<tr>
<td>Other Assets/Total Assets</td>
<td>1.0721</td>
<td>0.0010</td>
<td>***</td>
</tr>
<tr>
<td>log(Assets)</td>
<td>0.1006</td>
<td>0.0578</td>
<td>-0.1504</td>
</tr>
<tr>
<td>Liquidity</td>
<td>-0.6641</td>
<td>0.4549</td>
<td>0.0841</td>
</tr>
<tr>
<td>Transaction Deposits/Total Liabilities</td>
<td>-0.2916</td>
<td>0.5958</td>
<td>-1.1260</td>
</tr>
<tr>
<td>Subordinated debt/Total Liabilities</td>
<td>5.9510</td>
<td>0.2182</td>
<td>7.5080</td>
</tr>
<tr>
<td>Other Liabilities/Total Liabilities</td>
<td>0.3020</td>
<td>0.5334</td>
<td>-0.2928</td>
</tr>
<tr>
<td>Net Income/Total Assets</td>
<td>0.0639</td>
<td>0.7809</td>
<td>0.1004</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0014</td>
<td>0.2128</td>
<td>-0.0001</td>
</tr>
<tr>
<td>Capital Ratio*Log(Asset)</td>
<td>-0.5056</td>
<td>0.1463</td>
<td>0.1522</td>
</tr>
<tr>
<td># of observation</td>
<td>77358</td>
<td></td>
<td>77358</td>
</tr>
<tr>
<td># of events</td>
<td>514</td>
<td></td>
<td>685</td>
</tr>
</tbody>
</table>

Note: The first column reports the regression estimators, p-value, and significance result for regular merger subsample. The second column reports the regression estimators, p-value, and significance result for corporation reorganization merger subsample. The third column reports the regression estimators, p-value, and significance result for failed or closed bank merger subsample. * indicates significance at 0.1 level; * indicates significance at 0.05 level; ** indicates significance at 0.01 level; *** indicates significance at 0.001 level.
I focus on capital ratio and log(asset) impacts first. In regular merger and corporation reorganization merger, capital ratio and log(asset) are both insignificant. In the real world, these two mergers are more related to the firm’s strategic development. Therefore, acquirers might not be interested in bank at a bad capital cushion status, which is in an instantaneous risk of getting warning notice from regulators that requires capital injection. However, for failed or closed bank mergers capital ratio is important. To evaluate the effects on this merger type at the mean value:

\[
64.1100 - 8.2200 \times \log(\text{asset}) = -31.9841 < 0
\]

\[
0.2310 - 8.2200 \times \text{Capital Ratio} = -0.7143 < 0
\]

Better capital position, which provides adequate buffer, is likely to reduce the hazard for failed or closed mergers. The negative effect on log(asset) indicates that banks with assets on negative growth path are more likely to be acquired through failed or closed mergers. Combining all effects on capital ratio, it only has a negative effect on failed or closed decisions, which includes both failed or closed merger and failed or closed exit. There is no robust conclusion on the effect of log(asset).

As the regular merger associates more with strategic development, an unhealthy bank is hard to enter into the acquirer’s choice set, given the possible high cost involved in the merger process. Only acquiree’s asset composition attracts attention. Construction & land development loans rank higher in preference comparing to real estate loans, agricultural loans and loans to individuals rank the last to the associated risk. The insignificance in commercial & industry loans still holds as formal results. The debt structure for the regular merger decision is not
important. Results in Table 18 suggest that formal significance in debt composition variables in acquisition hazard regression in section 4.4.1 are driven by failed or closed bank mergers.

Corporation reorganization merger is a special case, which only happens between parent and affiliate institutions. If an affiliate bank has capital inadequacy problem, the parent bank would not like to take it over given limited liability in this firm organizational structure. Instead of a pure strategic development, this type of merger is more close to reorganization in its characteristic. Therefore, parent banks take both asset and debt composition variables into the decision process. Results on agriculture loans and loans to individuals show higher contributions than real estate loans, which is usually in long maturity and hard to adjust thereafter, to keep away from being merged by parent firm. Active transaction deposits are preferred than savings & time deposits, and subordinated debt if affiliate institutions want to stay in the industry.

Failed or closed merger shares more commonalities with failed or closed exit. Therefore, the effects of covariates follow almost the same pattern as failed or closed exit reported in Table 18. Asset and debt composition, capital ratio, and age all affect the decision. The impact of construction & land development loans is consistent in both failed or closed merger and failed or closed exit. However, in failed or closed merger, commercial & industry loans increase the corresponding likelihood; while in failed or closed exit, agricultural loans decrease the corresponding likelihood. The deviation of asset factor in failed or closed merger and exit may relate to bank location problem. In commercial and business active areas, usually there is financial institutions cluster effect. If failure or closure happens, it is easier to find a potential interested acquirer to take over the banks comparing to less developed rural areas, which gives the significance of commercial & industry loans in failed or closed merger, and the significance of agricultural loans in failed or closed exit.
4.6 Conclusion

The U.S. banking industry from 2000-2010 is stable in terms of regulation. Interstate restriction was repealed for seven years before 2000. The market became more concentrated with bank consolidation during the sample period. In this paper, I try to identify the bank characteristics that lead to the consolidation using a complete set of possible competing risks in order to provide a better understanding of merger process.

A well-capitalized bank is less likely to experience both failed or closed bank merger and failed or closed bank exit. Capitalization is not important for more strategic or developmental associated mergers, such as regular mergers and corporation reorganization mergers. Asset structure is important for all general exit decisions. Regular mergers focus only on the asset composition, agricultural loans, and loans to individual are negatively correlated to the regular merger hazard, and construction & land development loans is positive. Corporation reorganization mergers depend on both asset and debt structure. More agricultural loans, loans to individual, and transaction deposits reduce the risk; higher subordinated debt increases the risk. Failed or closed mergers and failed or closed exits share many similarities. There are positive relationship to construction & land development loans and subordinated debt, and negative relationship to capital ratio, transaction deposits, and age. The deviation of the effects between commercial & industry loans and agricultural loans in failed or closed mergers and exits may be a location problem. There is no robust result on the asset growth.
Bibliography


