Search for Yield under Prolonged Monetary Easing and Aging*

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Very preliminary. Can be revised substantially.

Abstract

We find several facts supportive of the search for yield, i.e., the phenomenon that a low loan spread encourages banks to extend less monitored and more risky loans, in Japanese regional loan market, where banks experience the prolonged monetary easing and the rapid population aging. We estimate the demand elasticity and the conjectural variation in local loan markets simultaneously with a structural model. The estimates show that the competition gets more intensified in the markets where the loan demand is less elastic against lowering interest rates due to the rapidly aging population. The 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 the monetary easing (e.g., Jiménez et al., 2014; Dell'Ariccia et al., 2017, among others). Regarding the effect of the monetary easing to bank risk-taking, the existing theory gives two opposite predictions. The traditional risk-shifting theory predicts that the monetary easing will reduce the bank risk-taking because the lower funding cost reduces their benefit to take additional risks by abusing the limited liability protection (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 the bank risk-taking because the monetary easing diminishes the spread between the loan interest rate and the financing cost, and so discourages banks from costly monitoring or screening against risky borrowers. Which of these counteracting force dominates is determined by whether the monetary easing diminishes the loan spread or not, in other words, the determinants of the extent of penetration from low financing costs to loan interest rates, such as the loan demand elasticity and the competitive conduct of banks (Dell'Ariccia et al., 2014). Despite of the abundant evidence for the risk-taking channel of the monetary easing, we lack in the evidence on these determinants of the price penetration. The present study is an attempt to fill in this gap of the empirical studies.

The first step to this goal is the estimation of the key parameters, such as the loan demand elasticity and the competitive conduct of banks. The traditional structural estimation methods in the 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, the competitive conduct is measured by the conjectural variation, which is defined as the response of the total market supply against the one-unit increase of the supply by one of suppliers. This methodology has already been applied to the loan market by many existing studies (e.g., Coccorese, 2005, 2009; Delis and Tsionas, 2009),[1], but it has never been used in the test for the search-for-yield and the risk-shifting hypotheses to the best of our knowledge. By applying

[1] More recently, several papers present an estimation model, which explicitly include the endogenous determination of the market share in 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 the estimation for the dynamic discrete choice of entry and exit (Sanches et al., 2018), and merger (Akkus et al., 2016).

the method, we can also identify the determinants for the competitive conduct and the demand elasticity, such as the monetary easing and the regional economic or demographic characteristics. In the second step, we test the sign of the correlation between the estimated conjectural variation and the risk-taking by banks. We can test whether the search-for-yield theory or the risk-shifting theory is at work by taking these two steps.

The above structural estimation requires a market-year panel data consisting of bank financial information including risk-taking, and the economic data in each market, to identify the demand function and the supply function. We construct such panel data by taking the share-weighted average of the financial variables of each bank who has a branch in each market. We assume the loan market is geographically segmented by prefecture, following the existing studies using Japanese data (e.g., Ishikawa and Tsutsui, 2013). The existing studies suggest that a loan market could be narrower than prefecture (Degryse and Ongena, 2005; Ono et al., 2016a), but we take the prefecture segmentation assumption since it is the smallest unit of municipality, for which we can obtain the economic data consistently. To measure the market share, we use primarily the share of the number of branches of each bank in each prefecture to overcome the unavailability of the 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 a branch size is positively correlated with a bank size.

To measure the extent of bank risk-taking, we use the ratio of the loan-loss provision over the total loan. Japanese banks are required to accumulate loan-loss provision in accordance with the internal credit rating of each loan since March 1998. This ex ante indicator of the credit cost is fit well with the theoretical model that focuses on the strategic risk-taking in the credit market by a bank. The requirement for the provision was reduced from 2009 to 2013 by the Small and Medium-sized Enterprises Finance Facilitation Act, but we can control for this effect by the year fixed effect since the reduction was even for all types of banks. Z-score and the default distance are more popular in the existing literature, but these measures capture the ex post outcome of risks rather than the ex ante risk-taking strategy. The latter include all risks in all business portfolio of banks including investment banking, securities trading, and other services. Given the difficulty in defining a border of a market and measuring competitive conduct and demand elasticity in these businesses, this all-inclusive measure is not suitable to our context.

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

Our findings are as follows. From the structural estimation in the first step, we find that the lending competition, measured by the conjectural variation, gets harsher as the lending capacity of banks increases due to the deepening monetary easing. The competition mode shifts from the Cournot competition to the perfect or Bertrand competition in the meanwhile. We also find that the competition tends to be harsher in the market where the loan demand elasticity is low, i.e., the loan demand does not increase in response to a lower interest rate due to the aging demography. We also find clear evidence that banks in a more competitive market take more credit risks, which is measured by the loan-loss provision. These findings are consistent with the theory of the search for yield.

The remaining part of this paper is organized as follows. We clarify our empirical questions or hypotheses based on the overview of the current Japanese regional loan market and the existing theories in Section 2. We introduce the structural model for the 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 is the concluding remarks.

2 Hypothesis development

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

2.1 Japanese regional lending market under the prolonged quantitative easing.

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

The suppressed loan spread has a more serious impact on regional banks and cooperative banks, which are called *shinkin* banks, whose main business line is the domestic lending and who has less access to the foreign market. The concern was made public by the commissioner of the Financial Service Agency, Japan, as early as 2014, "Financial Service Agency sharpens the stance to promote consolidations among regional and regional II banks. The commissioner [$\cdots$] made an unusual mention,'a consolidation is an important alternative.' He also showed the market shrinkage in the next 10 years $\cdots$" (Jan. 25, 2014 in p.5, *The Nikkei*, translated by author). BoJ also published a report showing the similar concern (Box 3: Intensified competition among regional financial institutions and its back ground, 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 into two directions. One is the surge of consolidations. A number of regional banks announced the consolidation plans, and many of them had carried them out (see Table 1), despite of the concerns of the Fair Trade Commission, Japanese anti-trust agency. The other way is the reckless loan provision for retail real estate investments. The news have reported that some banks extended these loans without a regular loan documentations and screening. For example, Suruga Bank received the special investigation by FSA on the lax lending for retail real estate investments in April 2018 ("FSA Alert Suruga Bank," The Nikkei, p.5., May 12, 2018). Seibu Shinkin Bank also received the 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 view versus concentration fragility view.

Regarding the relationship between bank competition and risk-taking, many theories and empirical studies had been conducted. We have a long history of the controversy between the competition fragility view and the concentration fragility view.

The most famous argument in the former view is the one based on the risk-shifting (e.g., Keeley, 1990). The increased competition in the deposit market pushes up the financing cost for banks and increases the incentive for banks to take more risks by abusing the limited liability protected by the deposit insurance. Many studies give 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 the efficiency enhancing investments (Koskera and Stenbacka, 2000) or by improving borrowing entrepreneurs' incentive for their increased stake (Boyd and de Nicoló, 2006). Akins et al. (2016) gives empirical support for this view.

There also several theoretical models in between of these two extremes, showing a non-linear relationship between the extent of competition and risk-taking (e.g., Allen and Gale, 2004; Martinez-Miera and Repullo, 2010). Many empirical studies report the non-linear 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, a large number of empirical studies provide evidence for the so-called risk-taking channel, i.e., the 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 to explain this phenomenon is the theory of the search-for-yield (Martinez-Miera and Repullo, 2017), which is also called the penetration effect (Dell'Ariccia et al., 2014) of lower money-market rate.

These models show that the diminished loan spread reduces the monitoring or screening incentive of banks since the benefit of monitoring reduces with the spread. If the monetary easing reduces the spread, in other words, if the lower financing cost for banks fully penetrate to the loan interest rate, the monetary easing diminishes the spread, and so it discourage their monitoring. The lax screening or less monitoring is equivalent to the provision of risky loans. Thus, the monetary easing can pushes banks to take more risks.

The traditional risk-shifting theory by Keeley (1990) suggests that the reduction in the financing cost with insufficient penetration induces less risk-taking by banks since the reduced interest expenses reduces the benefit of abusing the limited liability for 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 the interest rate penetration, such as the extent of competition and the 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 the prolonged monetary easing, and the anecdotes that regional banks scramble for mergers and lax risky lending, the theory that seems to fit the best, is the search-for-yield theory. To formally prove that the search-for-yield is at work in Japan, we need to empirically verify what factors affect the penetration of the low financing cost to the loan interest rate, especially, the

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

market conduct by competing banks, the loan demand elasticity, and the impact of the monetary easing and other factors to them.

To put more concretely, we attempt to ask the following questions to our dataset.

Empirical Questions

1. *Does the monetary easing drive the conduct of banks to more aggressive lending competition?*

2. *How does a demographic factor, such as the reduction in 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 the risk-taking by banks?*

3 Empirical strategy

To empirically answer the above questions, we take two steps. First, we estimate the key parameters, i.e., the market conduct of banks, which is often measured by the conjectural variation, and the demand elasticity in each regional loan market in each year, by a structural estimation method developed in the field of industrial organization. We include demographic factors and monetary policy factors in the estimation to answer to the first and second empirical questions. Second, we examine the correlation between the bank risk-taking and the estimated conjectural variation by the fixed-effect model with the 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 in 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 about the importance of geographical proximity in SME lending (Degryse and Ongena, 2005; Ono et al., 2016a) and the prefectural segmentation in Japanese loan market (Ishikawa and Tsutsui, 2013). Each bank may have a market power in the segmented loan market, while it is 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 the arbitrage pressure from the money market. We assume that the location of branches is fixed to focus on the decision 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 of loans $R(L_{it})$, which is decreasing in L_{it}, where $L_{it} = \sum_b l_{bit}$ is the total loan 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 loan 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 the 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].

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.

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

where $\theta_{it} \equiv \frac{\partial L_{it}}{\partial l_{bit}} \frac{l_{bit}}{L_{it}}$, and $\beta_{it} \equiv -\frac{\partial L_{it}}{\partial R_{it}} \frac{R_{it}}{L_{it}}$, i.e., θ_{it} is the conjectural variation, and β_{it} is the demand elasticity. θ_{it} equals one if a bank behaves as a monopoly for homogeneous services, zero under the

[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 $D_{bit} = \{R_{it}(L_{it}) - K_{bit})\}q(e_{bit})$ 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

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

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

perfect or Bertrand competition with a symmetric marginal cost, or the market share of the bank under the Cournot competition.

We assume that the marginal cost 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 up 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 to be estimated.

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

where

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

α's 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 conjectural variation Θ_{it} is zero under the perfect or Bertrand competition with symmetric marginal cost, one under the monopoly, and the Herfindahl index under the Cournot competition.

We assume the regional loan demand function with the 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 β's 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.

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 δ's and ζ's are coefficients to be estimated. Y_{it} is the covariates with the conjectural variation, which varies over year and region. Z_{it} is the covariates of the demand elasticity, which varies over region.

To control for the regional fixed effect, we subtract the regional mean from both sides of the demand function (7) under the assumption that the elasticity varies only cross-sectionally, i.e., $\beta_{it} = \beta_i$. To see the impact of the time-series variation of β_{it}, we estimate the model with the sub-period sample. As for the supply function (6), we include the regional dummy and the year dummy directly to the estimation.

We estimate the system equations (6) and (7) simultaneously by the full information maximum likelihood estimation with the BHHH sandwich standard error under the assumption that the error terms follow the 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 Test for the search for yield

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

We regress the estimated CV onto the credit cost after controlling for the unobservable region fixed effect and the unobservable year fixed effect to avoid the complication due to 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 the competition fragility view by examining the the sign and the significance of the estimated coefficient γ_1.

4 Data

4.1 Data source

The most important part of the dataset is the panel data of the annual financial statement of the banking account of each commercial banks in Japan, including major banks, which are called *city banks*, trust banks,[4] 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 part of dataset is collected from the Nikkei NEEDS Financial Quest database. We augment several items for several banks from the database on the Japanese Bankers Association website, and the Nikkin Shiryo Nenpo, published by Nihon Kin'yu Tsushinsha because Nikkei NEEDS often does not cover those banks who are not listed on the stock exchange, or in the last year before a merger. We also collect the bank merger information from the Nikkin Shiryo Nenpo.

We collect the 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. The database includes the name of banks, that of branches, their exact address, type, such as whether it is virtual or real; regular branch or sub-branch. We count the number of regular branches of each bank in each region for the calculation of the share of each bank in each region. We connect this information to the financial statement data in the next March; for example, we connect the branch information as of October 2002 to the financial statement data as of March 2003.

We connect this bank information to the regional economic data in the period from 2003 to 2018, which are collected from the online database of the Bank of Japan, 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 connect the regional dataset to the bank information in the same way as in connecting the branch information.

[4] We exclude the small trust banks, which are subsidiaries of major banks. The list of trust banks included in our dataset is .

4.2 Measurement issues

We need several considerations for the measurement issues under the limited availability of data. We summarize such considerations 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 small and medium-sized enterprises (SMEs), the main users of bank lending (e.g., Degryse and Ongena, 2005). In the context of Japan, Ono et al. (2016a) find that the median distance from a borrowing small firm to the branch of its main bank is 1.7 km from the huge dataset of SMEs in 2010, and that small firms more often switch its main banks after the closure of its nearest branch due to the restructuring after a bank consolidation. 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 and its commuting area, but the repeated consolidations among cities in the 2000s make almost impossible for us to obtain economic indicators of each area in a consistent manner. The smallest municipality unit, for which economic indicators are consistently available, is prefecture. Thus, We assume that the loan market is segmented by prefecture.

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

To obtain the prefecture-level aggregation of bank information, which is required for the estimation of the supply function (6), we need to calculate the share-weighted average of each items, such as spread, and loan rate R. However, the data of the loan share of banks in each prefecture is not available. To overcome this data limitation, we use two types of proxies for the shares for this purpose. The first one is the share of the number of regular branches of each bank in each prefecture, which we call branch-share. This measure of share is simple, but it can over-evaluate the share of small banks since the asset size of a branch tends to be larger for large banks and vice versa. 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 it the size-adjusted branch-share.

4.2.2 Risk-taking

Most of existing studies, which are mentioned before, use the Z-score or the default distance as a measure of the 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. In addition, these ex post measures are not perfectly consistent with the theoretical model of the search for yield or the risk shifting, where the ex ante decision for banks to take a credit risk competitively. We, therefore, use the ratio of loan-loss provision over total loan as such an ex ante risk-taking measure.

In Japan, banks are required to set aside the loan-loss provision for each loan to cover the expected default loss in accordance with their internal credit rating since March 1998 (Section 3.3.18, p.413, in Ginko Keiri Mondai Kenkyukai, 2008). The requirement for the provision was reduced from December 2009 to March 2013 in accordance with the SME Financial Facilitation Law, which was legislated as a policy response to mitigate the shock of the global financial crisis. We can control for this effect simply by year fixed effect since the law covers all SMEs all over the nation.

4.2.3 Mark-up after credit cost

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

4.2.4 Control variables

As for the loan demand shifter X_{it} in Equation (7), we include the total construction expenditure including both private and public, the total tax base, and the commercial land price in each prefecture. The construction and tax base indicates the level of the economic activities. We use the tax base in place of the gross prefectural product since the former is updated in a more timely manner.[5]. The commercial land price captures the nominal determinant for loan demand.

As the determinants of the conjectural variation Y_{it} in Equation (8), we consider the liquidity ratio, the percentage increase in the public construction expenditure and that in the private construction, the percentage change in tax base, the percentage change in the working-age population. The liquidity ratio captures the room for loan expansion due to QE, which injected massive reserve for banks. The idea is in the spirit of the standard empirical strategy to test the credit channel of the monetary policy (Kashyap and Stein, 2000). The change in construction expenditures, tax base, and population, tries to capture the change in the growth prospect of the local loan market, which may affect the competitive conduct of banks.

As the determinants of the demand elasticity Z_i in Equation (9), we include the prefecture means of the working-age population growth rate and the population density. We expect that the loan demand is more elastic against the declining interest rate in the metropolitan area where working-age people flow in steadily. We also expect that the densely populated metropolitan areas have more promising investment opportunities for firms.

In addition, we include the share of bank branches that experienced a merger in the past 3 years into the marginal cost part in Equation (6) to see the cost reduction by bank mergers. We also estimate with the specification where this merger indicator is included in the determinants of the conjectural variation Y_{it} to see the impact of bank mergers on the conjectural variation.

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.

[5] Gross prefectural product is available only upto 2016, as of 2019

To obtain the visual summary of the key variables, we plot the median (triangle), and the 90 percentile (top of the segment) and the 10 percentile (bottom of the segment) among 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 loan in Figure 2. The loan rate keep declining except for 2008 and 2009 when the monetary policy regime returned to the traditional one. The funding cost also increased in these years as well, but it is almost zero in the other years and has no variation among prefectures. In contrast, the credit cost has a big variation among prefectures, while it keeps declining. This is probably because the economic recovery from 2003 to 2007 and from 2013 to 2018 reduces the default probability, and the SME Financial Facilitation Law reduced the required loan-loss provisions from 2009 to 2013. The growth rate of the total loan keeps high level after the beginning of QQE in 2013.

Reflecting these recent development of each component, the spread before subtracting credit cost keeps declining as is mentioned in the introduction, while the spread after subtracting credit cost diminishes at a much slower speed with a big variation among prefectures (Figure 3).

Figure 4 shows the recent development of the factors affecting the loan supply and demand. Liquidity ratio, which is defined by the ratio of reserve assets and liquid security holdings over total asset, is increasing and at the highest level since 2013, the start of QQE. The working-age population keeps diminishing in almost all prefectures during our sample period. After the exceptional movement in 2011 due to the evacuation from the damaged area to other areas in 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 years old.

5 Result of the structural estimation

5.1 Estimated model

Table 4 shows the estimated coefficient of the model (6) and (7). Columns (1) and (2) are the result from the dataset aggregated by the branch-share weight. Column (1) is the result when we include the bank merger indicator into the marginal cost. Column (2) is the result from the specification that include the bank merger as a determinant of the conjectural variation. The difference of the estimated coefficients in Columns (1) and (2) is almost negligible. Column (3) is the result from the dataset aggregate by the branch-size adjusted branch-share weight (see Section 4.2.1). This result is also very similar to Column (1).

Supply function. δ's are the coefficients of the determinants of the conjectural variation. 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 increases the liquidity ratio of banks, intensify the lending competition among banks. This result does not change qualitatively when we define the liquidity ratio more narrowly by excluding government bonds and other securities in the asset side.[6] The percentage growth of tax base, which is the proxy for the local economic growth, has a positive and marginally significant coefficient. The competition is less harsh in a growing market.

α's 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^s_{it} and the average wage of bankers w_{it}. However, the marginal cost is at the minimum when L^s_{it} is about 87. Since this is above the sample maximum of L^s (Table 2), we should conclude that the marginal cost is decreasing in the bank size. In other words, the lending business exhibits the increasing returns to scale, as is shown by the existing literature in the U.S. data (e.g., Hugh and Mester, 1998; Wheelock and Wilson, 2018).

Likewise, the marginal cost is the minimum when w_{it} is about 9. More than 90% of our prefecture level observations are above this level. Thus, it is reasonable to conclude that the marginal cost is increasing in the wage.

The coefficient $\alpha(merger)$ is not statistically significant in column (1). The cost saving effect of a bank merger could be captured by the coefficients of the bank size L^s_{it}, which shows the increasing returns to scale.

Demand function. ζ's are the coefficients of the determinants of demand elasticity. The demand elasticity is larger in the regions where the working-age population is growing more or

[6] The result of the estimation using the reserve ration in place of the liquidity ratio is omitted from the manuscript but is available from the author upon request.

declining less rapidly. The mean density, which is supposed to feature the metropolitan area, has a negative and significant coefficients. This might reflect the possibility that the loan demand does not increase despite of the low interest rate due to the scant room for real-estate investments in the densely populated areas.

β's are the coefficients of demand shifters. The positive and significant coefficients of tax base are reasonable results since the loan demand is larger in a larger economy.

5.2 Estimated key parameters

Conjectural variation. The first key parameter is the conjectural variation (CV) Θ_{it}. The median, 10 percentile, and 90 percentile of CV among prefectures in each year are plotted in Figure 5. The figure indicates the result from the baseline estimation with the branch-share aggregate data (Panel (a)) and the branch-size-adjusted branch-share aggregate data (Panel (b)). CV keeps declining from the peak in 2004 to 2011. After that, the CV keeps very low level closer to zero in the period of QQE.

To clarify the change in the competition mode of banks, we plot the 95% confidence interval of the estimated CV of each prefecture by using the standard error of the estimated CV by the delta method and the branch-share Herfindahl index in the years of 2004, 2009, 2014, and 2018 in Figure 6. The panel of the year 2004 indicates that the Herfindahl index is in the confidence interval in most prefectures. The confidence interval reaches above 1 in two prefectures; Shiga (id=25) and Okinawa (id = 47). According to our model, many prefectures are under the Cournot oligopoly while the latter two prefectures could be under the monopoly in 2004. However, the confidence interval of CV gets considerably lower in 2009 and later years. The confidence interval is far below the Herfindahl index and cross zero, which means the competition becomes a Bertrand competition or the perfect competition in these prefectures. Shiga and Okinawa also shifts to the Cournot oligopoly.

The classical theory by Kreps and Scheinkman (1983) tells us that the 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 Bank of Japan mutes the capacity constraint for lending and makes the lending competition a pure

Bertrand competition.

Demand elasticity. Another key parameter is the loan demand elasticity $\hat{\beta}_i$. We allow the cross-section variation for this parameter in our estimation to make our estimation feasible. Table 6. Panel (a), indicates a quite 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 CV (Table 6, Panel (b), and Figure 7) indicates a positive correlation between the demand elasticity and the conjectural variation. The correlation coefficient between them is indeed significantly large, 0.48, which is statistically significant at a 1% level. This implies that the lending competition is more harsh in the market where the loan demand does not increase despite of the massive monetary easing, probably due to the demographic problem.

To examine the plausibility of the assumption that the demand elasticity is time-invariant. We estimated the model (6) and (7) in each of the sub-periods, from 2003 to 2012, and from 2013 to 2018, before and after the QQE. Table 5 shows the basic statistics of the estimated elasticity with the entire sample and the sub-samples. It indicates that the estimated elasticity is lower in the later sub-period than that estimated with the entire sample. Probably this is because of the accelerated reduction in the working-age population. The estimated CV with these sub-period also is somewhat smaller than the estimate with the entire sample, but we can obtain the similar picture as Figure 5 in terms of the time-series variation.[7]

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 CV $\hat{\Theta}_{it}$ by running the fixed-effect regression (11). The result is listed in Table 7. The first two columns are the result from the branch-share weighted aggregation. The third and fourth columns are the result from the branch-size-adjusted branch-share weighted aggregation. The second and fourth column is the result with the dataset excluding the outliers of top and bottom 1% with respect to D_{it} and Θ_{it}. The coefficient of the credit cost is negative and

[7] The result is omitted from the manuscript, but available from the author upon request.

significant in all columns.

To address the potential endogeneity problem, for example, due to an unobservable common factor that are correlated with both the conjectural variation and the credit cost, we estimate the baseline model (11) with the 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 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 low capital ratio is more willing to take more risks for the risk-shifting motivation. The other is that the accumulation of credit costs damages the capital.

On the other hand, the correlation between the capital ratio and the residual after regressing the conjectural variation to the credit cost can be either sign. The correlation can be negative since the harsh competition reduces the profit of banks, which also reduces the capital ratio in the long-run. However, if the competition pushes banks to more aggressive risk-taking, then the effect can be entirely absorbed by the change in the credit cost. If so, they are uncorrelated. The competition tends to be severer in the market where the demand does not respond against lower interest rates as we present in the previous section. The 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 with each other.

To check the latter point, we regress the conjectural variation to the credit cost and the capital ratio after two-way demeaning to subtract the prefecture fixed effect and the year fixed effect. Table 8 shows the result 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 dataset. Thus, the capital ratio reasonably satisfies the assumption of no correlation with the residual in the second stage, which is required for the valid instrumental variable.

The result of the IV regression is listed in Table 9. The first stage regression shows the negative correlation between the credit cost and the capital ratio as we expect. The F statistics for the IV exceeds 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 that the negative and significant correlation between the conjectural variation and the credit cost. This correlation is somewhat weaker in the branch-share weighted data (Column(1)), but it is very robust in the branch-size adjusted data (Column (2)).[8]

The result of the negative correlation implies that the harsher competition drives banks to more aggressive risk-taking in the loan market. The massive quantitative easing, especially after 2013, intensifies the lending competition in a region where the loan demand is not so responsive to a low interest rate due to the declining working-age population. The pressure of the diminishing spread leads to the 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 estimation for the key parameters, the conjectural variation, and the demand elasticity in Japanese loan market, reveals several important facts. We have found that the regional lending competition has got so harsher that the competition mode has shifted from the Cournot competition to the perfect or Bertrand competition as the quantitative easing increasingly expands the lending capacity of banks and the population aging progresses. The positive correlation between the conjectural variation and the demand elasticity implies that the lending competition is even severer in the markets where the loan demand does not increase despite of 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 prediction by the theory of the search for yield.

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

[8] Adjusted R^2 is much smaller in Table 9 than that in Table 7. This is because we use demeaned variables instead of including the year dummies.

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Figure 1: Loan spread

(Note) (Loan spread) = (loan yield) − (financing cost), where (loan yield) = (interests 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).

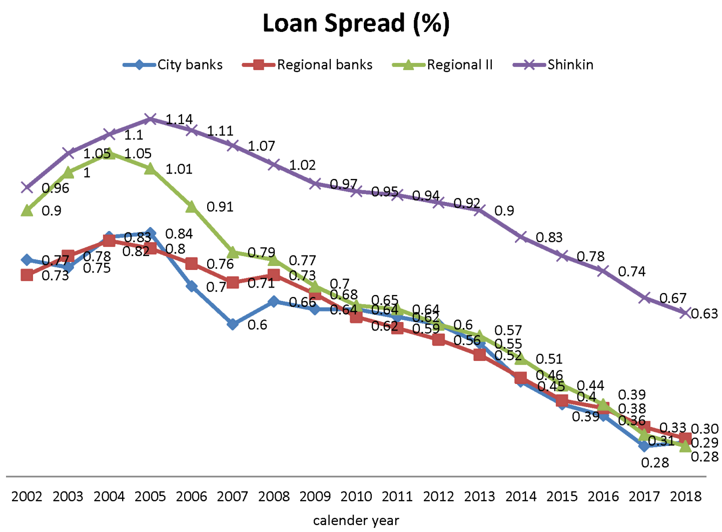


Figure 2: Component of spread and loan amount

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

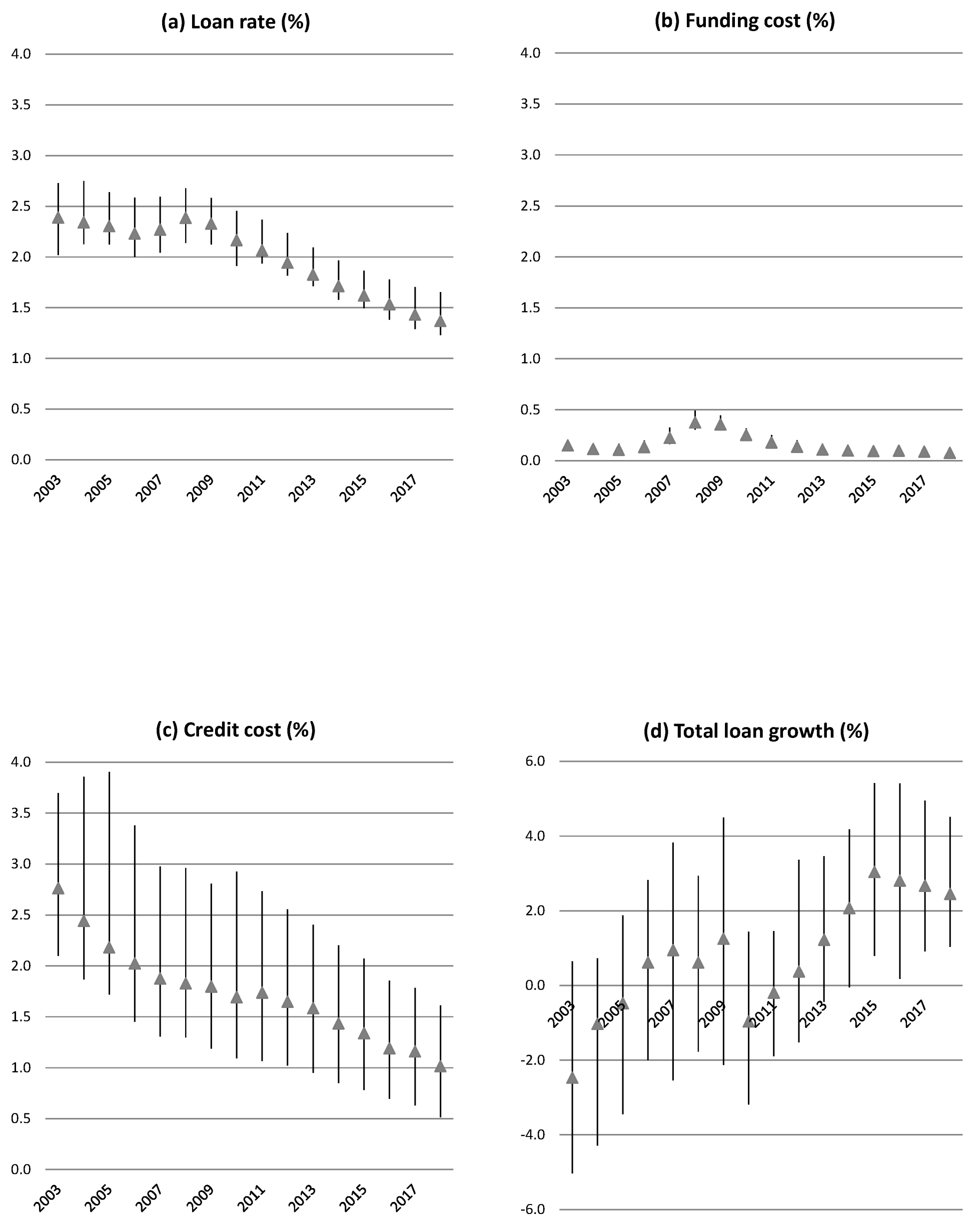


Figure 3: Spread

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

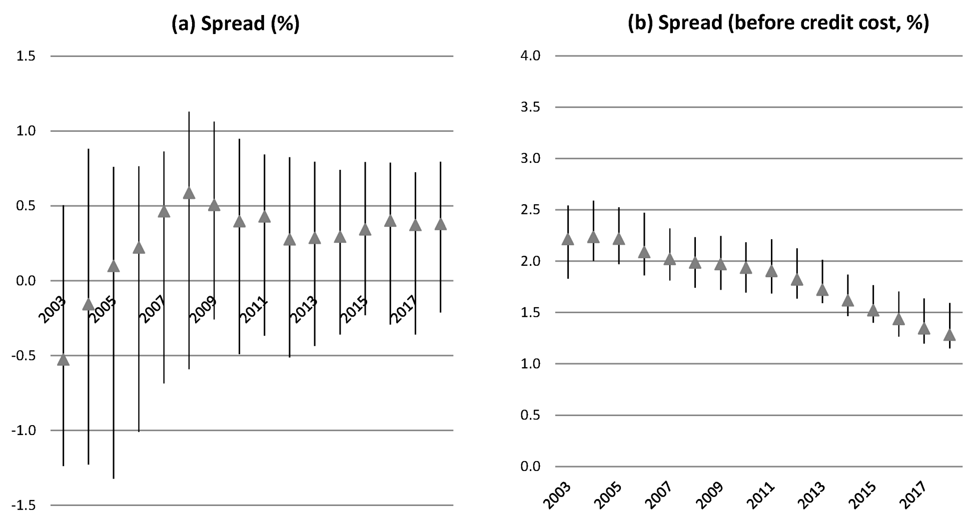


Figure 4: QE and Population

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

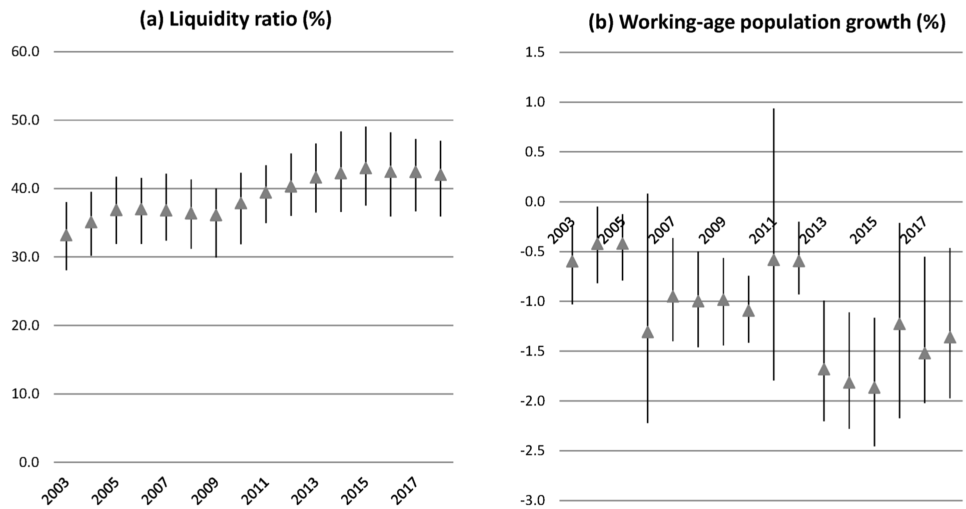


Figure 5: Estimated Conjectural Variation $\hat{\Theta}_{it}$

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

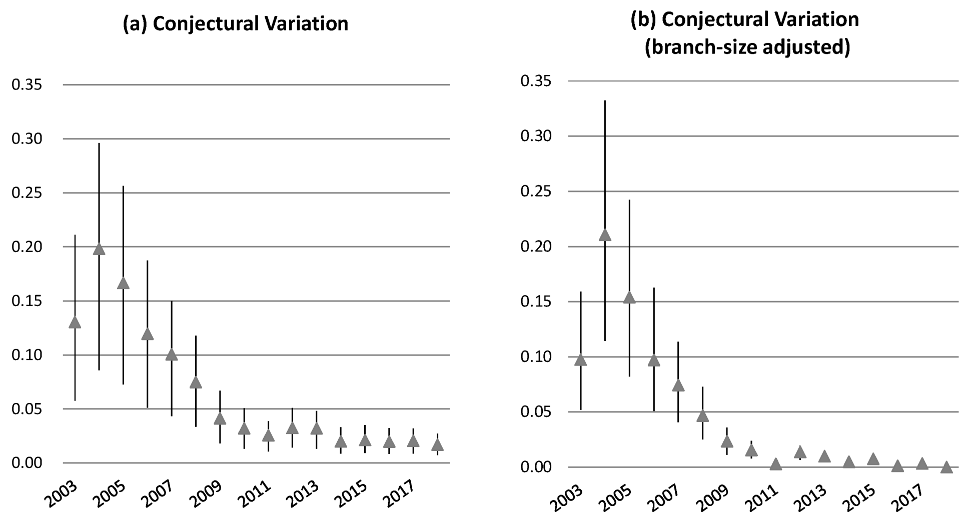


Figure 6: From Cournot to Bertrand
(Note) Horizontal: prefecture ID. Dot: Branch-share Herfindahl index. Bar: 95% confidence interval of $\hat{\Theta}$ from the baseline estimation (Column (1) in Table 4).

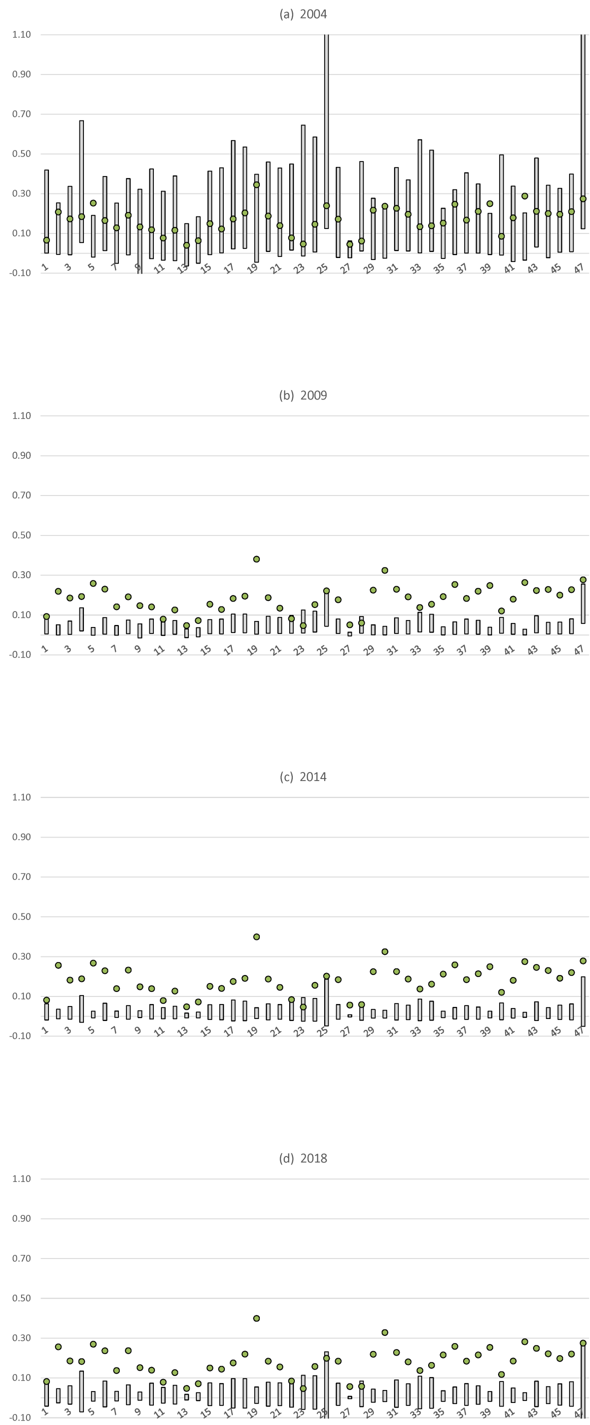
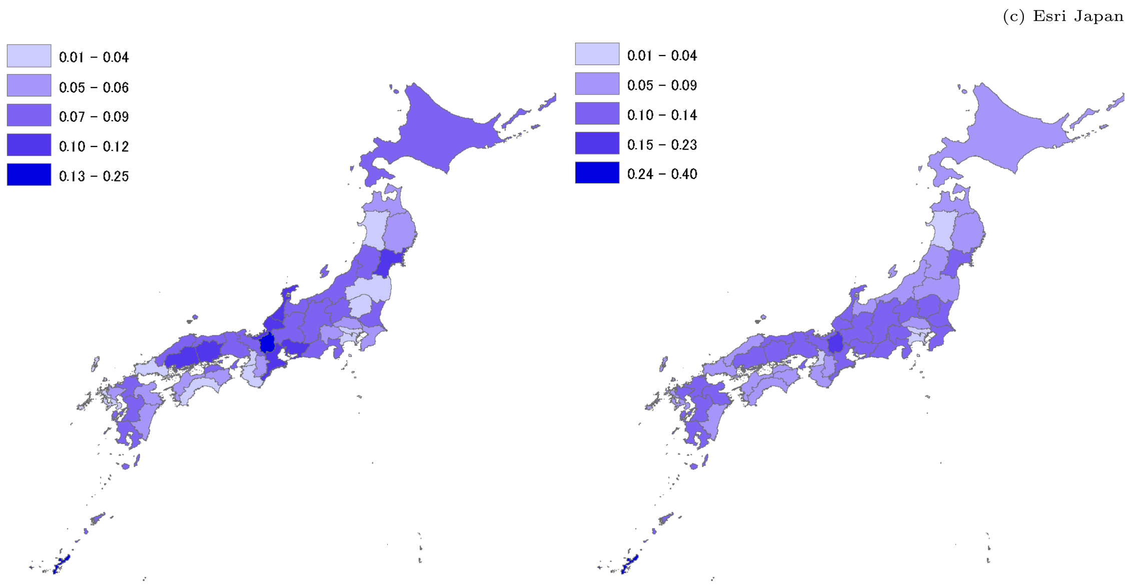


Figure 7: Estimated $\hat{\Theta}_{it}$ and $\hat{\beta}_{it}$ (mean in 2003-18)
(Note) The author produced from the digital map (geospatial information) by Geospatial Information Authority of Japan, and the National Municipality Border data by ESRI Japan.



(a) conjectural variation

(b) elasticity

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 loan outstanding by domestic banks including shinkin banks in each prefecture as of March, tril. JPY. Loan by domestic banks is collected from the long-term time-series database in the Bank of Japan website. Shinkin banks are the sum of loans by those headquarted 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 CDROM (Nihon Kin'yu Tsushin Sha). 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 the liquid asset over over total asset (%). Liquid asset is the sum of cash and due from banks, call loans, receivables under resale agreement, receivables under securities borrowing transactions, bills bought, money held in trust, and securities in the asset side in 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.
Capital ratio	Book-value gross capital / total asset (%). Weighted average by the branch number share of each bank in each prefecture.

Table 1: (cont.)

Variable	Definition
Construction	Total building construction started in each prefecture, fiscal year, tril. JPY. Construction General Statistics, Ministry of Land Infrastructure, Transport and Tourism (MLIT), Japan.
ΔPrivate construction	Annual % growth rate of the building construction started by the private sector in each prefecture, fiscal year, tril. JPY. Construction General Statistics, MLIT, Japan.
ΔPublic construction	Annual % growth building construction started by the public sector in each prefecture, fiscal year, tril. JPY. Construction General Statistics, MLIT, Japan.
Tax base	Total tax base of the municipality tax, i.e., household income in the previous calender year, in each prefecture. Survey on the Taxation Status of the Municipality Tax, Ministry of Internal Affairs and Communications (MIAC), Japan.
ΔTax base	Annual growth rate of tax base (%).
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.
Bank merger	Branch share of banks who 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	0.85	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	1.71	2.26	2.87	6.16
L^s_{it}	752	3.76	4.04	0.68	1.11	1.54	2.30	3.66	8.98	25.57
w_{it}	752	16.22	1.96	7.85	14.30	15.05	16.03	17.08	18.56	22.58
Liquidity ratio	752	38.68	5.10	22.88	32.25	35.14	38.65	42.10	44.99	54.70
Capital ratio	752	5.10	0.93	-0.94	4.09	4.58	5.10	5.57	6.08	9.32
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
ΔPublic constr.	752	0.63	29.05	-52.24	-26.58	-16.31	-3.08	11.85	31.89	470.53
ΔPrivate constr.	752	1.10	16.10	-50.43	-18.44	-8.27	-0.11	10.09	18.37	111.42
ΔTax base	752	-0.17	2.70	-9.60	-3.75	-1.65	0.28	1.56	2.79	9.47
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
Bank merger	752	0.05	0.09	0.00	0.00	0.00	0.01	0.04	0.17	0.49

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	0.176	1.000							
(3)	R	-0.093	-0.096	1.000						
(4)	ρ	0.229	0.121	0.474	1.000					
(5)	D	-0.856	-0.194	0.594	0.060	1.000				
(6)	L^s	0.302	0.743	-0.305	0.131	-0.404	1.000			
(7)	w	0.327	0.489	0.045	0.303	-0.241	0.662	1.000		
(8)	Liquidity ratio	-0.083	0.013	-0.553	-0.347	-0.217	0.087	-0.066	1.000	
(9)	Capital ratio	0.171	-0.123	-0.215	-0.237	-0.251	-0.134	-0.092	0.261	1.000
(10)	Construction	0.209	0.848	-0.152	0.073	-0.250	0.787	0.602	0.043	-0.117
(11)	Tax base	0.257	0.844	-0.146	0.144	-0.285	0.883	0.661	0.001	-0.144
(12)	ΔPublic constr.	0.023	0.024	-0.124	-0.011	-0.084	0.039	0.025	0.133	-0.005
(13)	ΔPrivate constr.	-0.032	0.005	-0.175	-0.286	-0.063	0.006	-0.051	0.131	0.077
(14)	ΔTax base	0.211	0.120	-0.346	-0.031	-0.350	0.172	0.090	0.178	0.208
(15)	ΔPopulation	0.079	0.313	0.289	0.188	0.085	0.253	0.268	-0.370	-0.240
(16)	Density	0.247	0.838	-0.095	0.177	-0.251	0.887	0.650	-0.089	-0.195
(17)	Land price	0.208	0.954	-0.105	0.149	-0.224	0.775	0.508	0.010	-0.101
(18)	Bank merger	-0.158	0.036	0.097	0.015	0.179	-0.006	-0.003	-0.176	-0.190

		(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(11)	Tax base	0.952							
(12)	ΔPublic constr.	0.077	0.016	1.000					
(13)	ΔPrivate constr.	0.042	-0.014	0.113	1.000				
(14)	ΔTax base	0.176	0.140	0.144	0.081	1.000			
(15)	ΔPopulation	0.356	0.377	-0.123	-0.051	-0.240	1.000		
(16)	Density	0.839	0.911	0.018	-0.008	0.115	0.353	1.000	
(17)	Land price	0.847	0.855	0.027	-0.006	0.126	0.334	0.835	1.000
(18)	Bank merger	0.042	0.021	-0.057	0.009	-0.070	0.041	0.055	0.023

Table 4: Baseline structural estimation

(Note) Estimated coeffcients of Equations (6) and (7) by FIML with the BHHH sandwich s.e. *** p<0.01, ** p<0.05, * p<0.1. The estimated constant term and the coefficient 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.

	(1)			(2)			(3)		
(Supply function)	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
δ(liquidity ratio)	-0.020	0.007	***	-0.020	0.008	**	-0.026	0.014	*
δ(Δpublic constr.)	0.000	0.000		0.000	0.000		-0.001	0.000	
δ(Δprivate constr.)	0.000	0.000		0.000	0.000		0.000	0.000	
δ(Δtax base)	0.012	0.006	*	0.012	0.007		0.020	0.011	*
δ(Δpopulation)	0.009	0.017		0.009	0.018		0.037	0.026	
δ(merger)				0.000	0.001				
$\alpha(L_{it})$	-0.174	0.072	**	-0.176	0.073	**	-0.074	0.026	***
$\alpha(L_{it}^2)$	0.001	0.001	*	0.001	0.001	*	0.001	0.000	***
$\alpha(w)$	-0.108	0.030	***	-0.106	0.031	***	-0.064	0.021	***
$\alpha(w^2)$	0.006	0.002	***	0.005	0.002	***	0.003	0.001	***
$\alpha(w \cdot L_{it})$	0.000	0.002		0.000	0.002		0.000	0.001	
α(merger)	-0.001	0.001					0.001	0.001	
(Demand function)									
ζ(mean Δpopulation)	1.310	0.226	***	1.311	0.226	***	1.088	0.196	***
ζ(mean density)	-0.562	0.205	***	-0.559	0.206	***	-0.369	0.158	**
β(ln construction)	0.019	0.014		0.019	0.014		0.018	0.014	
β(ln taxbase)	0.560	0.115	***	0.559	0.115	***	0.570	0.119	***
β(ln land price)	-0.012	0.013		-0.012	0.013		-0.010	0.014	
σ_1	0.216	0.012	***	0.216	0.012	***	0.196	0.014	***
σ_2	0.048	0.002	***	0.048	0.002	***	0.048	0.002	***
σ_{12}	0.002	0.001	**	0.002	0.001	**	0.001	0.001	
N	752			752			752		
log likelihood	1334.5			1321.8			1384.5		

Table 5: Estimated Demand Elasticity $\hat{\beta}_i$

(Note) Descriptive statistics of the estimated $\hat{\beta}_i$, which varies with prefecture, are listed. The first row is those of the base line estimation with the entire dataset. The first row is from the result of Column (1) in Table 4. The second and the third rows are those with the subperiods of the same data and the specification as in the first row.

Sample period	mean	s.d.	p10	med	p90
2003-18	0.095	0.058	0.048	0.092	0.132
2003-12	0.079	0.089	0.000	0.048	0.213
2013-18	0.030	0.070	0.003	0.014	0.055

Table 6: Regional heterogeneity in demand elasticity and CV

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

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

Hokkaido	0.082	Ishikawa	0.118	Okayama	0.132
Aomori	0.048	Fukui	0.108	Hiroshima	0.121
Iwate	0.071	Yamanashi	0.095	Yamaguchi	0.058
Miyagi	0.142	Nagano	0.097	Tokushima	0.069
Akita	0.037	Gifu	0.095	Kagawa	0.078
Yamagata	0.073	Shizuoka	0.092	Ehime	0.069
Fukushima	0.079	Aichi	0.134	Kouchi	0.052
Ibaragi	0.093	Mie	0.117	Fukuoka	0.109
Tochigi	0.128	Shiga	0.232	Saga	0.108
Gunma	0.110	Kyoto	0.099	Nagasaki	0.060
Saitama	0.069	Osaka	0.011	Kumamoto	0.111
Chiba	0.098	Hyogo	0.098	Oita	0.094
Tokyo	0.021	Nara	0.056	Miyazaki	0.086
Kanagawa	0.036	Wakayama	0.055	Kagoshima	0.091
Niigata	0.085	Tottori	0.096	Okinawa	0.403
Toyama	0.077	Shimane	0.079		

(b) Mean of estimated CV, $\hat{\Theta}_{it}$, in 2003-2018.

Hokkaido	0.071	Ishikawa	0.097	Okayama	0.100
Aomori	0.041	Fukui	0.094	Hiroshima	0.090
Iwate	0.056	Yamanashi	0.058	Yamaguchi	0.033
Miyagi	0.120	Nagano	0.079	Tokushima	0.054
Akita	0.028	Gifu	0.072	Kagawa	0.067
Yamagata	0.071	Shizuoka	0.082	Ehime	0.058
Fukushima	0.035	Aichi	0.109	Kouchi	0.031
Ibaragi	0.063	Mie	0.101	Fukuoka	0.078
Tochigi	0.034	Shiga	0.215	Saga	0.049
Gunma	0.069	Kyoto	0.072	Nagasaki	0.027
Saitama	0.049	Osaka	0.007	Kumamoto	0.085
Chiba	0.060	Hyogo	0.081	Oita	0.055
Tokyo	0.014	Nara	0.042	Miyazaki	0.057
Kanagawa	0.023	Wakayama	0.036	Kagoshima	0.069
Niigata	0.067	Tottori	0.076	Okinawa	0.249
Toyama	0.070	Shimane	0.064		

Table 7: CV and risk-taking

(Note) Dependent variable is $\hat{\Theta}_{it}$ (CV). 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) and (2) are the results from the data aggregated by branch-share weight, based on Column (1) in Table 4. Columns (3) and (4) are the results from the data aggregated by branch-size-adjusted branch-share weight, based on Column (3) in Table 4). Outliers in the bottom and top 1% w.r.t. $\hat{\Theta}$ and D are dropped in the estimation of Columns 2 and 4.

	(1)	(2)	(3)	(4)
D_{it}	-0.022***	-0.025***	-0.036***	-0.029***
	(0.007)	(0.006)	(0.007)	(0.008)
Observations	752	712	752	714
Number of pref_id	47	47	47	47
Adjusted R-squared	0.737	0.850	0.818	0.895
prefecture fe	yes	yes	yes	yes
year dummy	yes	yes	yes	yes

Table 8: Non-correlation between IV (capital ratio) and the error term

(Note) Dependent variable is $\hat{\Theta}_{it}$ (CV). OLS with the data set after two-way demeaning to delete 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. Columns (1) is the results from the data aggregated by branch-share weight, based on Column (1) in Table 4. Columns (2) is the results from the data aggregated by branch-size-adjusted branch-share weight, based on Column (3) in Table 4.

	(1)			(2)		
	Coef.	S.E.		Coef.	S.E.	
D_{it}	-0.017	0.010	*	-0.030	0.010	***
Capital ratio	0.009	0.010		0.007	0.007	
N	752			752		
Adj. R^2	0.054			0.143		

Table 9: IV regression of CV to risk-taking

(Note) IV regression, where D_{it} is instrumented by the capital ratio. Dependent variable in the first stage is D_{it}. Dependent variable in the second stage is $\hat{\Theta}_{it}$ (CV). The variables are all two-way demeaned to delete 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. Columns (1) is the results from the data aggregated by branch-share weight, based on Column (1) in Table 4. Columns (2) is the results from the data aggregated by branch-size-adjusted branch-share weight, based on Column (3) in Table 4.

	(1)			(2)		
	Coef.	S.E.		Coef.	S.E.	
(First stage)						
Capital ratio	-0.382	0.098	***	-0.378	0.059	***
F for excluded IV	15.24			41.54		
(p-value)	(0.000)			(0.000)		
(Second stage)						
D_{it}	-0.042	0.022	*	-0.049	0.014	***
N	752			752		
Adj. R^2	0.007			0.116		