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Productivity of Banks and its Impact on the Capital Investments of Client Firms

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Abstract

This paper proposes one measure for the productivity of banks and studies how it affects the sensitivity of a client firm's capital investment with respect to investment opportunity. As a direct measure for the productivity of banks, we employ the risk-adjusted profit of an individual bank, which is considered as output in a modified version of the FISIM (Financial Intermediation Services Indirectly Measured) concept, per its operating cost. We combine such productivity panel-data with bank and firm characteristics as well as the loan relationship data between Japanese listed companies and banks over the past three decades. The panel estimations for an extended investment equation based on Q-theory show, in a statistically and economically significant manner, that firms under cash flow constraints—as compared to those not—are more sensitive to capital investment opportunities, provided that these firms hold close relationships with a high performance bank. These results imply that it is necessary to relate firm performances not only to the discrete characteristics of banks, e.g., relations with the main bank, as in the extant literature, but to the continuously measured characteristics of the banks having relationships with the firms.

Keywords: productivity of banks, capital investment, and financial friction.

JEL classification: C23; D24; D92; E22; G21

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1. Introduction

Following the past episodes of financial/banking crises, the countries with relatively large share of financial sector have been experiencing the turbulent economic conditions in their real sector (e.g., Ireland, Luxembourg, and U.K.). Such an incident has necessitated a number of governmental institutions such as Eurostat and Fed to intensify the discussion for how to measure the activity/output of banks.

The discussion for the level of output from macroeconomic perspective naturally stipulates economists to further construct the measure of productivity based on the micro-level data, and examine its impact on the real economy. In Japan, for example, the banking sector has been notorious for their low performance, and even criticized as a main suspect of the slumped Japanese economy over the last several decades. Thus, it could be important to ask how the productivity of banks affects their client firms' performance.

According to this discussion, the existing literature in banking study has paid a large attention to constructing the efficiency measure of banks through various approaches, for example Data Envelopment Analysis (DEA).¹ Only a few studies, however, explicitly studies the connection between the incumbent bank's performance and client firm's performances. The central theme of this paper is to provide an empirical finding contributing to this discussion by applying one type of the productivity measure for banks to a unique firm-bank match-level panel data.

The first target of this paper is to apply one conceptual framework for quantifying bank output - FISIM (Financial Intermediation Services Indirectly

¹ See, for example, Fukuyama and Weber (2002), Drake and Hall (2003), and Tsutsui et al. (2006).

Measured) - to bank-level panel data.² According to this concept, the output of a bank is measured by subtracting the interest payment to depositors from the interest receipt from borrowers. By using a risk-free rate as a reference rate, FISIM further splits such an output into the outputs associated with lending service and with deposit service. Then, the former (latter) is counted as intermediate input (final consumption) in the extended SNA framework.

One criticism for this procedure is that the output level in such an original FISIM framework could be easily overestimated if we do not appropriately take into account the degree of risk (e.g., credit risk and/or term risk) taken by banks. This is the reason that we further put an adjustment in this paper for the credit risk taken by banks to the original measures in FISIM.³ By using the data on such a modified version of FISIM, we measure the output of more than 100 banks in Japan from 1976 to 2005 fiscal year.

Our second target in this paper is to quantify the correlation between the productivity of firm's incumbent banks, which is computed as the ratio of the FISIM output and operating cost, and the client firm's performance.⁴ In this paper, we implicitly assume that some of the sample firms are facing financial friction. Due to such a friction, which could be generated by information asymmetry between

² Fed and Eurostat are discussing the introduction FISIM to their SNA framework. In Japan, Cabinet Office (Economic and Social Research Institute) and Bank of Japan have been studying the concept.

³ In this version of paper, we have not finished the adjustment of term-premium, which is recognized as the other major risk for banks.

⁴ Precisely speaking, we need to represent the productivity measures corresponding to incumbent banks for a given firm. Then, we can quantitatively discuss how such a productivity of banks affects their client firms. In this paper, we do this by either focusing on the productivity of the top lender for a given firm or using a weighted average of each incumbent bank's productivity. We will detail in latter sections.

firms and outside financiers as well as insufficient internal fund held by firms, the firms might not be able to fully appropriate the investment opportunities. Our presumption is that firms keeping relations with relatively productive banks, which could exhibit higher screening and/or monitoring activities, tend to be less likely to suffer from such a financial friction. As we will briefly survey in the following section, some of the existing studies have already explored how the existence of "Main-bank" affects firm's financial availability and/or performance. In this paper, we employ a finer measure of a bank characteristic correlated with the ability to mitigate the financial frictions. We intend to construct the measure explicitly taking into account the heterogeneity of bank's characteristics in the dimension of the productivity of banks.

Note that as in the extant studies about the firm's behavior under any sort of frictions, it is not so obvious how to quantify the marginal impact of an additional factor onto the client firm's behavior. In order to quantify the marginal effect of the productivity of banks to client firm's capital investment flexibility, we need to model the firm's hypothetical investment choices in the absence of the bank relations.⁵ As detailed in the later section, we will challenge this technical difficulty by consulting on an empirical strategy proposed in the extant literature for the extended Q-theory (e.g., Asker et al. 2010).

This paper is structured as follows. Section 2 briefly surveys the related literature. Section 3 goes over FISIM concept, which gives us one conceptual framework for measuring the output of banks, describes the data, and constructs

⁵ In addition to this issue, we need to take into account for the possibility of reverse causality, or at least the amplifying mechanism between the performances of banks and firms.

the hypotheses relating the productivity of incumbent banks to firm performance measures. Section 4 presents the estimated results. Finally, Section 5 concludes and presents future research questions.

2. Related literature

First strand of the literature related to our study is the one classifying bank's input and output from several perspectives.⁶ The first group of papers characterizes banks as in the analogy of usual manufacturing companies. Such a "production approach" (e.g., Ferrier and Lovell 1990) considers, for example, the number of deposits and loans as output while the wage, rental price, and intermediation cost payments as input.⁷ Those studies naively consider the size of bank's balance sheet as the measure of output. One criticism for this approach is on their ignorance about the specific characteristics of banks as financial intermediations, which uses the mismatch between lending and borrowing to generate its profit.

The second group called "intermediation approach" responds to such criticism and intends to explicitly characterize banks as intermediaries between depositors and firms. This group is further categorized into two individual approaches based on their perspectives about intermediation.⁸ First, the "asset approach" treats the liability and other physical input as the input of bank's

⁶ The following categorization basically follows Das and Ghosh (2006).

⁷ Most of the studies in this group do not consider the interest payment to depositors as a cost.

⁸ See Berger and Humphrey (1992) for more detail.

production process and the asset as output.⁹ By putting a distinction between the two sides of bank's balance sheet, they intend to capture the role of banks as intermediaries. One shortcoming of this approach pointed out in literature is that we cannot analyze the productivity difference coming from the choice of capital structure (i.e., the composites of the liabilities and equities). Second, “user-cost approach” simply focuses on the return from the financial assets minus its reference rate, which corresponds to the opportunity cost of the funds. Whenever the net return is positive (negative), the bank’s output is considered as positive (negative). This framework shares a view with the standard FISIM approach employed in this paper. One technical difficulty common both in the user-cost approach and FISIM is that it is hard to have the consensus about the measurement for reference rate, especially whether risk should be taken into account for this measurement. As we will discuss later, challenging this technical difficulty is one contribution of this paper.

The second strand of research, which is most closely related to this paper, is the one attempting to directly measure bank output based on FISIM concept. As briefed above and detailed in the next section, FISIM is measuring bank's output by computing the net interest profit. Then, they split the output into the ones associated with lending and deposit services by using a reference rate. Notably, the recent FISIM literature further takes into account the risk adjustment since the user cost of money should be adjusted for risk. For example, Basu et al. (2008), and Colangelo and Inklaar (2008) uses various market rate data to construct an

⁹ In this category, the service for depositors is not considered as output.

appropriate risk-adjusted reference rate, which we will construct by using the panel data of the allowance for loan losses. As another example, Guarda and Rouabah (2007) employs a simple micro-econometrics model to structurally estimate the shadow price of loans. Note that the instable nature of the estimated shadow price is criticized from the practical consideration.

The third strand of related literature is on the empirical strategy we employ. In this paper, we test whether the productivity of banks are correlated with the flexibility of client firms' capital investment. For this purpose, we follow the standard formulation of the estimation for capital investments, which is supported by the theoretical foundations encouraging the usage of Tobin's Q (e.g., Uzawa 1969), and its alternatives (e.g., Price-to-Book Ratio (PBR); Acharya et al. 2007). In order to quantify the hypothetical firm's capital investment behavior in the case without banks, we consult on the studies about the capital investment under frictions. As one example, Asker et al. (2010) tests whether the frictions between stock holders and corporate managers induce the under-investment due to manager's "short-termism" or not. They introduce the interaction term between (i) the proxy for investment opportunity (e.g., Tobin's Q and sales growth) and (ii) the dummy variable for market listing to the otherwise standard capital investment equation. Through the estimation based on the firm-level panel data containing both listed and unlisted companies, they establish that the signs of the coefficient associated with the interaction term and the one with the proxy for investment opportunity alone are negative and positive, respectively. This result jointly implies the separation of the shareholding and management for the listed companies could lead

to under-investment. We basically apply the same empirical strategy to see the marginal effect of the incumbent banks productivity onto client firm's capital formation.¹⁰

3. Data

In this section, we describe the data we use for the empirical study. Before detailing our data, we go over the basic idea of FISIM, which we use for measuring bank outputs. Then, we explain the each data used in the following section.

3.1. FISIM concept

In principle, FISIM interprets bank's net interest profit, which stands for the loan interest receipts minus the deposit interest payments, as its output. As illustrated in Figure-1, FISIM also assumes in its computation that the bank pays the risk-free interest rate to its capital (the lower-right box of Figure-1). Such an equity cost is considered as bank's intermediate consumption in SNA manner. Based on this output measure, FISIM splits it into (i) the value of lending service (i.e., the service provided to borrowers) and (ii) the value of depositor service by employing a single reference rate. Most of the studies in FISIM use some notion of risk-free interest rate (e.g., 3-month inter-bank rate) as the reference rate. The value of the lending service is, then, considered as bank's intermediate consumption while the value of depositor service is treated as final consumption in SNA.

The most important point is that the output in FISIM concept is the simple

¹⁰ As another example following the same strategy, see also Hennessy et al. (2007).

summation of those two components. As widely pointed out in the literature (e.g., Basu et al. 2008), however, such a notion is somewhat problematic. In fact, the output associated with bank's lending service should be ideally computed as the loan interest receipts minus the required market return for the borrower's funding in the hypothetical situation where information asymmetry does not exist. This ideal reference rate for lending service is conceptualized in the right diagram in Figure-2.¹¹ Imagine the case where a firm is planning to finance its capital investment. If there is no information asymmetry between the firms and outside financiers, the firm can freely borrow from the market. Due to the existence of information problem, however, the firm needs to rely on banks, which could potentially mitigate the problem, and hence deserve rents. This is the reason why we need to measure the output associated with lending service by subtracting the required market return, in the case of no information asymmetry, from the loan interest receipts. Unless we take into account this issue, we inevitably over-estimate bank outputs by mistakenly subtracting risk-free interest, which is essentially lower than the hypothetical required market return.¹²

Of course, we could not generally observe the hypothetical required market return corresponding to the case without information problem. In this regard,

¹¹ Figure-2 visualizes the idea for risk-adjustment proposed in Wang and Basu (2008).

¹² Obviously, the output associated with deposit service could potentially suffer from the same problem. Ideally, we should construct the deposit output by subtracting the deposit interest payment from the depositor's required return for the bank in the case without the deposit insurance. In other words, the riskiness of each bank should be considered in the computation of the output. This idea is also captured in Figure-1. We believe, nonetheless, the possibility of bank failure is very low. Thus, we treat the risk-free rate and the required returns for banks in our sample as almost same.

some of the extant studies (e.g., Guarda and Rouabah 2007) estimate the shadow price of the loan provision through a structural estimation.¹³ As another approach, Wang et al. (2004) employs CAPM-type formulation to price the bank's asset. By subtracting the market-value of the loan based on the estimated bank asset prices from the interest receipt from lending, they adjust the gap between the risk-free rate and the hypothetical required market return in the case without information problem. One empirical problem here is that they could not obtain stable risk-adjusted reference rates. Corresponding to this concern, Basu et al. (2008) refers to the most plausible market indexes for the bank assets as possible. Those indexes containing the return of MBS, CMBS, or ABS, however, are not necessarily available. In this paper, we rely on the information about the allowance for loan losses, which we can observe in bank's financial statement. Precisely speaking, we use the average of the changes in the allowance for loan losses in the next three years from a given period where we measure bank output. By using this information, we compute the average of the realized losses in order to adjust the return. Note that the allowance for loan losses is the estimated loss out of the loan outstanding at each point. Thus, the average change in the allowance for loan losses could summarize credit risk associated with the loan asset from the ex-post perspective. If the hypothetical financial market works well and the competition in the market is perfect, the required market return for the loan asset is set to the rate exactly covering this credit risk. This is one justification for using the data of the allowance for loan losses in order to adjust the credit risk.¹⁴

¹³ Fixler and Zieschang (1992) further includes the non-asset bank activity (e.g., M&A advisory) into their analysis.

¹⁴ Of course, the risk which should be covered here is the non-systemic risk. It is our future task to disentangle

As one remark, we have not adjusted the term-risk taken by banks, which corresponds to the duration gap between asset and liability held by banks. Since we do not have detailed information about the durations of banks' asset and liability in our dataset, we could not adjust this risk component. Potential alleviation for this problem is to use the information about the asset and liability volumes in several categories (e.g., (i) loan outstanding to mortgage, capital investment, and (ii) liability outstanding from short-term and long-term deposits). We will leave this issue to the future research question.

3.2. Data overview

We have three independent data sources, which store firm-level, bank-level, and market-level data. First and second databases are for bank characteristics provided by NEEDS Financial Quest, and for the financial characteristics of firms, which is stored in Development Bank of Japan Corporate Financial Database while the third data is the publicly available macro and market data. After compiling the panel data for the productivity of banks and its characteristics, we combine the data with the client firm's characteristics. For this purpose, we employ the loan relationship information between the listed firms and their incumbent banks over our sample period, which covers 1976 to 2005 fiscal years.¹⁵ As a result of this operation, we end up with the large unbalanced panel data. Table-1 and Table-2 list the summary stat and the correlation coefficients, respectively. The first and

the systemic and non-systemic risks in our analysis.

¹⁵ In this version of paper, we employ the loan share information of all the loans (i.e., both short-term and long-term loans). It would be interesting extension to focus on either one of those two loan share information.

second tables in Table-1 and -2 correspond to the match-year-base and firm-year-base summary statistics. The former is computed by treating one match-year observation as one sample, which means that a firm appears multiple times in a year if the firm holds multiple loan relations. On the other hand, the latter is computed by picking up a firm only once in a year.¹⁶ In spite of this methodological difference, however, those two tables share large commonality. In the estimation implemented in the following section, we use the latter sample for our estimation.¹⁷

3.2.1. Bank data

Our first data base - NEEDS Financial Quest - stores bank's financial characteristics in the form of an unbalanced panel data. One remark is that the identification of each bank is based on the identity of each bank as of 2009 fiscal year. If a bank is merged with another bank before 2009, the recognized continuing bank at the timing of merger in the database is automatically treated as a survival one. This means, for example, the financial data of Mizuho Bank is connected to that of Dai-ichi Kangyo Bank, Mizuho-Corporate Bank is connected to the information of Fuji Bank, Mitsubishi-Tokyo-UFJ is connected to Mitsubishi-Tokyo, which is originally connected to Mitsubishi Bank, Risona Bank

¹⁶ Precisely speaking, we pick up the match observation consisting of a firm and its top lender in each year. For the case that the firm has more than one top lender (i.e., "tie"), we treat each match between the firm and each top lender as one separate sample.

¹⁷ As we will detail later, we represent the productivity of incumbent banks by (i) focusing on the top lender's productivity or (ii) computing a share-weighted average of each incumbent bank's productivity.

is connected to Daiwa Bank, and so on.¹⁸

Before implementing the risk-adjustment to the original FISIM output briefed in the precious section, we process two steps. First, the gross output of bank j at the period t is measured by simply following FISIM concept (i.e., loan interest receipt minus deposit interest payment).

$$\left\{ \begin{array}{l} \text{Gross Output}_{j,t} = \text{Interest Receipt}_{j,t} - \text{Interest Payment}_{j,t} \cdots (1) \\ \text{where} \\ \text{Interest Receipt}_{j,t}: \text{Bank } j\text{'s Interest Receipt during the period } t \\ \text{Interest Payment}_{j,t}: \text{Bank } j\text{'s Interest Payment during the period } t \end{array} \right.$$

This output measure in (1), however, are likely to be negative in many bank-year cases due to the unbalanced sizes of loan asset and deposit, which is a typical feature of Japanese banks. Corresponding to this problem, we adjust the deposit interest payment by multiplying the ratio of loan outstanding to deposit outstanding, and construct the so-called B/S Adjusted Output. Through this modification, we compute a hypothetical net interest profit for the bank, which finances all of the existing loan assets by deposit. Note that as a cost of this operation, we inevitably exclude the quality of asset-liability management in each bank from our analysis, which could be potentially an interesting research object.¹⁹

¹⁸ Among those data connection, sometimes the continuation looks somewhat controversial (e.g., Mitsui-Sumitomo Bank follows the financial characteristics of Wakashio Bank, which is relatively small among the member of the merger).

¹⁹ Note also that we exclude bank's business fee revenue associated with, for example, business consulting, remittance, or loan guarantee etc.

$$\left\{ \begin{array}{l} \text{B/S Adjusted Output}_{j,t} = \text{Interest Receipt}_{j,t} - \text{Interest Payment}_{j,t} \times \frac{\text{Loan Outstanding}_{j,t-1}}{\text{Deposit Outstanding}_{j,t-1}} \dots (2) \\ \text{where} \\ \text{Loan Outstanding}_{j,t-1}: \text{Bank } j\text{'s Loan Outstanding at the end of the period } t - 1 \\ \text{Deposit Outstanding}_{j,t-1}: \text{Bank } j\text{'s Deposit Outstanding at the end of the period } t - 1 \end{array} \right.$$

Finally, we subtract the average of the changes in the allowance of loan losses over the next three years from each point. Our productivity measure is computed through dividing this final output measure by the operating cost.

$$\left\{ \begin{array}{l} \text{Risk Adjusted Output}_{j,t} = \text{B/S Adjusted Output}_{j,t} \\ - \sum_{\tau=1}^3 \frac{(\text{Allowance of Loan Losses}_{j,t+\tau} - \text{Allowance of Loan Losses}_{j,t+\tau-1})}{3} \dots (3) \\ \text{where} \\ \text{Allowance of Loan Losses}_{j,t}: \text{Bank } j\text{'s Allowance of Loan Losses at the end of the period } t \end{array} \right.$$

Figure-3 plots the panel data for the productivity of banks in (4), over our sample period. We can immediately notice the large cross sectional dispersion and the seemingly structural change in time-series direction.

$$\left\{ \begin{array}{l} \text{Bank Productivity}_{j,t} = \frac{\text{Risk Adjusted Output}_{j,t}}{\text{Operationg Cost}_{j,t}} \dots (4) \\ \text{where} \\ \text{Operating Cost}_{j,t}: \text{Bank } j\text{'s Operation Cost over the period } t \end{array} \right.$$

3.2.2. Firm data

The firm characteristics are obtained from Development Bank of Japan Financial Data Bank. In addition to the various financial characteristics, the dataset contains the loan outstanding from each bank to each listed firm from 1982 to 1999 fiscal years. We further complement this data with the similar information stored in NEEDS Financial Quest from 1976 to 1981, and 2000 to 2009 fiscal years. About the capital investment ratio for period t , which is a key performance variable for firms in this paper, is simply computed as the ratio of (i) the capital investment accounting for the change in tangible and intangible assets from the end of $t - 1$ to the end of t plus the amount of depreciation, and (ii) the total tangible and intangible assets as of the end of $t - 1$.²⁰

We also use the TFP data for each firms, which is provided by EALC 2009 compiled by Japan Center for Economic Research(JCER), Center for Economic Institutions (IER, Hitotsubashi University), Center for China and Asian Studies (CCAS, Nihon University), and Center for National Competitiveness (Seoul University).

3.2.3. Matching data

As a result of the matching between firms and banks, we have a large size of firm-bank match level unbalanced panel data. By using the information about the short-term and long-term loan outstanding for each match, we also computed (i)

²⁰ We can immediately come up with much more fancy methods for the computation. We leave this to the task in near future.

the loan share of each incumbent banks out of the total short-term loan for each listed company, (ii) that of long-term loan, (iii) that of total loan, (iv) the number of incumbent banks for each listed company, (v) the Hershman-Herfindahl index of loan shares, and (vi) the duration of the relationship between each pair of a bank and a firm.

In order to determine the last object (vi), we consider the way extant studies use to define the spell of relationship. Each spell is detected to terminate at one-year before the date when the total loan share hits zero. For the initiation of the relation, we assume that any spell starting after 1977 fiscal year is a fresh spell. The left-censored spell, which has a relation as of 1976 fiscal year, is treated as a fresh spell starting from 1976 fiscal year.²¹ All the treatment of the spell follows the one in the recent literature (e.g., Ongena and Smith 2001; Ioannidou and Ongena 2010; Schenone (2010)).

4. Empirical analysis

In this section, we empirically examine the marginal impact associated with the productivity of incumbent banks onto client firm's performance. In order to see the correlation between the productivity of incumbent banks and client firm's performance, first we focus on the productivity of top lenders. This reflects our consideration that the largest lender's characteristics have the most important impact on its client firm's behavior. As a robustness check, we also summarize all the incumbent banks' productivity. Precisely speaking, we compute the weighted

²¹ As a usual problem in the analysis of spell data, we could employ various robustness checks considering the censored samples.

average of a given firm's incumbent banks' productivities by using each bank's total loan share (i.e., short-term and long-term) as the weight. We use a match between firm and its top lender as a group for our panel estimation. This means the group is changed when firms switch their top lender. This treatment allows us to partly control the endogeneity of matching between firms and their top lenders (see Fukao et al. 2005).

In the following subsection, we go over several theoretical illustration motivating our empirical study. Note that no attempt is made to create any original theoretical model in this paper. We simply intend to set up a conceptual framework we refer to in our empirical study.

4.1. Theoretical underpinnings and hypothesis formulation

The standard empirical study for firm's capital investment choice, which is theoretically motivated by the convex cost function (e.g., Uzawa 1969), employs Tobin's Q and/or other proxies for Tobin's Q as an important explanatory variable for the investment ratio (i.e., the gross capital investment flow divided by the lagged capital stock). The performance of the empirical model however, tends to be evaluated as not so successful.²²

Among the theoretical explanations for this misalignment between the theory and empirics, we focus on the existence of financial friction. A number of extant studies explore how the costly external finance arises due to the information problem between borrowers and lenders. They consider financial intermediaries

²² See Erickson and Whited (2000), and Tonogi et al. (2010) for the extensive discussion for this issue.

like banks as one devise to mitigate such an information problem. As one theoretical illustration, Hauswald and Marquez (2005) demonstrates that the market share of banks implementing the screening activity based on private information increases compared to the transaction-based lending, when the quality of public information about the borrower deteriorates. This implies that the quality of incumbent banks' information production affect the client firm's financial availability given the quality of public information. In other words, the heterogeneity in terms of bank performance could affect each firm's financial conditions.

The existing studies on this perspective have been, however, treating the characteristics of incumbent banks in a discrete manner. For example, the long strands of studies about "Mainbank" categorize incumbent banks into two types (i.e., main or sub-main) by mainly focusing on the tightness of relations. Except for a few recent studies (e.g., Fukao et al. 2005; Fukuda et al. 2009, Goto 2010; Amiti and Weinstein 2010), we know little about the impact of continuously measured bank characteristics onto its client firm's performance. The following hypothesis we test aims at fulfilling this gap by using our unique measure for bank productivity and focusing on firm's capital investment behavior.

***Hypothesis:** The sensitivity of firm's capital investment with respect to its investment opportunity is positively correlated with the productivity of incumbent banks, which is represented by the modified FISIM output divided by the bank's operational cost.*

In order to test this hypothesis, we consider the model (5). This is a typical extension of the standard capital investment equation motivated by Q-theory, which is theoretically derived in a number of extant studies (e.g., Hennesy et al. 2007).

$$\frac{I_{i,t}}{K_{i,t-1}} = \beta_0 + \beta_1 \times c_PBR_{i,t-1} + \beta_2 \times c_PBR_{i,t-1} \times BANKPROD_{i,t-1} + \gamma \times X_{i,t-1} + \alpha_i + \epsilon_{i,t} \dots (5)$$

In this capital investment equation, i and t denote the indexes for the pair of firm and its top lender, and time, respectively. $I_{i,t}$ stands for the gross capital investment implemented by firm i during period t , which is computed by adding the gross depreciation over the period t to the change in the stock of tangible and intangible assets during the period t . The denominator of the dependent variable $K_{i,t-1}$ is the size of firm i 's total capital at the end of $t-1$. As an important explanatory variable, $c_PBR_{i,t-1}$ stands for the investment opportunity proxied by the Price-to-Book Ratio of each firm i and t measured in % at the end of $t-1$, which are obtained from NEEDS Financial Quest. Another crucial variable $BANKPROD_{i,t-1}$ stores the productivity of the top lender for firm i at the period $t-1$. $X_{i,t-1}$ store the vector of the lagged control variables containing, for example, firm's size, cash ratio, leverage, ROA, and bank's size and so on. Finally, α_i and $\epsilon_{i,t}$ stand for the individual effect (fixed- or random-effect) and the error term in our panel estimation formulation, the characteristics of which depend on the model we

choose.²³ Note that the individual effect α_i is measured for the pair of each firm and top lender since the group of our panel data is a match of a firm and its top lender. This means that the group for the panel estimation is changed when a firm switches its top lender.

To test our hypothesis, we check if $(\beta_1 > 0 \ \& \ \beta_2 > 0)$ are the case or not. We expect $\beta_1 > 0$ from the standard theory of capital investment while $\beta_2 > 0$ is also expected under the presumption that the combination of firms facing some sort of financial friction and the group of incumbent banks exhibiting higher productivity increases the sensitivity of capital investment ratio of the firm with respect to the level of investment opportunity.

For this estimation, we split our sample based on the level of investment opportunity and the degree of firm's cash flow constraint. First, as pointed out in the literature on firm's capital investment, the response of firm's capital investment with respect to the investment opportunity could be non-linear due to, for example, the lack of flexibility in divestment. Thus, we split our sample into the ones exhibiting c_PBR_{it-1} (i) between the 25 percentile of the Firm-level samples (i.e., 291%) and the median (i.e., 540%), (ii) the median and the 75 percentile (i.e., 1013%), and (iii) the 75 percentile and the 95 percentile (i.e., 4045%). Second, we presume that the firms facing more severe cash-flow constraint is more appropriate for our empirical analysis. We use the $c_ROA_{i,t-1}$, which is computed by dividing the firm's EBITDA (i.e., Earning Before Interest payment, Tax payment, Depreciation, and Amortization) by the total asset of the firm at the end of $t - 1$ as a proxy for the firm's cash-flow constraint. We split our sample into the ones

²³ According to the results of the standard model specification procedure, we employ the fixed-effect model.

exhibiting $c_ROA_{i,t-1}$ (A) below and (B) above the median of the Firm-level samples (i.e., 0.087). We also focus on the firms whose gross capital investment is greater than the depreciation. This is because we want to restrict our samples to the firms actually facing a large investment opportunities as well as external financing needs.²⁴ We expect that the sample satisfying both the criterion (iii) and (A) provides ($\beta_2 > 0$), which supports the hypothesis constructed above.

4.2. Estimation results

The main estimation results are summarized in Table-3. The lower (upper) panels correspond to the samples having larger (smaller) investment opportunities. The first column is the results based on all the samples while the center (right) column corresponds to the severer (less severe) cash-flow constraint.

First, we confirm that our hypothesis is supported (i.e., the coefficient of $c_PBR_{i,t-1} \times BANKPROD_{i,t-1}$ is significantly positive) for the samples having relatively larger investment opportunities and facing more severe cash-flow constraint (i.e., the second column of the lower panel). Only in the samples with the high investment opportunity provides this feature. Moreover, the samples having large investment opportunities and facing relatively severe cash-flow constraint no longer shows the positive response of the investment ratio with respect to $c_PBR_{i,t-1}$. This implies that the existence of incumbent banks with high productivity is critical to the firms' capital investment under financial constraint.

²⁴ Other sample selection criteria are as follows: Capital investment ratio is equal to or less than three, and the weighted average of incumbent banks' productivity is between -2 and 5. These criteria are used to exclude outliers.

Second, the results imply that firms' capital investment ratio becomes larger when (i) the level of the firm's liquidity holding is higher ($c_CASHRATIO_{i,t-1}$), and (ii) the size of the firm is smaller ($c_LNSIZE_{i,t-1}$)²⁵, both of which are consistent with the predictions in the standard literature. Table-4 also confirms this result by using the summarized bank productivity based on each loan share.

We could also check if our statistically significant empirical results also have sizable economic impact. For the samples satisfying both the criterion (iii) and (A), which estimation results are listed lower-middle panel of Table-3, the average $c_PBR_{i,t-1}$ is 1,577 and the standard deviation of $BANKPROD_{i,t-1}$ is 1.03. Suppose there are two firms with the same investment opportunity equal to the average, the first (second) of which has relations with banks jointly showing productivity lower (higher) than average by one standard deviation. This could generate the difference between their investment ratios by $0.000047 \times 1,577 \times (1.03+1.03) = 0.15$. Considering that the average investment ratio for this sample is 0.2, this number could be interpreted to have a sizable economic impact.

Table-5 demonstrates the same estimation with including the interaction term between $c_PBR_{i,t-1}$ and the duration of the loan relationship of the party (i.e., the firm and the largest lender) as of the time t . The sign of the coefficient is not significant while the positive coefficient associated with $c_PBR_{i,t-1} \times BANKPROD_{i,t-1}$ is kept. One conjecture is that the long relationship, which presumably helps to accumulate “relationship capital”, could not work as a complement for the bank productivity. This partly sheds some light to the discussion about the benefit of

²⁵ Firm's size is measure by the natural logarithm of total asset.

relationship-based lending. We leave the further empirical investigation on this issue to our future research question.

4.3. Discussion

The estimation results presented in the previous section potentially missed several important dimensions related to firm's capital investment choice. First, it ignores other frictions or issues leading to the poor performance of Q-theory, which could be potentially interacted with the productivity of banks. For example, we are not taking into account the existence of fixed cost for capital investment, which induces the lumpy investment (Hennessy and Whited (2005)). Also, other financial frictions than the bank loan could affect the firm's capital investment behavior (Bayer 2006). Second, it would be necessary to allow the dependent variables (i.e., capital investment ratio) to capture firm's investment behavior over multiple periods. This reflects the realistic consideration that large capital investments take a few years to complete. Third, we need to focus not only on the whole risk-adjusted FISM but also the risk-adjusted FISIM associated with lending services. Those issues are recognized as our tasks in near future.

Another important issue is on our empirical strategy. All the estimations in this paper rely on the fixed-effect model, which is supported by the standard model specification procedure. The fixed-effect model also allows us to partly control the endogeneity in the matching process between firms and top lenders. This reflects the presumption that the estimated fixed-effect parameters account for the unobservable match-specific heterogeneity, which is potentially correlated with

the determinants of matching.²⁶ This issue also leads to the discussion about causality between bank productivity and client firm's performance. The appropriate usage of instrument variables would be another possibility to tackle this problem.

The choice of our measure for bank productivity is another point to be discussed. The current productivity measure is a simple ratio of risk-adjusted bank profit to the operation cost. We could expect, however, that the profits are affected by time-varying mark-up rates. Although we could potentially check if our results are robust to the variation in market-level mark-up by splitting the sample into the early and late periods, it could be insufficient. What we really need to measure is the one corresponding to TFP in the standard productivity literature. In this regard, we should consult on the recent studies about the TFP measurement in medical industry (e.g., Castelli et al. 2010). We leave the empirical investigation on this issue to our future research question.

5. Concluding Remarks

This paper proposes one measure for bank productivity and studies its impact on the capital investment of their client firms. We use the risk-adjusted profit of an individual bank per its operating cost as a direct measure for the productivity of banks. By using this panel-data with the wide varieties of bank and firm characteristics as well as the loan relationship data between Japanese listed companies and banks over the last three decades, we study how the performance of banks are correlated with the flexibility of firms capital investment.

²⁶ The method proposed in Fox (2010) is another way to control this aspect.

Our empirical results imply that firm's capital investment choice, which generically reflect firm's own characteristics, have also statistically and economically significant interactions with the bank performance measure. This implies it is necessary to expand the discussion for the determinants of firm performances to the characteristics of the parties having relationships with the firm. In this perspective, we believe this paper contributes to the recently accumulated researches on the economics of relation.

To conclude, we list several future research questions. First, in order to provide a valid answer to the question about the correlation between bank productivity and client firm performance, we should examine the impact of incumbent bank productivity onto, for example, client firm's ex-post TFP, profitability and/or survivability. Through this analysis, we could also discuss whether firms facing low ROA are actually financially constrained or not. Second, it is our another interest to study how match-specific characteristics (e.g., the share of loan, the duration of loan relations, and/or the dynamics of relations) have interactions with the bank productivity for the determination of client firm's capital investment behavior and performance. Third, our measure for the productivity of banks could be applied to the empirical discussion for (i) the determinants of firm's overseas activities, (ii) cash hoarding motives, and (iii) firm's choice of capital structure. Fourth, the technical issues mentioned in the previous section (e.g., focusing on the lending FISIM output, considering matching mechanism, using instrument variable methods, estimating TFP instead of the current naïve productivity measure etc.). Fifth, the time-series variation of the bank

productivity's contribution is another interesting issue. We believe all of these extensions provide further guides for better understanding about the productivity of banks as well as economic implication of firm-bank relations.

<Table and Figure>

Figure-1: FISIM Concept

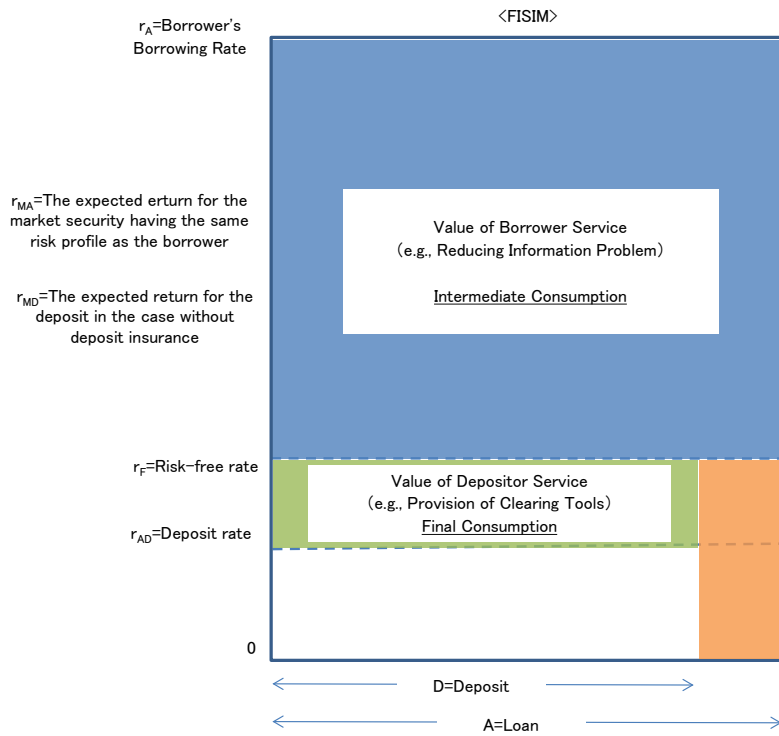


Figure-2: Risk-Adjusted Bank Output (Concept)

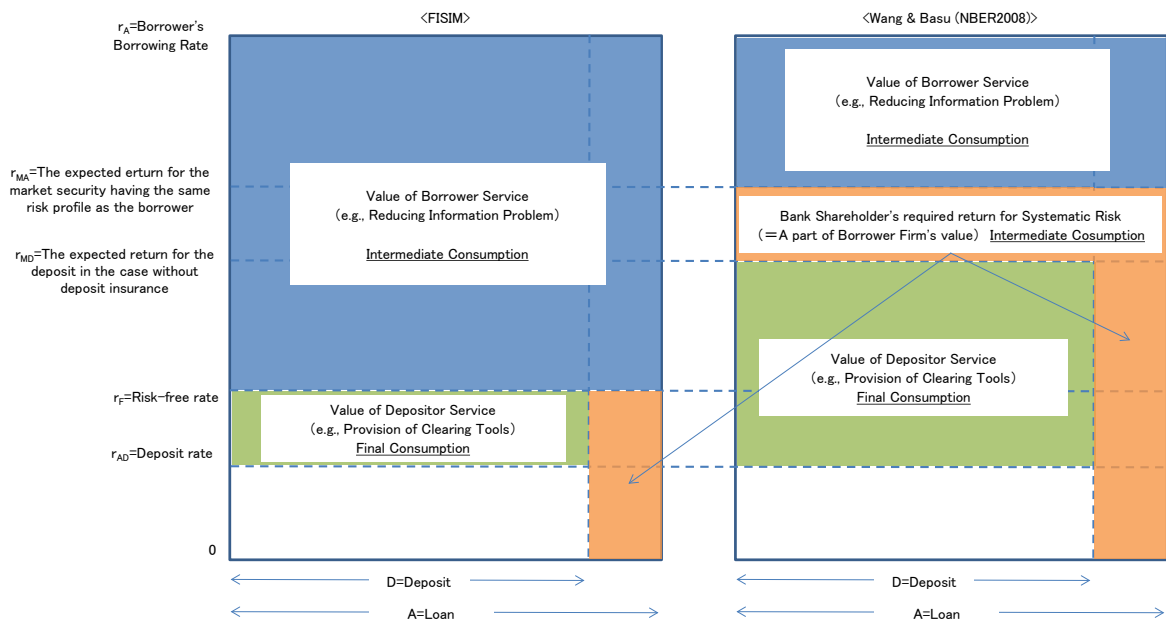


Figure-3: Measured Bank Productivity (Bank-Level)

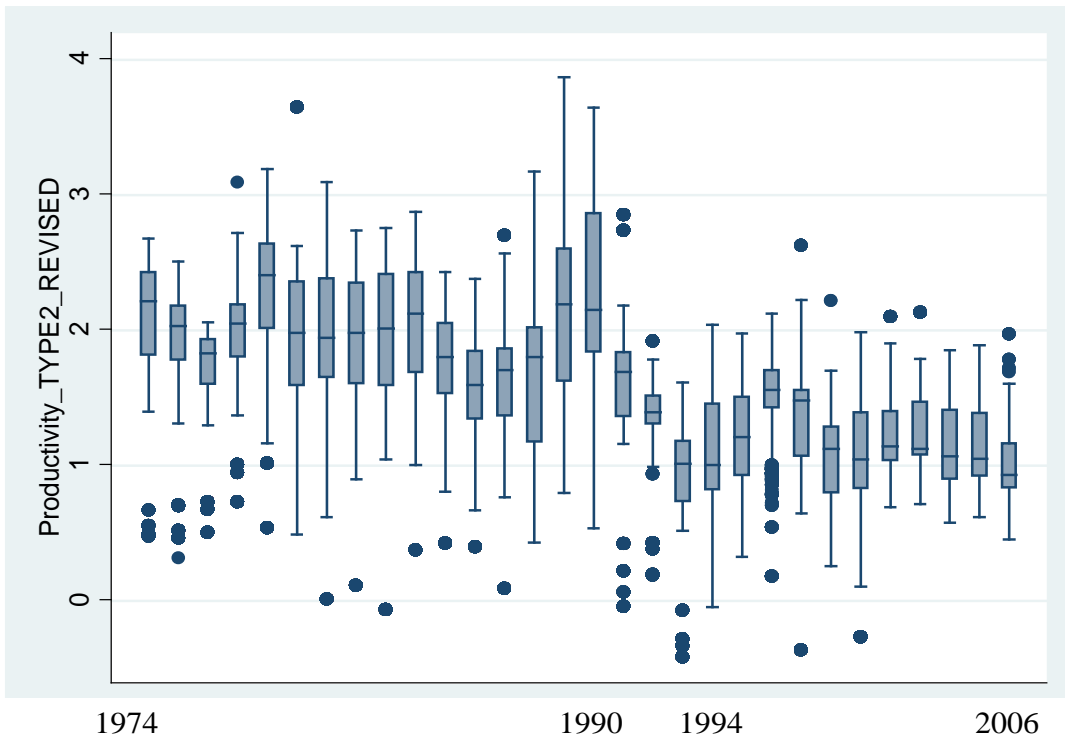


Figure-4: Measured Bank Productivity (Summarized in Firm-Level)

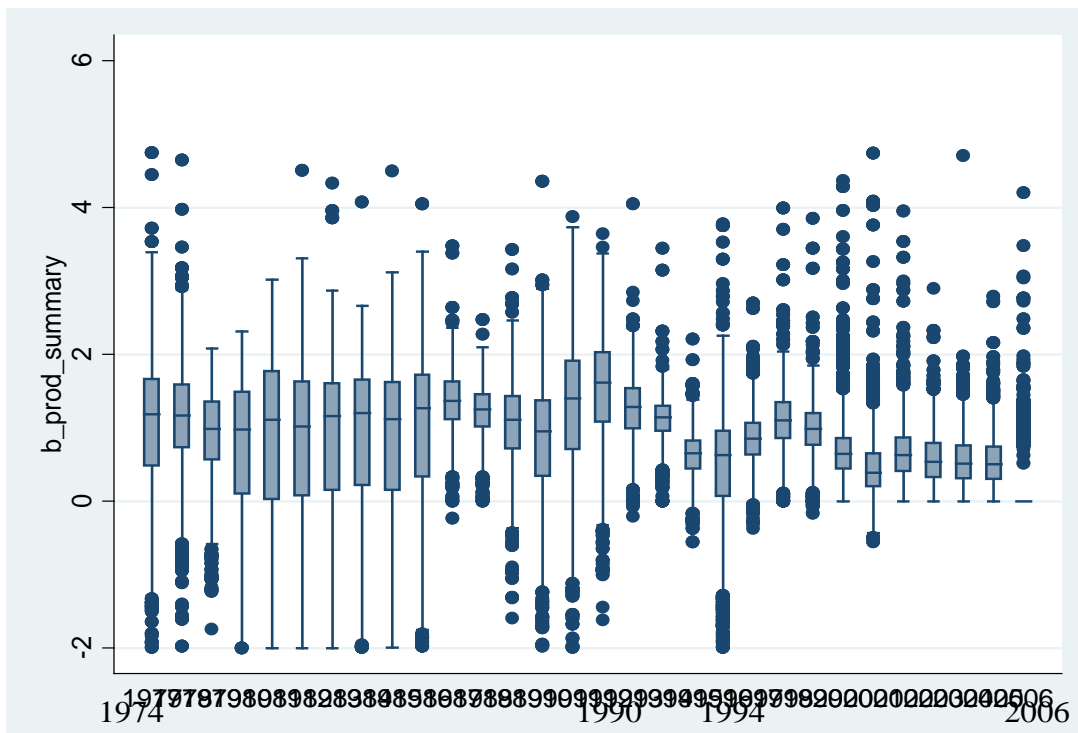


Figure-5: Expected Signs for Each Sample

	All ROA samples	(A) ROA<Median	(B) ROA>=Median
(i) Low Investment Opportunity C_PBR= 25~50 percentile	$\beta_2 = 0$	$\beta_2 = 0$	$\beta_2 = 0$
(ii) Medium Investment Opportunity C_PBR= 50~75 percentile	$\beta_2 = 0$	$\beta_2 = 0$	$\beta_2 = 0$
(iii) High Investment Opportunity C_PBR= 75~95 percentile	$\beta_2 > 0$	$\beta_2 \gg 0$	$\beta_2 = 0$

Table-1: Summary Stat

<Match-Base>

Category	Variable	Obs	Mean	Std.Dev.	Min	Max
Firm	Investment Ratio	366960	0.21	2.67	-1.00	596.35
	c_PBR	385152	10066	109817	13	5330745
	LN(c_PBR)	385152	6.43	1.17	2.58	15.49
	c_CASHRATIO	386463	0.12	0.08	0.00	0.86
	c_LEVERAGE	386463	0.72	0.16	0.04	8.34
	c_LNSIZE	386463	11.49	1.69	5.60	16.90
	c_ROA	372316	0.08	0.06	-1.05	3.27
	c_TFP	284645	0.02	0.18	-1.28	1.38
Bank	b_LNSIZE	253991	16.17	1.42	10.90	18.90
	BANKPROD	280191	1.07	2.71	-34.21	4.30
MATCH	c_PBR*BANKPROD	278130	11302	151660	-12600000	9241215

<FIRM & TOP LENDER-Base>

Category	Variable	Obs	Mean	Std.Dev.	Min	Max
Firm	Investment Ratio	35184	0.20	0.74	-0.98	74.77
	c_PBR	36498	10519	113379	13	5330745
	LN(c_PBR)	36498	6.48	1.22	2.58	15.49
	c_CASHRATIO	36619	0.13	0.08	0.00	0.80
	c_LEVERAGE	36619	0.65	0.19	0.05	8.34
	c_LNSIZE	36619	10.83	1.51	6.01	16.90
	c_ROA	35594	0.08	0.07	-1.05	3.27
	c_TFP	28263	0.02	0.19	-1.28	1.38
Bank	b_LNSIZE	25424	17.07	1.10	12.03	18.90
	BANKPROD	29818	1.12	0.99	-14.13	4.30
MATCH	c_PBR*BANKPROD	29643	9045	125598	-928301	5596971

Note: c_PBR is measure in percent points

Table-2: Correlation Table

◁Match-Base: OBS=114901▷												
Category	Variable	Investment Ratio	c_PBR	LN(c_PBR)	c_CASH RATIO	c_LEVERAGE	c_LNSIZE	c_ROA	c_TFP	b_LNSIZE	BANK PROD	c_PBR* BANK PROD
Firm	Investment Ratio	1.00										
	c_PBR	0.03	1.00									
	LN(c_PBR)	0.05	0.55	1.00								
	c_CASHRATIO	0.01	0.18	1.00								
	c_LEVERAGE	0.00	-0.03	-0.20	1.00							
	c_LNSIZE	-0.01	0.06	0.11	-0.28	0.30	1.00					
	c_ROA	0.06	0.15	0.43	0.13	-0.25	-0.03	1.00				
	c_TFP	0.01	0.09	0.04	-0.11	-0.11	0.12	0.13	1.00			
	b_LNSIZE	0.00	-0.03	0.01	0.01	-0.17	-0.10	-0.01	0.00	1.00		
	BANKPROD	0.00	0.01	0.00	0.03	-0.01	-0.02	-0.01	0.00	-0.05	1.00	
MATCH	c_PBR*BANKPROD	0.03	0.82	0.46	0.02	-0.02	0.05	0.12	0.08	-0.03	0.04	1.00
◁FIRM & TOP LENDER-Base: OBS=14398▷												
Category	Variable	Investment Ratio	c_PBR	LN(c_PBR)	c_CASH RATIO	c_LEVERAGE	c_LNSIZE	c_ROA	c_TFP	b_LNSIZE	BANK PROD	c_PBR* BANK PROD
Firm	Investment Ratio	1.00										
	c_PBR	0.10	1.00									
	LN(c_PBR)	0.16	0.47	1.00								
	c_CASHRATIO	0.06	0.07	0.25	1.00							
	c_LEVERAGE	-0.01	-0.06	-0.27	-0.20	1.00						
	c_LNSIZE	-0.02	-0.02	0.06	-0.18	0.19	1.00					
	c_ROA	0.15	0.11	0.40	0.15	-0.23	-0.04	1.00				
	c_TFP	0.01	0.04	0.03	-0.04	-0.10	0.10	0.13	1.00			
	b_LNSIZE	-0.01	0.00	-0.01	-0.05	-0.01	0.24	-0.07	0.13	1.00		
	BANKPROD	0.01	0.00	0.01	0.10	-0.03	-0.11	0.01	-0.06	-0.04	1.00	
MATCH	c_PBR*BANKPROD	0.11	0.90	0.46	0.08	-0.05	-0.02	0.11	0.04	-0.01	0.02	1.00

Table-3: Estimation Results (Capital Investment Ratio)

All Industry <Low Investment Opportunity> INVESTMENT RATIO (t)	(A) Fixed-Effect All INVOPP=PBR		(B) Fixed-Effect ROA<Median INVOPP=PBR		(C) Fixed-Effect ROA>=Median INVOPP=PBR	
	Coef.	Robuar Std.	Coef.	Robuar Std.	Coef.	Robuar Std.
c_PBR (t-1)	0.000277	0.000085 ***	0.000352	0.000164 **	0.000323	0.000128 **
c_PBR*BANKPROD (t-1)	0.000000	0.000010	-0.000010	0.000016	0.000012	0.000016
c_CASHRATIO (t-1)	0.359488	0.134240 ***	-0.063419	0.203362	1.004529	0.248062 ***
c_LEVERAGE (t-1)	-0.083822	0.084312	-0.186655	0.148639	-0.122072	0.169582
c_LNSIZE (t-1)	-0.192903	0.043223 ***	-0.173071	0.095386 *	-0.363153	0.087184 ***
c_ROA (t-1)	0.136446	0.195581	-0.047924	0.556661	0.532811	0.304503 *
b_LNSIZE (t-1)	-0.066210	0.055933	-0.051191	0.098310	-0.217940	0.110006 **
_cons	3.291149	1.277921 ***	2.889730	2.210006	7.004697	2.093213 ***
# Obs	2769		1345		1424	
# Group	1169		745		662	
R-sq (within)	0.1305		0.1322		0.1688	
<Medium Investment Opportunity> INVESTMENT RATIO (t)	INVOPP=PBR		INVOPP=PBR		INVOPP=PBR	
	Coef.	Robuar Std.	Coef.	Robuar Std.	Coef.	Robuar Std.
c_PBR (t-1)	0.000168	0.000057 ***	-0.000057	0.000090	0.000363	0.000091 ***
c_PBR*BANKPROD (t-1)	-0.000004	0.000007	0.000016	0.000012	-0.000005	0.000007
c_CASHRATIO (t-1)	0.331384	0.129163 ***	0.266258	0.265629	0.551800	0.220955 **
c_LEVERAGE (t-1)	-0.136971	0.095158	0.082619	0.164005	-0.116689	0.153198
c_LNSIZE (t-1)	-0.254302	0.043315 ***	-0.230715	0.089178 ***	-0.367243	0.076307 ***
c_ROA (t-1)	0.245664	0.192694	1.014191	0.535385 *	0.166612	0.354180
b_LNSIZE (t-1)	-0.025210	0.050783	-0.133009	0.086477	0.075920	0.079794
_cons	3.363307	1.007639 ***	4.986838	1.933545 ***	2.604575	1.616162
# Obs	2674		1142		1532	
# Group	1251		690		805	
R-sq (within)	0.1867		0.1300		0.2395	
<High Investment Opportunity> INVESTMENT RATIO (t)	INVOPP=PBR		INVOPP=PBR		INVOPP=PBR	
	Coef.	Robuar Std.	Coef.	Robuar Std.	Coef.	Robuar Std.
c_PBR (t-1)	0.000049	0.000024 **	0.000001	0.000040	0.000076	0.000030 **
c_PBR*BANKPROD (t-1)	0.000021	0.000009 **	0.000047	0.000022 **	0.000018	0.000012
c_CASHRATIO (t-1)	1.038890	0.269967 ***	0.315937	0.302922	1.066122	0.362833 ***
c_LEVERAGE (t-1)	0.258602	0.116478 **	-0.036025	0.428916	0.363513	0.168650 **
c_LNSIZE (t-1)	-0.284008	0.055434 ***	-0.181936	0.186711	-0.298575	0.084956 ***
c_ROA (t-1)	-0.412173	0.471027	-0.359577	0.572112	-0.661887	0.767948
b_LNSIZE (t-1)	0.025150	0.056476	0.053644	0.155187	0.002271	0.067672
_cons	2.792410	1.124818 **	1.152500	3.279023	3.337359	1.366741 **
# Obs	1897		609		1288	
# Group	905		368		674	
R-sq (within)	0.1942		0.2187		0.2081	

Note: ***:1%, **:5%, *:10%

Note: Time Dummy is included in all the model.

Note: All Sample is used.

Note: Low, Medium, and High Investment Opportunity correspond to the samples exhibiting [25 percentile, medium), [medium, 75 percentile], and (75 percentile, 95 percentile) in PBR.

Note: Fixed-Effect model is selected through the usual model selection procedures.

Table-4: Estimation Results (Capital Investment Ratio: Summarized BANKPROD)

All Industry <High Investment Opportunity> INVESTMENT RATIO (t)	(A) Fixed-Effect All INVOPP=PBR		(B) Fixed-Effect ROA<Median INVOPP=PBR		(C) Fixed-Effect ROA>=Median INVOPP=PBR	
	Coef.	Robuar Std.	Coef.	Robuar Std.	Coef.	Robuar Std.
c_PBR (t-1)	0.000059	0.000018 ***	0.000008	0.000036	0.000059	0.000021 ***
c_PBR*BANKPROD (t-1)	0.000007	0.000005	0.000037	0.000021 *	0.000006	0.000005
c_CASHRATIO (t-1)	0.977859	0.208483 ***	0.701204	0.328303 **	0.864401	0.251332 ***
c_LEVERAGE (t-1)	0.185943	0.108267 *	-0.018366	0.395634	0.228176	0.144911
c_LNSIZE (t-1)	-0.293248	0.056461 ***	-0.274701	0.172839	-0.246539	0.072202 ***
c_ROA (t-1)	-0.431627	0.462622	-0.293951	0.504433	-0.299820	0.696294
b_LNSIZE (t-1)	-0.022910	0.042626	-0.094123	0.099911	-0.034453	0.050503
_cons	3.684798	1.001794 ***	4.892456	2.348735 **	3.338536	1.183560 ***
# Obs	2257		723		1534	
# Group	1076		440		795	
R-sq (within)	0.1755		0.1910		0.1739	

Note: ***:1%, **:5%, *:10%

Note: Time Dummy is included in all the model.

Note: All Sample is used.

Note: Low, Medium, and High Investment Opportunity correspond to the samples exhibiting [25 percentile, medium), [medium, 75 percentile], and (75 percentile, 95 percentile] in PBR.

Note: Fixed-Effect model is selected through the usual model selection procedures.

Table-5: Estimation Results (Capital Investment Ratio: Relationship Duration)

All Industry <High Investment Opportunity> INVESTMENT RATIO (t)	(A) Fixed-Effect All INVOPP=PBR		(B) Fixed-Effect ROA<Median INVOPP=PBR		(C) Fixed-Effect ROA>=Median INVOPP=PBR	
	Coef.	Robuar Std.	Coef.	Robuar Std.	Coef.	Robuar Std.
c_PBR (t-1)	0.000061	0.000032 *	-0.000005	0.000038	0.000086	0.000049 *
c_PBR*BANKPROD (t-1)	0.000021	0.000009 **	0.000046	0.000024 *	0.000018	0.000012
c_PBR*R_DURATION (t-1)	-0.000001	0.000002	0.000001	0.000005	-0.000001	0.000003
c_CASHRATIO (t-1)	1.029340	0.261263 ***	0.315452	0.302250	1.053441	0.343924 ***
c_LEVERAGE (t-1)	0.253411	0.116567 **	-0.038808	0.427184	0.357052	0.167747 **
c_LNSIZE (t-1)	-0.276436	0.053929 ***	-0.186458	0.190354	-0.290595	0.083717 ***
c_ROA (t-1)	-0.427156	0.475078	-0.362615	0.574180	-0.676968	0.773951
b_LNSIZE (t-1)	0.026932	0.056396	0.049830	0.156148	0.002509	0.067318
_cons	2.698002	1.118402 **	1.258322	3.342213	3.261746	1.358286 **
# Obs	1897		609		1288	
# Group	905		368		674	
R-sq (within)	0.1945		0.2188		0.2084	

Note: ***:1%, **:5%, *:10%

Note: Time Dummy is included in all the model.

Note: All Sample is used.

Note: Low, Medium, and High Investment Opportunity correspond to the samples exhibiting [25 percentile, medium), [medium, 75 percentile], and (75 percentile, 95 percentile] in PBR.

Note: Fixed-Effect model is selected through the usual model selection procedures.

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