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Abstract

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Abstract

We find several facts that suggest the Japanese regional loan market conforms to the "search-for-yield" phenomenon, in which banks are driven to provide more risky loans by diminished loan spreads. We use a structural model to estimate demand elasticity and the degree of competition in local loan markets simultaneously. Our estimates show that competition intensifies in markets where banks hold more slack liquidity caused by monetary easing, and where loan demand is less elastic against lowering interest rates due to a rapidly aging population. We find reasonably robust evidence that banks in such competitive markets are driven to extend riskier loans.
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1 Introduction

A large number of recent empirical studies present evidence for the risk-taking channel of monetary easing (e.g., Jiménez et al., 2014; Dell'Ariccia et al., 2017, among others). Regarding this channel, existing theory gives two opposite predictions. The traditional risk-shifting theory predicts that monetary easing will reduce bank risk taking because the lower funding cost reduces the benefit of taking additional risks by abusing the protection of limited liability (Keeley, 1990). On the other hand, the search-for-yield theory (Martinez-Miera and Repullo, 2017), which is also called the penetration effect (Dell'Ariccia et al., 2014), predicts that monetary easing increases bank risk taking because monetary easing diminishes the spread between the loan interest rate and funding cost, and so discourages banks from costly monitoring or screening against risky borrowers. Which of these counteracting forces dominates is determined by whether monetary easing diminishes the loan spread or not, in other words, the determinants of the extent of penetration from low funding costs to loan interest rates, such as loan demand elasticity and the competitive conduct of banks (Dell'Ariccia et al., 2014). Despite the abundant evidence for the risk-taking channel of monetary easing, we lack evidence of these determinants of price penetration. The present study is an attempt to fill this gap in empirical studies.

The first step toward this goal is the estimation of the key parameters: loan demand elasticity and the competitive conduct of banks. The traditional structural estimation methods in an empirical industrial organization provide us with good tools for the simultaneous estimation of these parameters (Iwata, 1974; Bresnahan, 1982; Lau, 1982; Porter, 1983). In this strand of the literature, competitive conduct is measured by a parameter indicating the response of total market supply to a one-unit increase of supply by one supplier, which we call the degree of competition. This methodology has already been applied to the loan market by many existing studies (e.g., Coccorese, 2005, 2009; Uchida and Tsutsui, 2005; Delis and Tsionas, 2009),[1] but to our knowledge it has never been used in testing for the search-for-yield and risk-shifting hypotheses. By applying this method, we can also identify the determinants of competitive conduct and demand elasticity,

[1] More recently, several papers present an estimation model, which explicitly includes the endogenous determination of share of the deposit market (Ho and Ishii, 2011; Aguirregabiria et al., 2016; Egan et al., 2017; Kumar, 2018) and the loan market (Crawford et al., 2018). There are also estimates of the dynamic discrete choice of entry and exit (Sanches et al., 2018), and merger (Akkus et al., 2016).

such as monetary policy and regional economic or demographic characteristics. In the second step, we test the sign of the correlation between the estimated degree of competition and risk taking by banks. In this step, we test whether the search-for-yield theory or the risk-shifting theory is at work.

The above structural estimation requires market-year panel data consisting of bank financial information including risk taking, and the economic data in each market. We construct our panel data by taking the share-weighted average of the financial variables of each bank with a branch in each market. We assume the loan market is geographically segmented by prefecture, following existing studies using Japanese data (e.g., Ishikawa and Tsutsui, 2013). The existing studies suggest that a loan market could be narrower than the prefecture (Degryse and Ongena, 2005; Ono et al., 2016b), but we use the prefecture segmentation assumption because it is the smallest geographical unit for which we can obtain consistent economic data. To measure market share, we use the proportion of all bank branches in each prefecture that each bank represents because we do not have loan share information. As a robustness check, we also use the branch share adjusted by the average size of branches of each bank, to address the possibility that branch size is positively correlated with bank size.

To measure the extent of bank risk taking, we use the ratio of loan-loss provision over the total loans. Japanese banks have been required since March 1998 to accumulate loan-loss provision to cover the reasonably expected default loss in accordance with the internal credit rating of each loan. The Japanese Financial Service Agency regularly examines whether banks appropriately classify loans and accumulate loan-loss provisions in accordance with the detailed criteria listed in the supervision guideline, *Inspection Manual for Deposit-Taking Institutions*, which was published in 1999 and revised several times since. The manual has another section that applies to loans to small and medium-sized enterprises (SMEs), which emphasizes the use of qualitative soft information in credit rating and allows less restrictive treatments. Both criteria indicate that inspectors from the agency conduct sample investigations of individual loans to assess the appropriateness of its credit rating and the assumptions in the calculation of loan-loss provisions. Thus, we can reasonably assume that the heterogeneity in loan-loss provisions caused by the discretion of individual banks does not significantly affect our analysis. A caveat on this measure is the reduced requirement for the provision for SME loans since November 2008 by the Small and Medium-sized Enterprises Finance Facilitation Act and related measures. We control for this effect by introducing an interaction term with a dummy indicating this period and the ratio of small firms in each prefecture into our structural estimation.

Z-score and the default distance are more popular in the existing literature. Nonetheless, we take the loan-loss provision for two reasons. One is data availability. To calculate the default distance, we need stock price information. However, this requirement reduces the data coverage severely because many banks delisted after establishing a bank-holding company and not all cooperative banks are listed on the stock exchange. Another reason is compatibility with the theoretical model. The theoretical models of search-for-yield focus on risk taking in the loan market. The key to the theory is the trade-off between the cost and benefit of monitoring, i.e., monitoring cost and loan spread. Z-score and default distance are not fully consistent with the theory because they capture all-inclusive risks from the entire business portfolio of banks including investment banking, securities trading, and other services.

The most popular index of competition is the Lerner index, or the price-cost margin, which is defined by (price minus marginal cost)/price. The higher the value of this index, the weaker is competition. In many existing studies, the numerator is assumed to be the loan spread after subtracting marginal cost. However, usually, the loan spread is higher for riskier loans to cover the loan-loss provision. Thus, the simple Lerner index may confuse aggressive risk taking with weaker competition. We avoid this confusion by explicitly taking into account the loan-loss provision in calculating spread. Another potential problem for the Lerner index is the notorious difficulty in the estimation of marginal cost, as is documented by Kim and Knittel (2006). We avoid using the estimated marginal cost directly for our key test for the correlation between competition and risk taking. Instead, we use the estimated degree of competition in the test. In the first-order condition for bank profit maximization, the Lerner index equals the ratio of the degree of competition over demand elasticity. Our estimation strategy enables us to see how monetary easing and demographic changes, such as aging, affect each of these components separately.

Our findings are as follows. From our structural estimation in the first step, we find that lending competition, measured by the degree of competition, gets stronger as the lending capacity of banks increases with deepening monetary easing. The competition mode shifts from Cournot to perfect or Bertrand competition. We also find that competition tends to be stronger in markets where the loan demand elasticity is low, i.e., loan demand does not increase in response to a lower interest rate due to an aging demographic. We also find clear evidence that banks in a more competitive market take more credit risks, which is measured by the loan-loss provision, from the two-way fixed-effect model with respect to prefecture and year. Instrumental variables (IV) regression and subsample regressions before and after the SME Financial Facilitation Act also consistently support the negative correlation between the degree of competition and risk taking. These findings are consistent with the search-for-yield theory.

The remainder of this paper is organized as follows. We clarify our empirical questions, or hypotheses, based on an overview of the current Japanese regional loan market and the existing theories in Section 2. We introduce our structural model for estimation and the test strategy for the correlation between competition and risk taking in Section 3. We describe the dataset in Section 4. We summarize our findings from the structural estimation in Section 5 and the panel regression for the second step in Section 6. Section 7 concludes.

2 Hypothesis development

In this section, we clarify our empirical questions. We first overview the current status of the Japanese loan market. We then review the existing theories that potentially explain the observed symptom and list the points that we will prove in our dataset.

2.1 The Japanese regional lending market under prolonged quantitative easing.

Under the threat of deflation, since 1999 the Bank of Japan (BoJ) has maintained an expansionary monetary policy to keep the money-market interest rate around zero, with two periods of nontraditional monetary policy, that is, quantitative easing (QE). The first QE was implemented from March 2001 to March 2006. The second QE, called quantitative and qualitative easing (QQE) and more aggressive in terms of the quantity and variety of assets to be purchased by the BoJ than the first, began in April 2013. QQE still continues as of July 2019 with reinforcement by negative interest on a part of the excess reserve in January 2016 and fine-tuning by the introduction of yield-curve control in September 2016. Under this prolonged quantitative easing, the loan spread of all types of banks kept declining from 2004 and reached an extremely low level recently (Figure 1).

The suppressed loan spread has a more serious impact on regional banks and cooperative banks, known as *shinkin* banks, whose main business is domestic lending and have less access to the foreign market. The concern was made public by the commissioner of Japan's Financial Service Agency as early as 2014, in the news article "Financial Service Agency sharpens its stance to promote consolidations among regional and regional II banks. The commissioner [· · ·] said, unusually, 'consolidation is an important alternative.' He also predicted market shrinkage over the next 10 years · · · " (Jan. 25, 2014 on p.5, *The Nikkei*, translated by the author). The BoJ also published a report showing a similar concern (Box 3: Intensified competition among regional financial institutions and its background, p.85, Bank of Japan, 2017). In the report, they argue that "in both metropolitan and provincial areas, population decline and the increase in the number of competing branches, as well as the tightening of term spreads, contribute to pushing down markups."

The diminished loan spread pushed regional banks in two directions. One is the surge of consolidations. A number of regional banks announced consolidation plans, and many had carried them out (see Table 1), despite the concerns of the Fair Trade Commission, Japan's antitrust agency. The other is the reckless loan provision for retail real-estate investments. It was reported that some banks extended these loans without regular loan documentation and screening. For example, Suruga Bank was investigated by FSA in April 2018 for its lax lending for retail real-estate investments ("FSA Alert Suruga Bank," The Nikkei, p.5, May 12, 2018). Seibu Shinkin Bank also received an operation improvement order for similar matters from FSA in May 2019 ("Champion of Shinkin, Crooked Management," The Nikkei, p.7, June 14, 2019).

2.2 Existing theories

2.2.1 Competition fragility versus concentration fragility.

Many theories and related empirical studies have examined the relationship between bank competition and risk taking. There is a long history of controversy between studies expounding competition fragility and those focusing on concentration fragility.

The most famous argument for the former view is that based on risk shifting (e.g., Keeley, 1990). Increased competition in the deposit market pushes up the financing cost of banks and increases the incentive for banks to take more risks by abusing the limited liability protected by their deposit insurance. Many studies provide empirical evidence for this view (e.g., Gan, 2004; Berger et al., 2009; Beck et al., 2013; ck and Shehzad, 2015).

The concentration fragility view argues that increased competition reduces loan interest rates, which improves borrowers' performance by encouraging efficiency-enhancing investments (Koskera and Stenbacka, 2000) or by improving borrowing entrepreneurs' incentive for their increased stake (Boyd and Nicoló, 2006). Akins et al. (2016) gives empirical support for this view.

There are also several theoretical models between these two extremes, showing a nonlinear relationship between the extent of competition and risk taking (e.g., Allen and Gale, 2004; Martinez-Miera and Repullo, 2010; Arping, 2017). Many empirical studies report nonlinear or mixed results (e.g., Bretschger et al., 2012; Tabak et al., 2012; Mirzaei et al., 2013; Kick and Prieto, 2015; Ojima, 2018).

2.2.2 Monetary easing and risk taking.

More recently, many empirical studies provide evidence for the so-called risk-taking channel, i.e., monetary easing drives banks to more aggressive credit risk taking by lowering the credit standard against riskier borrowers and riskier form of loan contracts (e.g., Jiménez et al., 2014; Delis et al., 2017; Dell'Ariccia et al., 2017; Paligorova and ao Santos, 2017; Heider et al., 2019).[2] The widely accepted theory explaining this phenomenon is the search-for-yield theory (Martinez-Miera and Repullo, 2017), which is also called the penetration effect (Dell'Ariccia et al., 2014) of lower money-market rates.

These models show that the diminished loan spread reduces the monitoring or screening incentive of banks because the benefit of monitoring falls with the spread. If monetary easing reduces the spread, in other words, if the lower financing cost for banks fully penetrates to the loan interest rate, the monetary easing diminishes the spread, and so it discourages their monitoring. The lax screening or reduced monitoring is equivalent to the provision of risky loans. Thus, monetary easing

[2] In the context of the Japanese economy, Nakashima et al. (2016) gives evidence for listed companies and Ono et al. (2016a) for SMEs.

can push banks to take more risks.

The traditional risk-shifting theory of Keeley (1990) suggests that the reduction in the financing cost with insufficient penetration induces less risk taking by banks because reduced interest expense reduces the benefit of abusing the limited liability of bank shareholders. Thus, Dell'Ariccia et al. (2014) argues that whether the search-for-yield effect dominates the risk-shifting effect depends on the determinants of interest rate penetration, such as the extent of competition and demand elasticity in a loan market.

2.3 Empirical questions

In light of the current status of the Japanese regional lending market, where the spread diminishes under prolonged monetary easing, and the anecdotal evidence that regional banks scramble for lax risky lending, the theory that seems to fit the best is the search-for-yield theory. To prove formally that search-for-yield is at work in Japan, we need to verify empirically which factors affect the penetration of low financing cost to the loan interest rate, especially the market conduct of competing banks, loan demand elasticity, and the impact of monetary easing and other factors.

To put this more concretely, we ask the following questions of our dataset.

Empirical Questions

1. *Does monetary easing drive banks to more aggressive lending competition?*
2. *How does a demographic factor, such as the reduction of the working-age population, shift the regional loan demand function?*
3. *How does the shift in the competitive conduct of banks and the loan demand function affect risk taking by banks?*

3 Empirical strategy

To answer the above questions empirically, we take two steps. First, we estimate the key parameters, i.e., the degree of competition, and the demand elasticity in each regional loan market in each year, using a structural estimation method developed in the field of industrial organization. We include demographic factors and monetary policy factors in our estimation to answer the first and second empirical questions. Second, we examine the correlation between bank risk taking and the estimated degree of competition using a fixed-effect model with panel data.

3.1 Structural estimation for the regional lending market

We consider a model where a bank, with access to a single or multiple regional markets, allocates the optimal amount of loans to each market so as to maximize its total profit under the assumption that the loan market is segmented by region. This segmentation assumption is plausible under the empirical findings on the importance of geographical proximity in SME lending (Degryse and Ongena, 2005; Ono et al., 2016b) and the prefectural segmentation in Japan's loan market (Ishikawa and Tsutsui, 2013). Each bank may have market power in the segmented loan market while being a price-taker in the deposit market or the money market to finance itself. The latter assumption comes from the observation that the central bank exerts a very strong grip on the money market in our data period and that the deposit market is subject to arbitrage pressure from the money market. We assume that the location of branches is fixed to focus on decisions about loan amounts.

At time t, bank b decides the amount of the loan l_{bit} (≥ 0) in region i. Each bank takes into account the inverse demand function for loans $R(L_{it})$, which is decreasing in L_{it}, where $L_{it} = \sum_b l_{bit}$ is the total loaned in region i at time t. We denote the funding cost per unit of loan by ρ_{it}. We express the total cost of bank b in all regions, excluding funding costs, by a continuously differentiable function $c(L_{bt}, w_{bt})$, where $L_{bt} = \sum_i l_{bit}$, the total amount of loans of bank b, w_{bt} is the wage for each banker at bank b. We denote the expected default cost or the credit cost by D_{bit}. We set up the model for structural estimation as if D_{bit} were an exogenous variable, but the model does not essentially change even if we explicitly model the banker's choice of risk level[3].

[3]For example, we can assume a default probability $q(e_{bit})$, which is decreasing and convex with respect to a banker's effort e_{bit}, i.e., $q'(e_{bit}) < 0$ and $q''(e_{bit}) > 0$. We also assume that $q(\infty) = 0$ and $q(0) = \bar{q} \leq 1$. We assume the cost of effort is expressed by $\phi(e_{bit})$ which is increasing and convex in e_{bit}. If we denote the recovery rate of defaulted loans by K_{bit}, then the required modification for the profit maximization problem (2) in the main text is to plug in $D_{bit} = \{R_{it}(L_{it}) - K_{bit})\}q(e_{bit})$ and to subtract the effort cost $\phi(e_{bit})$. The additional first-order condition with respect to e_{bit}, which determines the level of D_{bit}, is

$$q'(e_{bit})\{K_{bit} - R_{it}(L_{it})\}l_{bit} - \phi'(e_{bit}) = 0. \tag{1}$$

Because we cannot obtain data for the recovery rate and the cost for monitoring, we treat D_{bit} as an exogenous variable, instead of explicitly including this first-order condition in our estimation model.

Under these assumptions, bank b's profit maximization problem is

$$\max_{\{l_{bit}\}_{i,t}} \pi_{bt} \equiv \sum_{i \in N_{bt}} \{R_{it}(L_{it}) - D_{bit} - \rho_{bit}\} \, l_{bit} - c(L_{bt}, w_{bt}). \tag{2}$$

The first-order condition with respect to l_{bit} is

$$R_{it}(L_{it}) - D_{bit} - \rho_{it} + \frac{\partial R_{it}}{\partial L_{it}} \frac{\partial L_{it}}{\partial l_{bit}} l_{bit} - \frac{\partial c}{\partial L_{bt}} = 0, \tag{3}$$

Following the IO literature (e.g., Porter, 1983), we can rewrite the first-order condition (3) as follows:

$$R_{it}(L_{it}) - D_{bit} - \rho_{it} - \frac{\theta_{bit}}{\beta_{it}} R_{it}(L_{it}) - \frac{\partial c}{\partial L_{bt}} = 0, \tag{4}$$

where $\theta_{bit} \equiv \frac{\partial L_{it}}{\partial l_{bit}} \frac{l_{bit}}{L_{it}}$, and $\beta_{it} \equiv -\frac{\partial L_{it}}{\partial R_{it}} \frac{R_{it}}{L_{it}}$, i.e., θ_{it} is the degree of competition, and β_{it} is the demand elasticity. θ_{it} equals one if a bank behaves as a monopoly for homogeneous services, zero under the perfect or Bertrand competition with a symmetric marginal cost, or the market share of the bank under Cournot competition.

We assume that the marginal cost function has a quadratic form,

$$\frac{\partial c}{\partial L_{bt}} = \alpha_0 + \alpha_1 L_{bt} + \alpha_2 L_{bt}^2 + \alpha_3 w_{bt} + \alpha_4 w_{bt}^2 + \alpha_5 L_{bt} \cdot w_{bt}. \tag{5}$$

Adding the FOC (4) in region i over banks after multiplying both sides by the market share s_{bit} of bank b in region i gives our supply function.

$$Spread_{it} = \frac{\Theta_{it}}{\beta_{it}} R_{it} + \alpha_0 + \alpha_1 L_{it}^s + \alpha_2 L_{it}^{s2} + \alpha_3 w_{it} + \alpha_4 w_{it}^2 + \alpha_5 L_{it}^s \cdot w_{it} + \iota_t^s + \mu_i^s + \epsilon_{it}^s, \tag{6}$$

where

$$\begin{aligned}
Spread_{it} &\equiv \sum_b s_{bit} \{R_{it}(L_{it}) - D_{bit} - \rho(L_{bt})\}, \quad \Theta_{it} \equiv \sum_b s_{bit} \theta_{bit}, \\
L_{it}^s &\equiv \sum_b s_{bit} L_{bt}, \qquad L_{it}^{s2} \equiv \sum_b s_{bit} L_{bt}^2, \quad w_{it} \equiv \sum_b s_{bit} w_{bt}, \\
w_{it}^2 &\equiv \sum_b s_{bit} w_{bt}^2, \quad w_{it} \cdot L_{it}^s \equiv \sum_b s_{bit} L_{bt} w_{bt}.
\end{aligned}$$

αs are coefficients to be estimated, ι^s is the year fixed effect, μ^s is the region fixed effect, ϵ_{it}^s is the error term. The aggregated version of the degree of competition Θ_{it} is zero under perfect or Bertrand competition with symmetric marginal cost, one under monopoly, and the Herfindahl index under Cournot competition. Another method of aggregation is bank-level aggregation, but we use region-level aggregation to avoid additional estimation complication [4]

We assume the regional loan demand function with price elasticity β_{it} as follows.

$$\ln L_{it} = \beta_0 - \beta_{it} \ln R_{it} + \beta_2' X_{it} + \iota_t^d + \mu_i^d + \epsilon_{it}^d, \tag{7}$$

where βs are the coefficients to be estimated, X_{it} is the vector of demand shifters, ι^d is the year fixed effect, μ^d is the region fixed effect, and ϵ_{it}^d is the error term.[5]

To estimate the time-varying or cross-sectionally heterogeneous Θ_{it} and β_{it} under the restriction that these are positive, we formulate these key parameters as follows:

$$\Theta_{it} = \exp\left\{\delta_0 + \delta_1' Y_{it} + \sum_{k=2}^{47} \delta_k \mathbf{1}(i=k) + \sum_{k=2004}^{2018} \delta_k \mathbf{1}(t=k)\right\}, \tag{8}$$

$$\beta_{it} = \exp\left\{\zeta_0 + \zeta_1' Z_i\right\}, \tag{9}$$

where δs and ζs are coefficients to be estimated. Y_{it} is the vector of covariates with the degree of competition, which varies over year and region. Z_{it} is the vector of covariates of demand elasticity, which varies between regions. The last point implies that we assume that the demand elasticity β_{it} is time invariant. Although the primary purpose of this assumption is to keep the model simple and to make our estimation feasible, it is also economically acceptable. Demand elasticity is likely to be dependent on the availability of alternative funding instruments for potential borrowers and the fundamental determinants of loan demands, such as demographic factors. We do not observe any significant developments for alternative instruments in our data period from 2003 to 2018. The demographic factors move very slowly. For these reasons, we assume time-invariant demand elasticity.

To control for the regional fixed effect, we subtract the regional mean from both sides of the demand function (7) under the assumption that elasticity varies only cross-sectionally, i.e., $\beta_{it} = \beta_i$.

[4] If we aggregate the first-order condition for each bank over regions after multiplying the share of each region over the total loan of the bank $\tilde{s}_{bit}$, the first term in the right-hand side is $\sum_i \frac{\theta_{bit}}{\beta_{it}} \tilde{s}_{bit} R_{it}$. If we assume that $\theta_{bit} = \theta_{it}$, i.e., the degree of competition in each region is identical for all banks, we can obtain the time-invariant version of the estimate of $\frac{\theta_i}{\beta_i}$ by regressing the spread to the 47 variables, $\tilde{s}_{bit} R_{it}$ $(i = 1, 2, \cdots, 47)$. To allow for the time variation in the estimates, we need the interaction term of these 47 variables with other time-varying variables or year dummies, in our dataset 15 dummies. The model quickly gets too complicated to converge or yield reliable estimates.

[5] An alternative specification is the one including the trend term of each prefecture in place of the prefecture fixed effect, which controls for the prefecture-specific trend. The estimation result does not significantly differ from the baseline model. The result is available from the author upon request.

To see the impact of the time-series variation of β_{it}, we estimate the model with the subperiod sample. For the supply function (6), we include the regional dummy and the year dummy directly in the estimation.

We estimate the system equations (6) and (7) simultaneously by the full information maximum likelihood estimation with Berndt-Hall-Hall-Hausman (BHHH) sandwich standard error under the assumption that the error terms follow an i.i.d. joint-normal distribution $N(\mathbf{0}, \mathbf{\Sigma})$ where

$$\mathbf{\Sigma} = \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix}. \tag{10}$$

3.2 Testing for search-for-yield

We test the sign of the correlation between the extent of lending competition, which is measured by the estimated degree of competition $\hat{\Theta}_{it}$, and risk taking, which is measured by the ratio of loan-loss provision over the total loan, D_{it}, using the region-year panel data.

We regress the estimated degree of competition onto credit cost after controlling for the unobservable region fixed effect and the unobservable year fixed effect to avoid complication due to the measurement error of the estimated regressor.

$$\hat{\Theta}_{it} = \gamma_0 + \gamma_1 D_{it} + \iota_t + \mu_i + \epsilon_{it}, \tag{11}$$

where ι_t is the year fixed effect, μ_i is the region fixed effect, and ϵ_{it} is the error term satisfying the standard assumptions for a fixed-effect model. We test for search-for-yield by examining the sign and significance of the estimated coefficient γ_1.[6]

4 Data

4.1 Data source

The most important part of the dataset is the panel data of the annual financial statements of the banking accounts of all commercial banks in Japan, including major banks, which are called *city*

[6]It appears possible to estimate a linear relationship between $\hat{\Theta}_{it}$ and D_{it} without flipping sides with the supply function (6) and the demand function (7) as a simultaneous equation model of three equations. However, it is not feasible to estimate it after two-way demeaning with respect to region and year because of the extra complication of the estimated covariate $\hat{\Theta}_{it}$.

banks, trust banks,[7] regional banks including the second-tier regional banks, and cooperative banks, which are called *Shinkin* banks. The sample period is from the accounting year ending in March 2003 to that in March 2018. Most of this dataset is collected from the Nikkei NEEDS Financial Quest database. We augment this for several banks using the database of the Japanese Bankers Association, and the Nikkin Shiryo Nenpo, published by Nihon Kin'yu Tsushinsha because Nikkei NEEDS does not cover all of those banks that are not listed on the stock exchange, or in the last year before a merger. We also collect bank merger information from the Nikkin Shiryo Nenpo.

We collect branch location information from the CD-ROM appendix of Nihon Kin'yu Meikan, published by Nihon Kin'yu Tsushinsha, which is available since October 2002. This database includes the name of banks, their branches, their exact address, type, such as whether it is virtual or real; a regular branch or a subbranch. We connect this information to the financial statement data for the next March; for example, the branch information as of October 2002 is connected to the financial statement as of March 2003.

We connect this bank information to regional economic data for the period from 2003 to 2018, which are collected from the online database of the BoJ, the Ministry of Internal Affairs and Communications, and the Ministry of Land, Infrastructure, Transport and Tourism. The details are listed in the definition of variables (Table 2). We assume the timing for matching in the same way as for connecting the branch information.

4.2 Measurement issues

We must pay special attention to measurement issues given the limited availability of data. We summarize these in this section.

4.2.1 Aggregating to the regional level

First, we need to set an assumption about the border of a regional loan market. Many studies have found that the geographical proximity with a bank branch has a significant impact on information production and lending for SMEs, the main users of bank lending (e.g., Degryse and Ongena,

[7]We exclude the small trust banks that are subsidiaries of major banks. The list of trust banks included in our dataset is Mitsubishi UFJ Trust (created from the merger of Mitsubishi Trust and UFJ Trust in 2005), Mizuho Trust (known as Mizuho Asset Trust until 2002), and Mitsui-Sumitomo Trust (Chuo-Mitsui Trust and Sumitomo Trust until 2011).

2005). In the context of Japan, Ono et al. (2016b), using a huge dataset of SMEs in 2010, find that the median distance from a small firm borrower to the branch of its main bank is 1.7 km, and that small firms more often switch their main bank after the closure of its nearest branch following a bank restructuring. In light of these findings, it is reasonable to assume that the geographical reach of each regional loan market is as small as a city including its commuting area. However, the repeated consolidations among cities in the 2000s make it almost impossible for us to obtain economic indicators for each area in a consistent manner. The smallest municipality unit, for which economic indicators are consistently available, is the prefecture. Thus, we assume that the loan market is segmented by prefecture.

More than half of all loans is for SME financing even at major banks, whose main business area is in metropolitan areas. The ratio is more than 75% for regional banks and cooperative deposit-taking institutions, which are called *shinkin* banks, as documented in Ogura (2018). Thus, the target of our analysis includes the lending businesses recorded on the banking account of city banks, trust banks, regional banks, and shinkin banks in our analysis.

To obtain information at prefecture level of aggregation, which is required for the estimation of the supply function (6), we need to calculate the share-weighted average of each item, such as spread and loan rate R. However, data on the loan share of banks in each prefecture are not available. To overcome this data limitation, we use two types of proxies. The first is the share of the number of regular branches of each bank in each prefecture, which we call branch share. In calculating branch share, we drop virtual online branches and subbranches and treat multiple branches as one branch if their addresses are identical to avoid double counting. This measure of share is simple, but it can overestimate the share of small banks because the asset size of a branch tends to be larger for large banks. To address this issue, we use the second measure of share, which is adjusted by the average size of branches of each bank, as follows:

$$s_{bit} = \frac{n_{bit} \times \frac{L_{bt}}{\sum_i n_{bit}}}{\sum_b \left\{ n_{bit} \times \frac{L_{bt}}{\sum_i n_{bit}} \right\}}, \tag{12}$$

where n_{bit} is the number of branches of bank b in prefecture i at time t, and $\frac{L_{bt}}{\sum_i n_{bit}}$ is the average size of bank b at time t. We call this the size-adjusted branch share.

4.2.2 Risk-taking

Most existing studies, mentioned above, use the Z-score or the default distance as a measure of risk taking by banks. A potential problem of using these popular measures in our context is that these measures capture not only the risk taken in the loan market but also that in other markets or businesses. At this point, these measures are not perfectly consistent with the theoretical search-for-yield model or of risk shifting, where the relationship between the loan spread and the monitoring incentive for banks is the key concept. We, therefore, use the ratio of loan-loss provision over the total loan as a risk-taking measure specific to the loan market.

In Japan, banks have been required since March 1998 to set aside a loan-loss provision for each loan to cover the expected default loss in accordance with their internal credit rating (Section 3.3.18, p.413, in Ginko Keiri Mondai Kenkyukai, 2008). The Japanese Financial Service Agency regularly examines whether banks appropriately classify loans and accumulate loan-loss provisions in accordance with the detailed criteria listed in the supervision guidelines, *Inspection Manual for Deposit-Taking Institutions*, which was published in 1999 and revised several times since then. The manual has another section that applies to loans to SMEs, which emphasizes the use of qualitative soft information in credit rating and allows less restrictive treatments. Both sections of the manual indicate that inspectors from the agency conduct sample investigations of individual loans of 50 million JPY or more[8] to assess the appropriateness of its credit rating and the assumptions in the calculation of loan-loss provisions. The manual requires banks to prepare the provision for the next year for loans classified as "normal" and three years for loans classified as "needs attention." It also requires banks to calculate the provision from the expected default probability and the expected recovery rate that are estimated from the data in the past three years. Thus, we can reasonably assume that the heterogeneity in loan-loss provisions caused by the discretion of individual banks does not significantly affect our analysis.

A caveat to this measure is that the regulatory requirement for the provision varies over time to affect bank lending stances. The single most important change in our dataset is the loosened criterion for "normal" loans, which is the least risky class. The required provision is smaller

[8] Loans of 20 million JPY or more were the target of sampling before 2004.

for normal class than those that need attention. Thus, this loosened criterion reduces the loan-loss provision. The manual defines the "needs attention" class as borrowers who have "problems with lending conditions (i.e., waivers, reductions, or deferrals of interest), have problems with fulfillment (i.e., de facto arrears on principal or interest payments), have poor results or are unstable, have problems with its financial position)" (English version in June 2014). The revision of the inspection manual in 2004 allowed banks to classify those that are in these troubled categories into the "normal" class if they have a business improvement plan that is "deemed rational and possessed of a high potential for achievement." One requirement for judging achievability is that the plan reasonably helps a firm overcome the above troubles within about three years. In response to plummeted corporate performance in the 2008–09 financial crisis, the last requirement was loosened from three years to five years for SMEs in November 2008. This reduction was reinforced and formally legislated as a temporary statute, the Small and Medium-sized Enterprises Finance Facilitation Act, in November 2009. The revision of the manual in 2009 expanded the target of this exception to SME borrowers for one year that do not have a rationally achievable business improvement plan but are expected to make it in one year. The manual retains this exception currently, as of September 2019, after the expiration of the Act in March 2013.

These policy changes started to affect bank financial statements in March 2009 because March is the regular end of the accounting year for Japanese banks. The target of the policy is SMEs. Therefore, we control for this effect by introducing an interaction term with a dummy indicating the years 2009 and after and the ratio of small firms in each prefecture in our structural estimation model. To address this problem in the fixed-effect regression for the search-for-yield hypothesis, we examine the subsample regressions for the period before 2008 and that after.

4.2.3 Mark-up after credit cost

Most of the existing studies define the mark-up, i.e., price minus marginal cost, of lending business by the difference between the income per asset and its marginal cost including the funding cost. This difference has a positive correlation with the credit premium to cover the credit cost. Thus, aggressive risk taking can be (mis-)interpreted as higher market power under this definition of the mark-up. To avoid this critical misrepresentation, we subtract the credit cost, which we defined in the previous subsection, in calculating the spread in Equation (6).

4.2.4 Control variables

For the loan demand shifter X_{it} in Equation (7), we include the natural logarithm of total construction expenditure, total tax base, working-age population (15–65 years old) and commercial land price in each prefecture. The tax base is that of the municipality residence tax, which is closer to total household income. The construction and tax base indicate the level of economic activity. We use the tax base in place of the gross prefectural product (GPP), and construction expenditure in place of investment as a component of GPP, because the former is updated in a more timely manner.[9] The commercial land price captures the nominal determinant of loan demand.

We added two supply shifters to the left-hand side of the supply function (6). One is the share of bank branches that experienced a merger in the past 3 years. The other is the interaction term of the dummy indicating the years 2009 and after and the small firm ratio in each prefecture, which we name "exempt." The former is to look at the effect of mergers on cost efficiency. The latter is to control for the regulatory change of the loan-loss provision.

As the determinants of the degree of competition Y_{it} in Equation (8), we consider the liquidity ratio. This captures the room for loan expansion caused by QE, which injected massive reserves for banks. The idea is in the spirit of the standard empirical strategy to test the credit channel of monetary policy (Kashyap and Stein, 2000). In addition, we include the share of bank branches that experienced a merger in the past 3 years to see the anticompetitive effect of bank mergers.

As the determinants of demand elasticity Z_i in Equation (9), we include the prefecture means of the working-age population growth rate, population density, and the large firm ratio. We expect that loan demand is more elastic against the declining interest rate in the metropolitan area where working-age people flow in steadily. There may be more promising investment opportunities in more densely populated areas, but there might not be enough physical space for new investment projects in such areas. Larger firms tend to have access to funds in addition to bank loans, and so their demand for loans might be more sensitive to interest rates.

[9] Gross prefectural product is available only up to 2016, as of 2019.

4.3 Descriptive statistics

The detailed definition of the variables for estimating the model (6) and (7) are listed in Table 2. The descriptive statistics and the correlation matrix for the entire sample from 2003 to 2018 in 47 prefectures are given in Tables 2 and 3.

To obtain a visual summary of the key variables, we plot the median (triangle), and the 90th percentile (top of the segment) and the 10th percentile (bottom of the segment) of the 47 prefectures in each year, with respect to the loan rate R_{it}, the funding cost ρ_{it}, the credit cost D_{it}, and the annual growth rate of total loans in Figure 2. The loan rate keeps declining, except for 2008 and 2009 when the monetary policy regime returned to the traditional one. The funding cost also increased in these years, but it is almost zero in the other years and has almost no variation between prefectures. In contrast, credit cost varies widely between prefectures, while it keeps declining. The economic recovery from 2003 to 2007 and from 2013 to 2018 reduces the default probability and reduces the required loan-loss provision. Another cause is the SME Financial Facilitation Law and related regulatory changes, which reduced the required loan-loss provisions for SME loans in 2009 and later years. The growth rate of the total loans by all the banks in our data set remained at a high level following the QQE in 2013.

Reflecting these recent developments of each component, the spread before subtracting credit cost keeps declining as mentioned in the introduction, while the spread after subtracting credit cost diminishes at a much slower speed, varying greatly between prefectures (Figure 3).

Figure 4 shows the recent development of the factors affecting loan supply and demand. Liquidity ratio, which is defined by the ratio of reserve assets and liquid security holdings to total assets, has increased since 2010 and maintained its highest level since 2013. The working-age population diminishes continuously in almost all prefectures during our sample period. After the exceptional movement in 2011 evacuations caused by the Great Eastern Japan Earthquake, the reduction of the working-age population accelerated in 2013. This is because the first baby-boomers in Japan, born in the period from 1947 to 1949, reached the age of 66.

5 Result of the structural estimation

5.1 Estimated model

Table 4 shows the estimated coefficients of the model (6) and (7). Column (1) is the result from the dataset aggregated by branch-share weight. Column (2) is the result from the dataset aggregated by branch-size-adjusted branch-share weight (see Section 4.2.1). This result is very similar to Column (1).

Supply function δs are the coefficients of the determinants of the degree of competition. The most notable estimate is the coefficient of the liquidity ratio. This is negative and significant. This result implies that the massive quantitative easing, which increased the liquidity ratio of banks, intensified lending competition between banks. The coefficient of merger indicates no visible impact on competitive conduct.

αs are the coefficients related to the marginal cost of banks. The estimated coefficients indicate that the marginal cost is U-shaped both in the average asset size of banks L_{it}^s and the average wage of bankers w_{it}. However, marginal cost is at its minimum when L_{it}^s is about 65 in Column (1) and 36 in Column (2). Because they are above the sample maximum of L^s (Table 2), we should conclude that the marginal cost is decreasing in bank size. In other words, the lending business exhibits increasing returns to scale, as shown in the existing literature for U.S. data (e.g., Hugh and Mester, 1998; Wheelock and Wilson, 2018).

Likewise, marginal cost is at its minimum when w_{it} is about 8 in both columns. More than 90% of our prefecture-level observations are above this level. Thus, it is reasonable to conclude that marginal cost increases with wage levels.

The coefficient α(exempt) has a positive and marginally significant coefficient. This is consistent with our intuition that the regulatory change to reduce the loan-loss provisions for SME loans increased the spread. This also implies that the effect of the regulatory change is well controlled by this coefficient, at least partially.

The coefficient α(merger) is not statistically significant in both columns. The cost-saving effect of a bank merger could be captured by the coefficients of bank size L_{it}^s, which shows increasing returns to scale.

Demand function ζs are the coefficients of the determinants of demand elasticity. Demand elasticity is larger in regions where the working-age population is growing more or declining less rapidly. The mean density, which is supposed to feature the metropolitan area, has a negative and significant coefficient. This might reflect the possibility that loan demand does not increase despite the low interest rate due to the scant room for real-estate investment in densely populated areas. The large firm ratio has a positive coefficient, which is consistent with the intuition that larger firms have more alternatives for access to funds and more price elasticity although it is not statistically significant.

βs are the coefficients of demand shifters. The positive and significant coefficients of the tax base are reasonable results because loan demand is larger in a larger economy. Consistently, total construction expenditure and working-age population also have positive coefficients.

5.2 Estimated key parameters

Degree of competition The first key parameter is the degree of competition Θ_{it}. The median, 10th percentile, and 90th percentile of the degree of competition among prefectures in each year are plotted in Figure 5. The figure indicates the result from the baseline estimation with branch-share aggregate data (Panel (a)) and the branch-size-adjusted branch-share aggregate data (Panel (b)). The degree of competition keeps declining from its peak in 2004 to 2011. After the further drop to almost zero in 2014, the first fiscal year end after QQE, the degree of competition remains at a very low level, close to zero.

To clarify the change in the competition mode of banks, we plot the 95% confidence interval of the estimated degree of competition of each prefecture using the standard error calculated by the delta method and the branch-share Herfindahl index in the years 2004, 2009, and 2014 in Figure 6. The panel for the year 2004 indicates that the Herfindahl index is within the confidence interval in most prefectures, i.e., Cournot oligopoly is not rejected in these prefectures. The confidence interval exceeds 1 in two prefectures; Shiga (id=25) and Okinawa (id=47). According to our model, many prefectures are under Cournot oligopoly or perfect competition, while the latter two prefectures could be under monopoly in 2004. Cournot oligopoly is rejected and only perfect competition is accepted in several prefectures: Tokyo (id=13), Kanagawa (Yokohama, id=14), Osaka (id=27), Akita (id=5), Kouchi (id=39), and Nagasaki (id=42). The former three are the largest metropolitan areas in Japan where many banks compete strongly. The latter three are rural areas far from the metropolitan areas. The low spread for these areas is mainly caused by the higher loan-loss provision D_{it}. Average D_{it} in our data period is 3.152% in Akita, 2.142% in Kochi, and 2.514% in Nagasaki (Panel (c), Table 5).

However, the confidence interval of the degree of competition is considerably lower in 2009 and later years. The confidence interval is far below the Herfindahl index and includes zero values in many prefectures, which means competition becomes Bertrand or perfect competition in these prefectures.

The classical theory of Kreps and Scheinkman (1983) tells us that Cournot competition is a Bertrand competition with a predetermined capacity constraint. According to this theory, a possible explanation for our observed shift is that the massive injection of the reserve by the BoJ mutes the capacity constraint for lending and makes the lending competition a pure Bertrand competition.

Demand elasticity Another key parameter is loan demand elasticity $\hat{\beta}_i$. We allow the cross-section variation for this parameter in our estimation to make our estimation feasible. Table 5 Panel (a), indicates quite a large cross-sectional variation. We observe a higher elasticity in the prefectures where the working-age population is increasing or decreasing less rapidly, such as Okinawa and Shiga. The comparison with the cross-section variation of the degree of competition (Table 5, Panel (b), and Figure 7) indicates a positive correlation between demand elasticity and the degree of competition. The correlation coefficient between them is indeed significantly large, 0.38, which is statistically significant at a 1% level. This implies that lending competition is stronger in markets where loan demand does not increase despite the massive monetary easing, probably because of the demographic problem.

6 Competition and risk-taking

We test the sign of the correlation between risk taking, measured by the loan-loss provision ratio D_{it}, and the estimated degree of competition $\hat{\Theta}_{it}$ by running a fixed-effect regression (11). The result is listed in Table 6. The first three columns are the results of the branch-share weighted aggregation. The next three columns are the results of the branch-size-adjusted branch-share weighted aggregation. Columns (1) and (4) are the estimates from the entire sample. Columns (2) and (5) are those from the period before the SME Financial Facilitation Act in 2009. Columns (3) and (6) are those after it. The coefficient of credit cost is negative and significant in all columns.

To address the potential endogeneity problem, for example, due to an unobservable common factor that is correlated with both the degree of competition and credit cost, we estimate the baseline model (11) using instrumental variable estimation. We use the weighted average of the capital ratio, which is defined by the ratio of the book-value gross capital over the total asset, as the instrumental variable.

This variable is highly likely to be negatively correlated with the credit cost for two reasons. One is that those with a low capital ratio are more willing to undertake more risk shifting. The other is that the accumulation of credit costs damages their capital.

On the other hand, the correlation between the capital ratio and the residual after regressing the degree of competition with credit cost can show either sign. The correlation can be negative because strong competition reduces bank profits, which also reduces the capital ratio in the long-run. However, if competition pushes banks to more aggressive risk taking, then the effect can be entirely absorbed by the change in credit cost. If so, they are uncorrelated. Competition tends to be more severe in markets where demand does not respond to lower interest rates as we showed in the previous section. Money creation is so slow in such markets that the capital ratio can be higher. Thus, the correlation can be positive. We expect that they are uncorrelated because these forces cancel out.

To check the latter point, we regress the degree of competition on credit cost and the capital ratio after two-way demeaning to remove the prefecture fixed effect and the year fixed effect. Table 7 shows the results when we use the dataset aggregated by the branch-share weight (Column (1)) and that by the branch-size-adjusted branch-share weight (Column (2)). The null hypothesis that the coefficient of the instrumental variable, capital ratio, is zero is not rejected in both datasets. Thus, the capital ratio reasonably satisfies the assumption of no correlation with the residual in the second stage, which is required for a valid instrumental variable.

The results for the IV regression are listed in Table 8. The first stage regression shows the negative correlation between credit cost and the capital ratio as we expect. The F statistics for IV exceed 10, the rule of thumb criterion. Thus, the IV satisfies the relevance assumption, which is another requirement for a valid instrument, very strongly.

The second stage shows the negative and significant correlation between the degree of competition and credit cost in both the branch-share weighted aggregation (Column 1) and the size-adjusted branch-share weighted aggregation (Column 2). The Hausman test statistics show that the endogeneity significantly matters in both datasets.

The negative correlation implies that stronger competition drives banks to more aggressive risk taking in the loan market. The massive quantitative easing, especially after 2013, intensifies lending competition in regions where loan demand is not very responsive to a low interest rate due to the declining working-age population. The pressure of the diminishing spread leads to aggressive risk taking by banks in such regions. Our findings are consistent with the search-for-yield/penetration effect (Dell'Ariccia et al., 2014; Martinez-Miera and Repullo, 2017).

7 Concluding remarks

Our structural estimations of the key parameters, the degree of competition and demand elasticity in the Japanese loan market, reveals several important facts. We have found that regional lending competition has become so strong that the competition mode has shifted from Cournot competition to perfect or Bertrand competition as the quantitative easing increasingly expanded the lending capacity of banks. The positive correlation between the degree of competition and demand elasticity implies that lending competition is even more severe in markets where loan demand does not increase despite lower interest rates because of the declining working-age population. The competitive pressure pushes local banks to take credit risks more aggressively. These findings are consistent with the predictions of the search-for-yield theory.

An additional implication of this result is that the expansionary effect of monetary easing through the usual credit channel of monetary policy, which is identified by, for example, Kashyap and Stein (2000), is weak in an economy where loan demand is inelastic against interest rate, possibly due to the lack of growth prospects.

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Figure 1: Loan spread

(Note) (Loan spread) = (loan yield) − (financing cost), where (loan yield) = (interest on loans and discounts)/(average outstanding loans and bills discounted) and (financing cost) = (interest expenses + overhead)/(average outstanding of financing accounts). Source: Japanese Bankers Association website (banks), and Shin'yo Kinko Gaikyo, Shinkin Central Bank (shinkin banks).

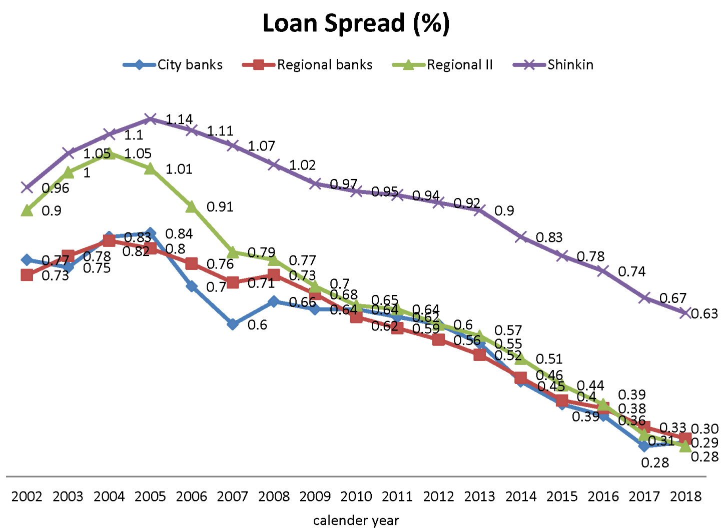


Figure 2: Components of spread and loan amount

(Note) Triangle indicates the median of 47 prefectures in each year. The top of the segment is the 90th percentile. The bottom is the 10th percentile.

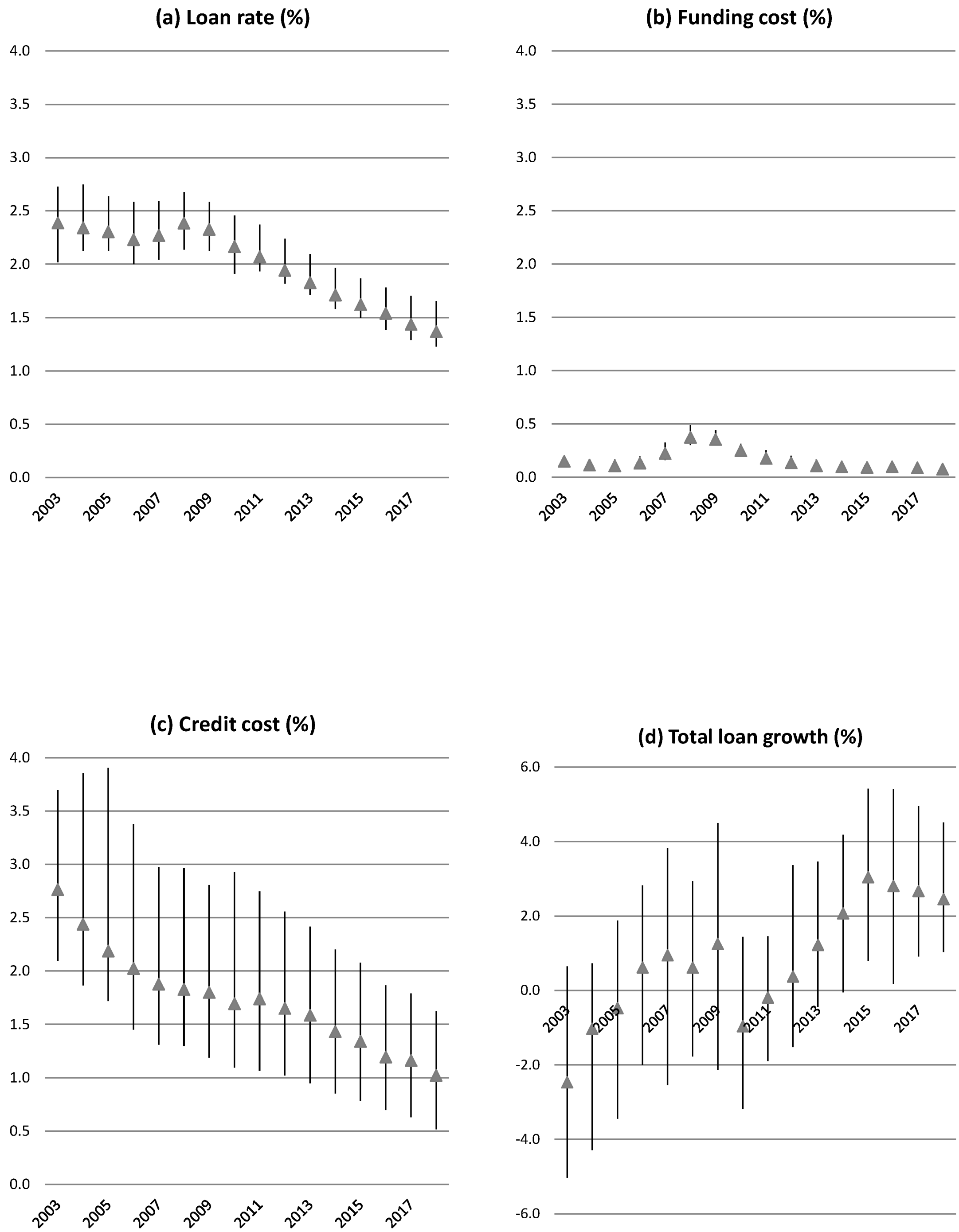


Figure 3: Spread

(Note) Triangle indicates the median of 47 prefectures in each year. The top of the segment is the 90th percentile. The bottom is the 10th percentile.

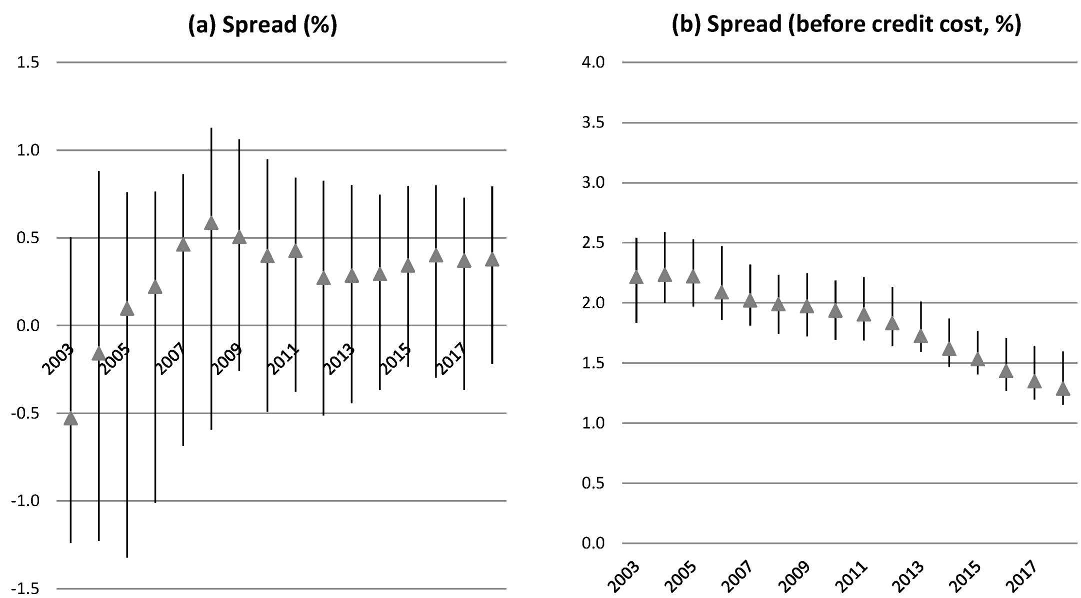


Figure 4: QE and Population

(Note) Triangle indicates the median of 47 prefectures in each year. The top of the segment is the 90th percentile. The bottom is the 10th percentile.

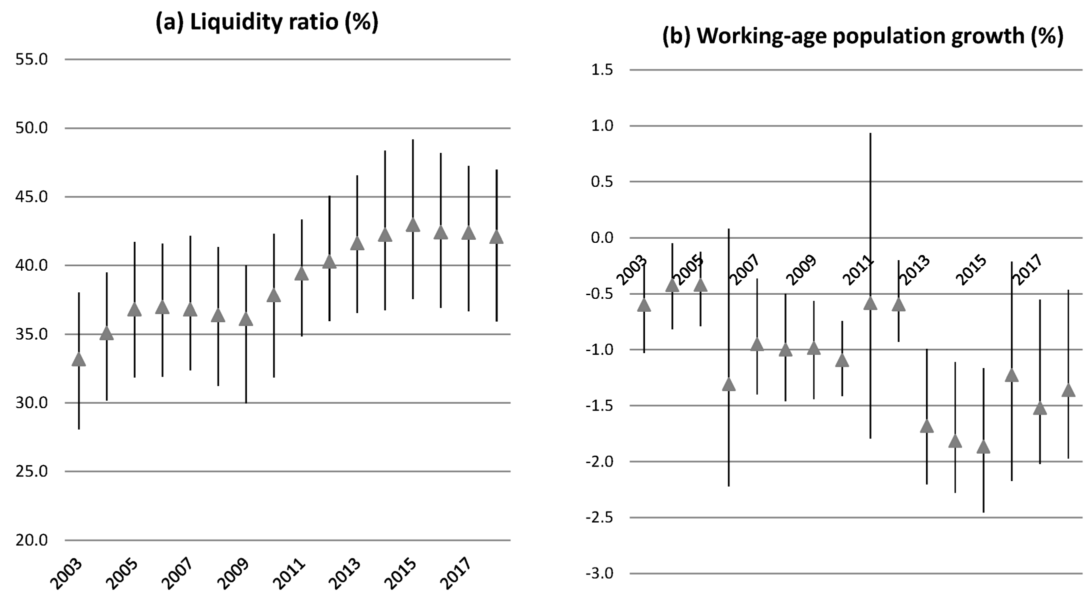


Figure 5: Estimated Degree of Competition $\hat{\Theta}_{it}$

(Note) Triangle indicates the median of 47 prefectures in each year. The top of the segment is the 90th percentile. The bottom is the 10th percentile. Panel (a) is the estimate from the branch-share weighted aggregation (Column (1) in Table 4). Panel (b) is that from the branch-size-adjusted branch-share weighted aggregation (Column (3) in Table 4).

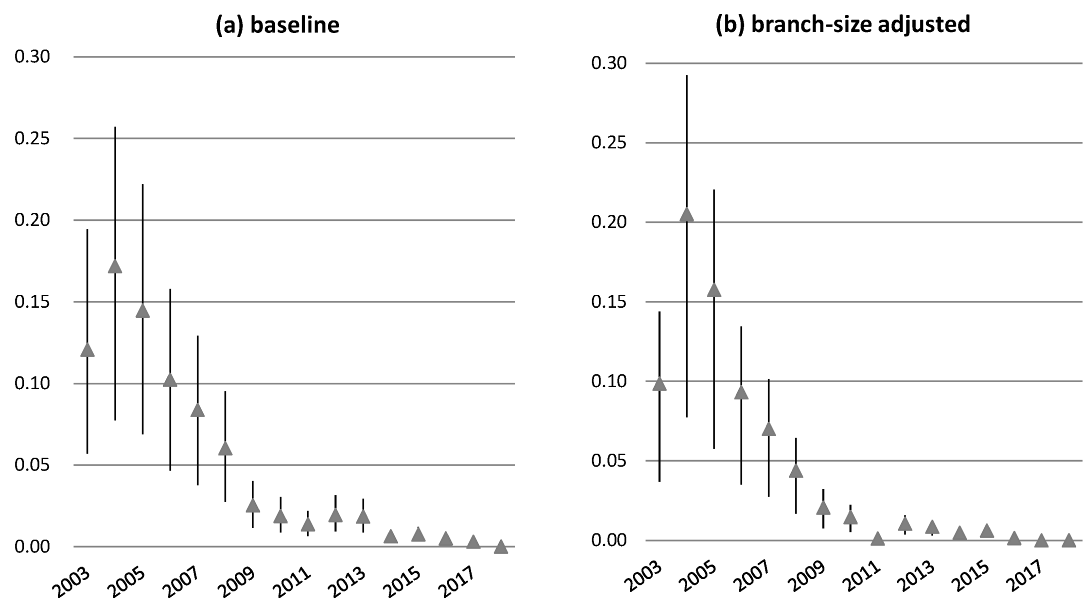


Figure 6: From Cournot to Bertrand

(Note) Horizontal: prefecture ID. Dot: Branch-share Herfindahl index. Bar: 95% confidence interval of $\hat{\Theta}$ from the baseline estimation (Column (1) in Table 4).

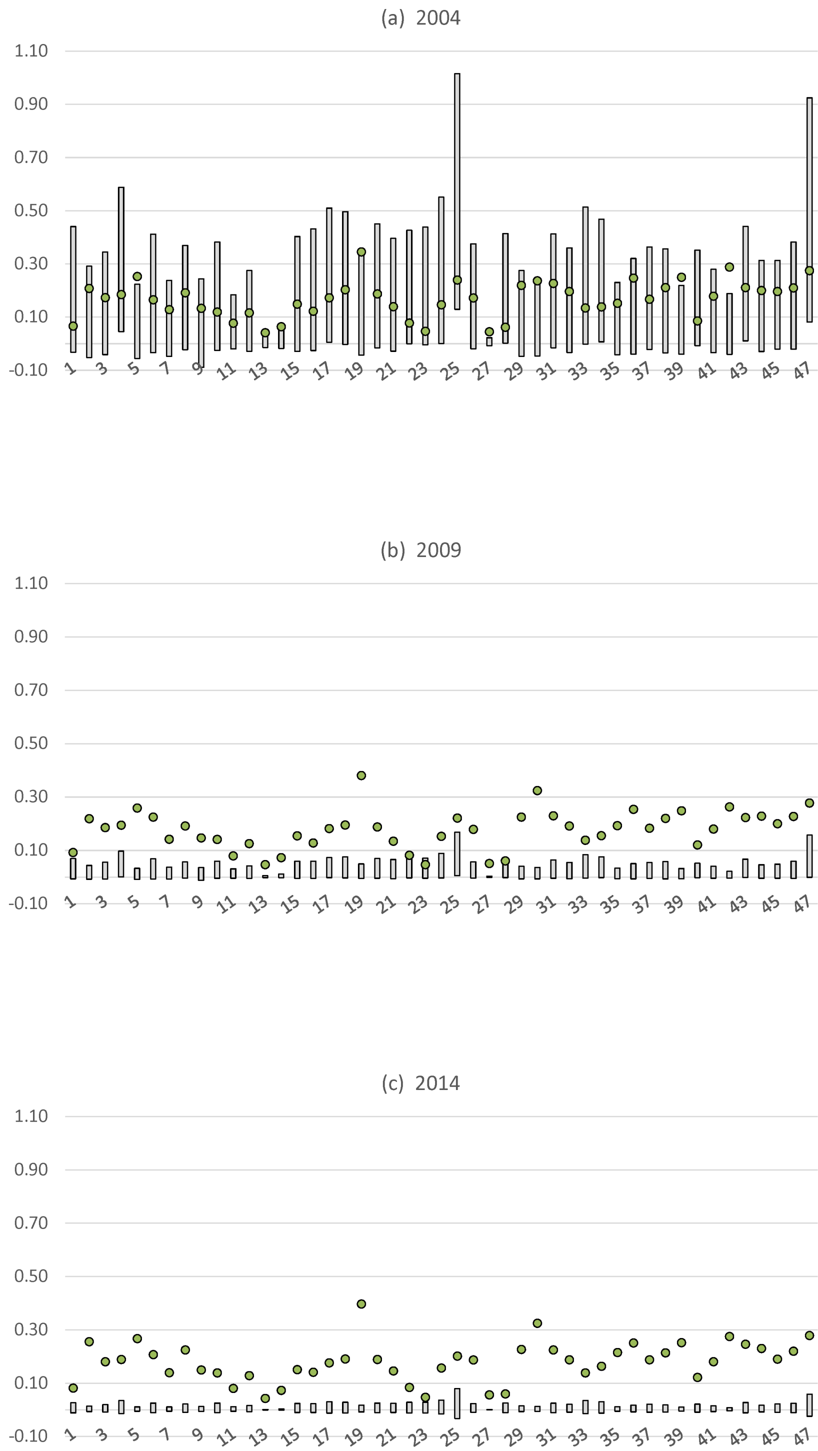
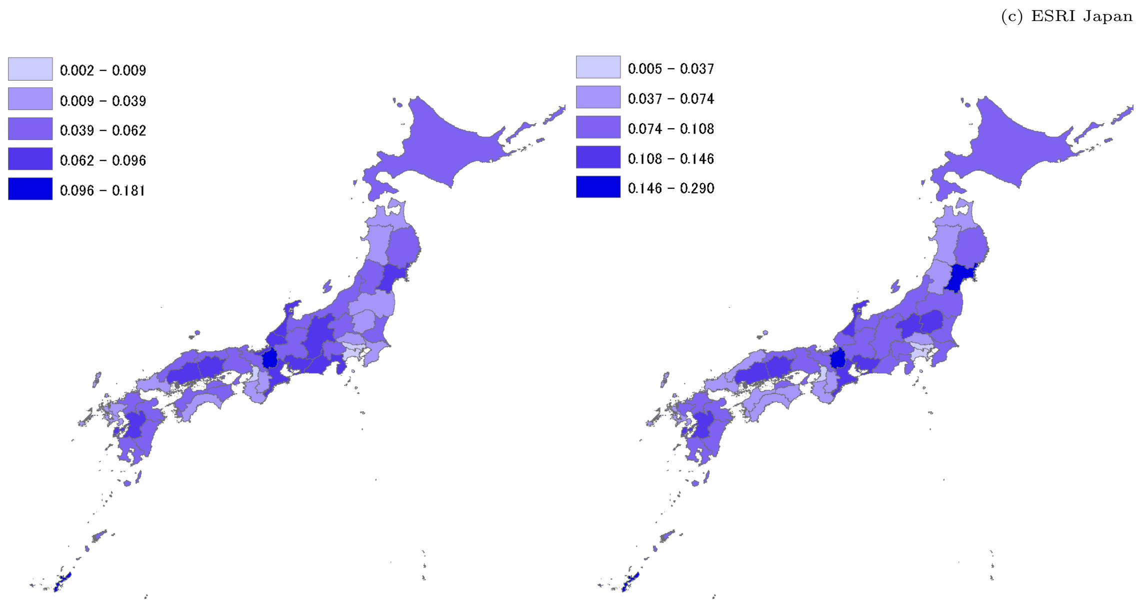


Figure 7: Estimated $\hat{\Theta}_{it}$ and $\hat{\beta}_{it}$ (mean in 2003–18)
(Note) Produced by the author from the digital map (geospatial information) by Geospatial Information Authority of Japan, and the National Municipality Border data by ESRI Japan.



(a) degree of competition (b) elasticity

Figure 8: Scatter plot: Degree of competition $\hat{\Theta}_{it}$ vs loan-loss provision D_{it}
(Note) Degree of competition is the estimate from the baseline estimation 4, Column (1). Both variables are two-way demeaned to remove the fixed effect of prefecture and year.

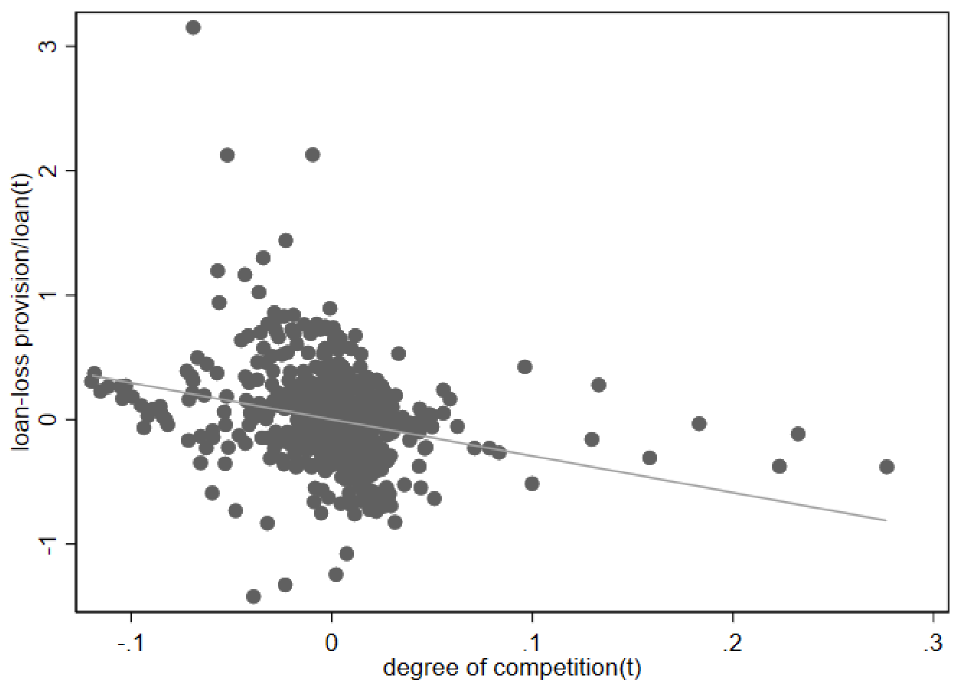


Table 1: Recent bank mergers
(Source) Nikkin Shiryo Nenpo (Nihon Kinyu Tsushinsha).

Bank name before merger	Bank name after merger	Merger date
Higo, Kagoshima	Kyushu Financial Group (FG)	October, 2015
Tokushima, Kagawa, Taisho	Tomoni Holding	April, 2016
Yokohama, Higashi Nihon	Concordia FG	April, 2016
Ashikaga, Joyo	Mebuki FG	October, 2016
Nishi Nihon City, Nagasaki	Nishi Nihon FG	October, 2016
Tokyo Tomin, Yachiyo	Kiraboshi	May, 2018
Mie, Daisan	Sanjusan FG	April, 2018
Daishi, Hokuetsu	Daishi Hokuetsu FG	October, 2018
Kansai Mirai FG, Kansai Urban FG, Minato	Kansai Mirai FG	April, 2018
Kinki Osaka, Kansai Urban	Kansai Mirai	April, 2019
Juhachi, Shinwa	Juhachi Shinwa	October, 2020 (exp.)

Table 2: Variable definition

Variable	Definition
L_{it}: total loan	Total loans outstanding by domestic banks including shinkin banks in each prefecture as of March, tril. JPY. Domestic bank data collected from the long-term time-series database in the BoJ website. Shinkin banks are the sum of loans of those headquartered in each prefecture. All are collected from Nikkei NEEDS Financial Quest.
R_{it}: loan rate	Weighted average of the ratio of interest on loans and discounts over loans and bills discounted in the accounting period ending in March in each year (%). Weight is the branch share of each domestic bank including shinkin banks, which is calculated from the database in the Nihon Kin'yu Meikan CD-ROM (Nihon Kin'yu Tsushin Sha). In calculating branch share, we drop subbranches and online virtual branches. We count as one branch if multiple branches have an identical address. Augmented for Jonan Shinkin and Kakegawa Shinkin in 2005 by Zenkoku Shinyo Kinko Zaimu Shohyo (Kin'yu Tosho Konsarutanto Sha), and for Saitama Risona Bank (2005,06), Gifu Bank (2011), Nagasaki Bank (2015–16), Kinki Osaka Bank (2012–16), and Ashikaga Bank (2005–2012) by the database on the Japanese Bankers Association (JBA) Bankers Library Website https://www.zenginkyo.or.jp/en/statistics/.
ρ_{it}: funding cost	Weighted average of the ratio of interest expenses over total funding in each prefecture (%). Weight is the branch share of each domestic bank including shinkin banks. Total funding is the sum of deposits, negotiable certificates of deposit, debentures, call money, payables under repurchase agreements, payables under securities lending transactions, bills sold, commercial papers, borrowed money, foreign exchanges, bonds payable, bonds with subscription rights to shares, borrowed money from trust account in the liability (English translation by JBA).
D_{it}: Credit cost	Ratio of provision for loans over total loans (%). Weighted average by the branch number share of each bank in each prefecture. Augmented for Towada Shinkin and Ninohe Shinkin in March 2008 in the same way as R.
Liquidity ratio	Ratio of liquid assets over total assets (%). Liquid assets are the sum of cash and due from banks, call loans, receivables under a resale agreement, receivables under securities borrowing transactions, bills bought, money held in trust, and securities on the asset side (English translation by JBA).
Spread$_{it}$	$R_{it} - \rho_{it} - D_{it}$ (%).
L^s_{it}: average bank size	Weighted average of bank size, measured by the total amount of loans located in each prefecture, tril. JPY. The weight is the branch number share.
w_{it}: banker's wage	Overhead cost per staff at each bank, mil. JPY. Weighted average by the branch number share of each bank in each prefecture. Augmented for Yamaguchi Shinkin in March 2003–2008 in the same way as R.

Table 1: (cont.)

Variable	Definition
Capital ratio	Book-value gross capital/total asset (%). Weighted average by the branch number share of each bank in each prefecture.
Construction	Total building construction started in each prefecture, fiscal year, tril. JPY. Construction General Statistics, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan.
Small firm ratio	Ratio of #private firms with less than 20 employees over #all private firms located in each prefecture, %. Enterprise Census in 2001, 2004, and 2006; Economic Census in 2009, 2012, 2014, and 2016, Statistics Bureau, Ministry of Internal Affairs and Communications, Japan.
Large firm ratio	Ratio of #private firms with 100 employees or more over #all private firms located in each prefecture, %. Enterprise Census in 2001, 2004, and 2006; Economic Census in 2009, 2012, 2014, and 2016, Statistics Bureau, Ministry of Internal Affairs and Communications, Japan.
Tax base	Total tax base of the municipality tax, i.e., household income in the previous calendar year, in each prefecture. Survey on the Taxation Status of the Municipality Tax, Ministry of Internal Affairs and Communications.
ΔTax base	Annual growth rate of tax base (%).
Population	Production age, 15–64 years old, population (thousands) as of October 1 in each year. From Population Projections, Statistics Bureau, MIAC, Japan.
ΔPopulation	Annual growth rate of the production age, 15–64 years old, % as of October 1 in each year. From Population Projections, Statistics Bureau, MIAC, Japan.
Density	Population density, 1000 persons per km^2.
Land price	Highest official land price in commercial districts in each prefecture, 100 thousand JPY per m^2. MLIT, Japan.
Exempt	(Small firm ratio) × a dummy, which equals 1 if the observation is in the fiscal years ending in 2009 and after.
Merger	Branch share of banks that had merged in the last 3 years including the current year, %. Merger information was collected from Nikkin Shirho Nenpo (Nihon Kin'yu Tsushin Sha).

Table 2: Descriptive statistics

(Note) Spread, L, R, ρ, D, L^s, and w are branch-share weighted average in each prefecture.

	N	mean	s.d.	min.	10%	25%	median	75%	90%	max.
Spread$_{it}$	752	0.20	0.64	-3.65	-0.67	-0.07	0.28	0.60	0.86	1.69
L_{it}	752	10.45	27.06	1.19	1.71	2.43	3.64	8.44	16.44	221.39
R_{it}	752	2.03	0.41	1.05	1.46	1.71	2.08	2.31	2.51	3.37
ρ_{it}	752	0.17	0.10	0.03	0.07	0.10	0.13	0.20	0.33	0.58
D_{it}	752	1.83	0.79	0.42	0.92	1.27	1.72	2.25	2.87	6.16
L^s_{it}	752	3.65	3.81	0.68	1.11	1.54	2.24	3.58	8.68	23.23
w_{it}	752	16.19	1.93	7.71	14.30	15.03	16.02	17.08	18.51	22.51
Liquidity ratio	752	38.71	5.10	22.88	32.29	35.16	38.65	42.12	45.02	54.72
Capital ratio	752	5.11	0.93	-0.94	4.09	4.59	5.10	5.59	6.08	9.44
Construction	752	1.08	1.09	0.18	0.35	0.46	0.66	1.24	2.42	8.15
Tax base	752	3.89	4.86	0.61	0.94	1.27	1.93	3.80	10.75	30.63
ΔTax base	752	-0.17	2.70	-9.60	-3.75	-1.65	0.28	1.56	2.79	9.47
Population	752	1730.15	1767.50	318	501	688	1014	1755	4627	9021
ΔPopulation	752	-1.05	0.71	-3.02	-1.95	-1.55	-1.01	-0.57	-0.24	3.88
Density	752	0.66	1.17	0.06	0.11	0.18	0.28	0.52	1.43	6.32
Land price	752	0.20	0.47	0.01	0.03	0.04	0.06	0.18	0.41	5.05
Small firm ratio	282	90.96	1.30	86.88	89.33	90.12	91.03	91.90	92.55	94.34
Large firm ratio	282	0.90	0.21	0.45	0.67	0.75	0.87	1.03	1.16	1.87
Merger	752	4.62	9.17	0.00	0.00	0.00	0.49	4.36	16.29	75.18

Table 3: Correlation matrix

(Note) Correlation coefficients are listed. Variables (1)–(9) and (18) are the branch-share weighted average in each prefecture.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	Spread	1.000								
(2)	L	0.179	1.000							
(3)	R	-0.089	-0.093	1.000						
(4)	ρ	0.229	0.115	0.477	1.000					
(5)	D	-0.855	-0.195	0.592	0.061	1.000				
(6)	L^s	0.306	0.737	-0.295	0.137	-0.402	1.000			
(7)	w	0.330	0.475	0.057	0.306	-0.237	0.652	1.000		
(8)	Liquidity ratio	-0.083	0.009	-0.556	-0.351	-0.218	0.072	-0.080	1.000	
(9)	Capital ratio	0.171	-0.124	-0.216	-0.238	-0.251	-0.144	-0.094	0.262	1.000
(10)	Construction	0.212	0.848	-0.150	0.067	-0.251	0.788	0.593	0.038	-0.118
(11)	Tax base	0.260	0.844	-0.143	0.139	-0.287	0.884	0.650	-0.005	-0.146
(12)	ΔTax base	0.210	0.120	-0.346	-0.033	-0.349	0.174	0.089	0.180	0.209
(13)	Population	0.258	0.772	-0.119	0.138	-0.272	0.860	0.662	-0.042	-0.172
(14)	ΔPopulation	0.083	0.313	0.290	0.186	0.082	0.251	0.266	-0.377	-0.242
(15)	Density	0.250	0.838	-0.092	0.171	-0.252	0.889	0.639	-0.094	-0.196
(16)	Land price	0.211	0.954	-0.102	0.143	-0.225	0.767	0.493	0.004	-0.102
(17)	Small firm ratio	-0.256	-0.441	0.669	0.188	0.570	-0.651	-0.286	-0.270	0.035
(18)	Large firm ratio	0.284	0.658	-0.431	0.025	-0.465	0.757	0.427	0.124	-0.109
(19)	Bank merger	-0.162	0.031	0.092	0.038	0.180	0.002	0.001	-0.168	-0.184

		(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(11)	Tax base	0.952	1.000							
(12)	ΔTax base	0.176	0.140	1.000						
(13)	Population	0.941	0.982	0.113	1.000					
(14)	ΔPopulation	0.356	0.377	-0.240	0.385	1.000				
(15)	Density	0.839	0.911	0.115	0.893	0.353	1.000			
(16)	Land price	0.847	0.855	0.126	0.785	0.334	0.835	1.000		
(17)	Small firm ratio	-0.582	-0.622	-0.262	-0.606	0.118	-0.526	-0.486	1.000	
(18)	Large firm ratio	0.747	0.792	0.242	0.766	0.185	0.705	0.678	-0.875	1.000
(19)	Bank merger	0.034	0.016	-0.068	0.035	0.036	0.054	0.027	0.047	-0.026

Table 4: Baseline structural estimation

(Note) Estimated coefficients of Equations (6) and (7) by FIML with the BHHH sandwich s.e. *** p<0.01, ** p<0.05, * p<0.1. Column (1) is the result from the branch-share weighted data. Column (2) is that from the size-adjusted branch-share weighted data. The estimated constant term and the coefficients of year and prefecture dummies are omitted. Prefecture dummies are not included in the demand function because the prefecture mean is subtracted from both sides of (7) in the estimation. The tolerance for the coefficients and the log likelihood are set at 1e-6 and 1e-7, respectively.

	(1)			(2)		
(Supply function)	Coef.	S.E.		Coef.	S.E.	
δ(liquidity ratio)	-0.022	0.008	***	-0.033	0.014	**
δ(merger)	0.001	0.001		-0.001	0.001	
$\alpha(L_{it})$	-0.135	0.068	**	-0.072	0.034	**
$\alpha(L_{it}^2)$	0.001	0.001	*	0.001	0.000	***
$\alpha(w)$	-0.103	0.027	***	-0.050	0.019	***
$\alpha(w^2)$	0.006	0.001	***	0.003	0.001	***
$\alpha(w \cdot L_{it})$	1.20.E-04	0.002		2.38.E-04	0.001	
α(merger)	-0.003	0.002		0.000	0.001	
α(exempt)	0.173	0.096	*	0.095	0.055	*
α(liquidity ratio)	-0.004	0.008		0.007	0.006	
(Demand function)						
ζ(mean Δpopulation)	1.154	0.454	**	0.939	0.352	***
ζ(mean density)	-0.777	0.186	***	-0.559	0.180	***
ζ(mean large firm ratio)	0.579	0.363		0.444	0.349	
β(ln construction)	0.023	0.014	*	0.021	0.014	
β(ln taxbase)	0.451	0.138	***	0.484	0.135	***
β(ln land price)	-0.018	0.014		-0.014	0.014	
β(ln population)	0.286	0.194		0.272	0.222	
σ_1	0.215	0.012	***	0.197	0.014	***
σ_2	0.048	0.002	***	0.047	0.002	***
σ_{12}	0.002	0.001	**	0.001	0.001	
N	752			752		
log likelihood	1331.1			1385.9		

Table 5: Regional heterogeneity in demand elasticity and the degree of competition

(Note) Calculated from the baseline result (Column (1) in Table 4).

(a) Mean of estimated elasticity, $\hat{\beta}_{it}$, in 2003–2018.

Hokkaido	0.094	Ishikawa	0.115	Okayama	0.142
Aomori	0.052	Fukui	0.107	Hiroshima	0.126
Iwate	0.075	Yamanashi	0.091	Yamaguchi	0.063
Miyagi	0.147	Nagano	0.099	Tokushima	0.066
Akita	0.039	Gifu	0.093	Kagawa	0.075
Yamagata	0.073	Shizuoka	0.095	Ehime	0.070
Fukushima	0.086	Aichi	0.116	Kouchi	0.052
Ibaragi	0.101	Mie	0.126	Fukuoka	0.095
Tochigi	0.132	Shiga	0.255	Saga	0.108
Gunma	0.116	Kyoto	0.095	Nagasaki	0.057
Saitama	0.052	Osaka	0.005	Kumamoto	0.110
Chiba	0.088	Hyogo	0.099	Oita	0.094
Tokyo	0.008	Nara	0.058	Miyazaki	0.083
Kanagawa	0.020	Wakayama	0.053	Kagoshima	0.089
Niigata	0.088	Tottori	0.096	Okinawa	0.286
Toyama	0.082	Shimane	0.074		

(b) Mean of estimated degree of competition, $\hat{\Theta}_{it}$, in 2003–2018.

Hokkaido	0.061	Ishikawa	0.075	Okayama	0.077
Aomori	0.035	Fukui	0.073	Hiroshima	0.071
Iwate	0.046	Yamanashi	0.045	Yamaguchi	0.028
Miyagi	0.093	Nagano	0.064	Tokushima	0.042
Akita	0.024	Gifu	0.056	Kagawa	0.050
Yamagata	0.058	Shizuoka	0.065	Ehime	0.048
Fukushima	0.029	Aichi	0.065	Kouchi	0.026
Ibaragi	0.051	Mie	0.081	Fukuoka	0.049
Tochigi	0.023	Shiga	0.172	Saga	0.036
Gunma	0.054	Kyoto	0.053	Nagasaki	0.021
Saitama	0.025	Osaka	0.002	Kumamoto	0.066
Chiba	0.037	Hyogo	0.062	Oita	0.042
Tokyo	0.003	Nara	0.033	Miyazaki	0.044
Kanagawa	0.008	Wakayama	0.029	Kagoshima	0.053
Niigata	0.054	Tottori	0.059	Okinawa	0.147
Toyama	0.057	Shimane	0.049		

Table 5: (cont.)

(c) Mean of the loan-loss provision rate (%), D_{it}, in 2003–2018.

Hokkaido	1.746	Ishikawa	2.255	Okayama	2.109
Aomori	2.108	Fukui	2.156	Hiroshima	1.932
Iwate	1.980	Yamanashi	2.887	Yamaguchi	2.310
Miyagi	1.850	Nagano	2.723	Tokushima	1.907
Akita	3.152	Gifu	1.781	Kagawa	1.673
Yamagata	1.486	Shizuoka	1.644	Ehime	1.387
Fukushima	2.300	Aichi	1.153	Kouchi	2.142
Ibaragi	1.897	Mie	1.536	Fukuoka	1.674
Tochigi	2.129	Shiga	1.278	Saga	2.442
Gunma	1.615	Kyoto	1.493	Nagasaki	2.514
Saitama	1.280	Osaka	1.318	Kumamoto	1.508
Chiba	1.291	Hyogo	1.498	Oita	2.888
Tokyo	1.229	Nara	1.200	Miyazaki	2.079
Kanagawa	1.389	Wakayama	1.270	Kagoshima	1.797
Niigata	1.261	Tottori	1.975	Okinawa	1.072
Toyama	1.615	Shimane	2.254		

Table 6: Degree of competition and risk taking

(Note) Dependent variable is $\hat{\Theta}_{it}$ (degree of competition). OLS with prefecture fixed effect and year dummies. Prefecture-clustered standard errors in parentheses. *** p<0.01, ** p<0.05, and * p<0.1. Columns (1)–(3) are the results from the data aggregated by branch-share weight, based on Column (1) in Table 4. Columns (4)–(6) are the results from the data aggregated by branch-size-adjusted branch-share weight, based on Column (3) in Table 4).

	(1)	(2)	(3)	(4)	(5)	(6)
	Branch-share weighted			Size-adjusted-share-weighted		
	2003–18	2003–08	2009–18	2003–18	2003–08	2009–18
D_{it}	-0.024***	-0.011**	-0.006**	-0.036***	-0.021***	-0.007***
	(0.006)	(0.005)	(0.002)	(0.007)	(0.007)	(0.002)
N	752	282	470	752	282	470
Adj. R^2	0.069	0.026	0.038	0.163	0.082	0.071
prefecture fe	yes	yes	yes	yes	yes	yes
year fe	yes	yes	yes	yes	yes	yes

Table 7: Noncorrelation between IV (capital ratio) and the error term

(Note) Dependent variable is $\hat{\Theta}_{it}$ (degree of competition). OLS with the dataset after two-way demeaning to remove prefecture fixed effect and year fixed effect. The estimated coefficient and the prefecture-clustered standard errors are listed. The estimated constant term is omitted from the report. *** p<0.01, ** p<0.05, and * p<0.1. Column (1) contains the results from the data aggregated by branch-share weight, based on Column (1) in Table 4. Column (2) contains the results from the data aggregated by branch-size-adjusted branch-share weight, based on Column (3) in Table 4.

	(1) Branch-share weight			(2) Size-adj. share weight		
	Coef.	S.E.		Coef.	S.E.	
D_{it}	-0.020	0.009	**	-0.030	0.009	***
Capital ratio	0.009	0.008		0.008	0.006	
N	752			752		
Adj. R^2	0.078			0.173		

Table 8: IV regression of the degree of competition on risk taking

(Note) IV regression, where D_{it} is instrumented by the capital ratio. The dependent variable in the first stage is D_{it}. The dependent variable in the second stage is $\hat{\Theta}_{it}$ (degree of competition). The variables are all two-way demeaned to remove prefecture fixed effect and year fixed effect. The estimated coefficient and the prefecture-clustered standard errors are listed. Estimated constant terms are omitted from the report. *** p<0.01, ** p<0.05, and * p<0.1. F is the Wald statistic for the test H_0: the coefficient of capital ratio is zero. H_0 for the Hausman is the OLS estimate in Table 6 (1) and (4), are consistent. Column (1) contains the results from the data aggregated by branch-share weight, based on Column (1) in Table 4. Column (2) contains the results from the data aggregated by branch-size-adjusted branch-share weight, based on Column (3) in Table 4.

	(1) Branch-share weight			(2) Size-adj. share weight		
	Coef.	S.E.		Coef.	S.E.	
(First stage)						
Capital ratio	-0.379	0.099	***	-0.382	0.058	***
F for excluded IV	14.61			42.77		
(p-value)	(0.000)			(0.000)		
(Second stage)						
D_{it}	-0.042	0.018	**	-0.050	0.011	***
Hausman $\chi^2(1)$ (p-value)	7.73	(0.01)		9.71	(0.00)	
N	752			752		
R^2 (1st stage)	0.191			0.284		
Adj. R^2 (2nd stage)	0.029			0.136		