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Regional Financial Soundness and R&D Activities*

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Abstract

In order to explore the impact of financial factors on the real economy, many researchers are analyzing the relationship between finance and real economic activity using new theories and approaches. This paper focuses on the relationship between financial soundness and corporate R&D activities on a regional scale. By measuring regional financial performance using data series including periods of financial crisis and recovery (from the end of the 1990s to the middle of the 2000s), this paper statistically examines the correlation with factors such as corporate R&D expenditure.

Analysis of the whole sample including large corporations reveals that regional financial soundness and R&D activities have a positive, albeit weak, correlation. However, a stronger correlation is observable if we (i) narrow down the sample to small and medium-sized enterprises (SMEs), which are more strongly affected than large corporations by adverse financial conditions, and (ii) use as an independent variable a common component capturing the trends from multiple banking financial indicators. This holds true even if we take into account the possibility that financial soundness might be endogenous or non-financial elements of the regional economy might have impacts on R&D activities. In addition, the correlation becomes even stronger if we take into account, through a Tobit model, the effect of corporations in the sample not actually performing R&D activities.

This paper's empirical findings suggest that regional finance plays an important role in revitalizing regional economies. Policies on a regional scale for stabilizing the financial system would also be meaningful in the development of regional economies.

JEL classification: G31, L26 and O30

Keywords: Regional finance, innovation, R&D investment, Tobit model, instrumental variables, and prudence policy

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1. Introduction

Many researchers have sought to identify a relationship between finance and real economic activity through the ages. The real economy obviously has impacts on finance, but inverse causality, i.e., impacts of financial factors on the real economy, has been discussed for a long time. The real economy and finance have various aspects, but this paper mainly focuses on corporate R&D activities on the real economy side as well as regional financial soundness on the finance side.

Since the late 1980s, many researchers have been analyzing the relationship between finance and real economic activity based on new theories or empirical approaches. In particular, since Fazzari et al. (1988), empirical analyses with focus on corporate investment activities have formed a major stream. Fazzari et al. empirically analyzed the internal finance of US firms as an indicator of financial restrictions and argued that corporate financial restrictions is an important factor that influences physical investments. After them, researchers continued analyzing the relationship between internal finance and investment by using corporate data in various nations. (These researchers include Hoshi et al. (1991), Devereux and Shiantarelli (1989), and Gertlter and Gilchrist (1994).) However, controversy has remained since Kaplan and Zingales (1997, 2000) raised an objection about the feasibility of corporate internal finance as a proxy variable of financial restrictions.

In this context, some are working on their research assuming that a similar argument might also hold true in terms of corporate innovation activities, including R&D investments. Himmelberg and Petersen (1994), which handles the relationship between internal finance restrictions and R&D investments, is a pioneering work in this topic. Researchers have been studying on various research projects by recognizing finance and innovation activities from multifaceted aspects.

Actually researchers have long had the viewpoint of the impacts of financial restrictions on innovation activities. Schumpeter pointed out this topic (Schumpeter (1911, 1942)) and later Nelson (1959) and Arrow (1962) suggested theoretical models. However, theoretical advancements, including incompleteness of the capital market resulting from asymmetric information, and an improved data analysis environment have enabled advancement of research activities in this area both from theoretical and empirical perspectives.

Based on preceding researches, this paper empirically analyzes the relationship between a change in the financial environment and corporate innovation activities. The data used have the following characteristics: (i) The data on the finance side indicate the financial system's soundness from the end of the 1990s to the mid-2000s when Japan's financial system became significantly unstable; and (ii) the data on the innovation side come from micro data of the "Basic Survey of Japanese Business Structure and Activities," which include abundant information on Japanese firms' innovation activities.

This paper has the following structure. First, Section 2 briefly reviews preceding literatures on

relationships between finance and innovation activities. Section 3 discusses this paper's theoretical perspectives and hypothesis. Section 4 explains the data used, while Section 5 discusses analytical findings. The final section presents the conclusion and describes future research tasks.

2. Finance and innovation activities

2-1 Finance and real economic activity

As for the relationship between finance and real economy, Schumpeter suggested that finance would play important roles in the real economy, while Robinson (1952) recognized finance as a subordinate factor of corporate activities. In this way, researchers have been claiming possible causalities between these two factors. In recent years, researchers have conducted theoretical and empirical research projects on whether or how much the finance side factors would have impacts on the real economy side. However, finance and the real economy might have various relationships, depending on which element of finance or the real economy researchers focus on.

For example, Rajan and Zingales (1998) and Beck et al. (2008) are pioneering works handling the effects of financial development on economic/industrial growth based on macro level perspectives. By employing international comparison data, the former concludes that nations that have developed financial markets enjoy quicker advancement of the manufacturing sector that needs external finance, while the latter suggests that development of the financial sector would encourage growth of industries that depend on SMEs facing financial restrictions. Beck and Levine (2002) analyze impacts of types of financial systems (bank-oriented or market-oriented). According to them, efficient financial legislation and the overall financial development would encourage industrial growth, but they do not see a clear impact of whether financial system is bank-oriented or market-oriented.

Many researchers are also conducting empirical research on corporate activities in specific areas. Since the 2000s, Carpenter and Peterson (2002) and Oliveira and Forturato (2006) suggested that internal finance might have a significant influence on the growth of small-sized firms. Similarly, Audretsch and Elston (2002) argue that the amount of internal finance would have strong impacts on the capacity investment of medium-sized firms. In addition, Guiso et al. (2004) concludes improvement in regional finance will encourage entrepreneurial endeavors and market entries.[1]

From the viewpoints stated above, there are many variations, depending on which element of finance or real economic activity is emphasized (Table 1).

[Table 1. Studies on the relationship between financial elements and real economic elements]

[1] It should pose stronger impacts on small-sized firms, but Guiso et al. argues that it is not necessarily the case in Germany (the nation analyzed) due to government policies for small-sized firms.

2-2 Innovation activities

Researchers are also paying attention not only to impacts of finance on corporate activities directly connecting to relatively short-term production plans, such as capacity investment, but also to impacts on corporate innovation activities from long-term perspectives. Pioneering researches in this context include Himmelberg and Petersen (1994). They focus attention on the relationship between internal finance restrictions and R&D investment. By using panel data of small-sized high-tech firms that would face stronger financial restrictions, they showed a significant relation between R&D investment and internal finance.

Research projects on the relationship between innovation activities and finance have been developing, and they incorporate their own viewpoints to grasp innovation activities and financial elements. Based on the hypothesis that banks influence corporate innovation through their role to support R&D funds, Herrera and Minetti (2007) empirically analyze how much a difference in firm-bank relationships would pose impacts on the number of innovations. By using the loan period as a proxy variable of corporate information accumulated in banks, they showed that it has a positive relation with corporate innovation. Based on corporate data in 57 countries, mainly consisting of developing nations, Sharma (2007) confirms that nations with developed financial sectors tend to enjoy a higher level of R&D activities of small-sized firms.

How the financial side data are grasped is important in empirical analysis on the relationship between finance and innovation activities. In this context, some researchers pay attention to regional finance. Guiso et al. (2004) estimate “entrepreneur’s accessibility to the credit market” for each region and use it as an indicator of regional financial development. Their analysis has revealed that developed regional finance will enhance the probability of launching new businesses and encourage market entries, leading to economic growth. By using the number of banks and branch offices per capita as proxy variables of regional finance’s development, Benfratello et al. (2008) also empirically shows regions that have highly developed financial services will encourage corporate capacity investment, R&D investment and innovation.

3. Analytical perspectives

Regional finance can be interpreted in different ways, but this paper puts the main focus on regional financial soundness, and employs the hypothesis that improvement in regional financial soundness poses positive impacts on corporate innovation activities. Here are theoretical and empirical analytical viewpoints related with this basic hypothesis.

3-1 Investment-like characteristics of innovation activities

As mentioned earlier, Fazzari et al. (1988) examined whether financial restrictions pose impacts

on real investment. This is also the case for innovation-related expenditure because it is similar to investment in the sense that business owners use the present business resources for the future. Below, some related viewpoints are examined putting the main focus on R&D investment as a typical innovation-related expenditure.

One of the major reasons why finance has impacts on corporate investment is the cost gap between internal and external finance. This can be attributable to the following two factors. First is asymmetric information. As typical lemon market problems would occur, financial premiums might become larger (Szewczyk et al. (1996), etc.). Second, moral hazard would occur. As corporate ownership is usually separated from corporate management, corporations do not make their investments, including R&D, at a level that maximizes their corporate value. If such agent problem emerges, corporations tend to focus on short-term investment, rather than long-term one.[2]

This is an analogy of capacity investment and generally holds true of corporate investments, but it is necessary to pay attention to the specialty of R&D investment. In this relation, analysts point out the following three main factors (Hall (2005)). First, R&D investment has larger adjustment cost. Firms spend R&D expenditure in the form of personnel cost in many cases, and outcomes of R&D efforts are usually absorbed by researchers. For this reason, if a firm fires researchers, it will lose many of its R&D outcomes. Due to such circumstances, firms might smooth their R&D investment in order to eliminate the necessity of dismissing their intellectual workers (Lach and Schankerman (1988), etc.). From the viewpoint of empirical analysis based on actual data, this means that estimation will become more difficult due to lower investment sensitivity. Second, it is not easy to eliminate the asymmetric property of information. Disclosing R&D investment information engenders the risk of imitation (Bhattacharya and Ritter (1985)), which will probably push down investment potential. In this context, firms have an incentive to conceal their information. However, because this means increased asymmetry of information from the viewpoint of funders, they face increased difficulty when making decisions on lending money or making investment.[3] The third factor is the significance and characteristics of uncertainty. R&D investment is highly uncertain. In addition, it has dynamic property because more information is available as R&D projects progress.

These factors might serve to weaken the correlation between finance and R&D investment. As a result, will significant impacts from the finance side disappear? Alternatively, will it stay at a certain level? This is an important point empirically analyzed in this paper.

3-2 Financial soundness

Before examining how regional financial soundness would pose impacts on corporate innovation activities, concepts of financial soundness need to be clarified. According to many researches on the

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[2] This is pointed out by many empirical studies, such as Pugh et al. (1999)

[3] Loan providers do not have the expertise to evaluate R&D investment in many cases. This also serves to enhance asymmetric information.

relationship between financial restrictions and corporate activities, if external finance incurs larger cost than internal finance, a developed banking sector will push down the cost of external finance. This is because of (i) improved competitiveness on the fund supply side, and (ii) less asymmetric information through stronger relations between financial institutions and firms.[4]

Based on a similar analogy, if regional financial institutions enjoy improved business performance or financial position, their risk-bearing capacity will improve, providing more funds to high-risk firms or corporations with poor collateral. In addition, if financial institutions see improved financial positions, they will be able to afford an increased number of branch offices, possibly leading to improved fund availability for firms or lower financial costs (incorporating access costs).[5]

Financial institutions provide funds mainly through loans, but they also invest in corporate bonds or stocks. Japan has an indirect-finance dominant financial system centering on banks, but equity participation is one of fund supply methods by regional financial institutions even in Japan. Financial institutions make such equity participation in large-sized public firms as well as in relatively smaller regional private companies.

As for asymmetric information, if financial institutions have enough business leeway, they will be able to increase their staff or expenditure to examine borrowers' growth potential or long-term projects, possibly accumulating more information on the financial institution side. On the contrary, if financial institutions become less prudent, they might put more emphasis on short-term fund collection, rather than loan screening from long-term perspectives.

3-3 Points in empirical analysis

3-3-1 Basic relationships between finance and innovation

Based on the aforementioned perspectives, this paper makes empirical analysis in several directions. Basic relationships between regional financial soundness and innovation activities are the starting point. As discussed earlier, innovation activities are similar to investment, but they might not have a strong correlation with finance. The point here is whether they still have a significant and positive correlation.

3-3-2 Financial restrictions on SMEs

As suggested by many preceding researches, SMEs suffer stronger financial restrictions than

[4] However, a development of banking sector might also work in a negative way. If stiffer competition decreases market concentration, intertemporal profit sharing between lender and borrower might become more difficult, pushing up financial costs for small-sized firms, as pointed out by some researchers (Petersen and Rajan (1995)). Some empirical studies are conducted on this topic (such as Bonaccorsi di Patti and Dell'Ariccia (2004)). For more information, refer to the survey by Benfratello et al. (2008)

[5] This paper does not make clear arguments, but regulatory/supervisory authority's policies also serve as external elements that pose impacts on the relationship between bank's financial position and corporate loans. Capital adequacy requirements set forth by the Basel Committee of the Bank for International Settlements (BIS) directly restricts available credits of banks engaging in international business operations. On a national basis, many governments have introduced regulations based on financial institution's business performance indicators.

large-sized firms and are likely to face severer negative impacts from financial shocks.[6] On the other hand, SMEs (i) are working on weaker innovation activities, such as R&D, than large-sized firms, and (ii) suffer from stronger asymmetric information due to poor information disclosure. These factors will result in weaker sensitivity to changes in financial factors. By extracting SMEs from samples, the responses of SMEs to changes in financial soundness are quantitatively evaluated.

3-3-3 Consideration of causal relations, etc.

Analyzing the relationships between finance and real economic activity is always accompanied by the causal relation between them. Regional financial soundness and real economic activity might have a two-way relationship. This paper assumes that improvement in the financial environment contributes to revitalizing regional economies, but an active regional economy should enhance regional financial soundness. It is very difficult to entirely control such causal relations, but it is important to take such factors into consideration.

In addition, since this paper assumes regional finance as a financial-side indicator, it employs a regional-based financial soundness indicator as an independent variable. This approach might mix up impacts of non-financial regional elements in the estimation. It is meaningful to determine whether financial elements would pose some impacts even if considering non-financial regional elements.

3-3-4 Addressing abundant zero responses

As discussed later, innovation-related indicators, such as R&D expenditure, have the statistical characteristic that respondents tend to provide zero values as their response. This trend is particularly remarkable among small-sized firms. As linear regression (OLS and linear panel regression) based on such data is likely to yield biased estimation, it is necessary to estimate data, taking into consideration the fact that responses will take the number zero as the lower limit value (tobit model here).

4. Data

This paper mainly employs two types of data in empirical analysis. First, recognizing regional financial soundness as an independent variable, regional-based indicators have been prepared by processing regional financial institutions' financial data described in their annual security report. Second, as for corporate side data, METI's "Basic Survey of Business Structure and Activity" has been used to extract R&D-related micro data as a dependent variable. In line with the framework of

[6] Gertler and Gilchrist (1994) analyze how macroeconomic financial shock becomes spread out from the viewpoint of imperfect capital markets, which is a representative work that suggests finance's strong impacts on small-sized firms.

empirical analysis, here are detailed explanations on the data.

4-1 Financial soundness indicators

The regional finance indicator is a prefecture-level indicator calculated from the data of regional banks.[7] Regional banks are typical regional financial institutions in Japan and are conducting most of their business operations within a certain prefecture where their headquarters is located. For the purpose of this paper, financial soundness indicators have been prepared by converting regional bank's financial indicators to prefectural level data based on their headquarters locations. However, Japan's three major cities Tokyo, Osaka and Nagoya have a different financial structure from other cities. In these cities, city banks play central roles in financial intermediation tasks within the region.[8] For this reason, the analysis this time covers 44 prefectures, excluding the three prefectures Tokyo, Osaka and Aichi to which the three large cities belong. In 38 of these 44 prefectures, loans from regional banks register more than 50% of the total lending amount.[9]

We focus on "financial soundness" as a financial element, but it may not be necessarily a solid concept to be represented in a single indicator. For this reason, analysis is performed using several indicators that could be proxy variables of financial soundness. Fortunately, some researchers have attempted to quantitatively evaluate financial soundness mainly for practical purposes. Drawing on these data, this paper uses: (i) the ratio of nonperforming loans, (ii) ROA (return on asset) and (iii) "financial soundness composite indicators" that come from several financial indicators available from principal component analysis. Data (i) capture the stock-based aspects, while Data (ii) are flow-based ones. These are defined here as the percentage of risk managed credits and current profit/loss to total assets.[10] The capital adequacy ratio is one of the typical stock-based indicators that capture bank's financial soundness. However, in the estimation period of this paper (in particular, in the late 1990s), the capital adequacy ratio might have distorted due to policy impacts, such as introducing the "system of prompt corrective action" and the Basel capital accord (capital adequacy requirement).[11] For this reason, the capital adequacy ratio is used as basic data for (iii), rather than

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[7] Regional banks in a narrow sense, as well as second-tier regional banks. Regional banks in Japan are not defined by legislation. Regional banks mean the banks belonging to the Regional Banks Association of Japan or the Second Association of Regional Banks.

[8] Some major city banks have (or used to have) their headquarters in these three cities.

[9] They are more than 80% in three prefectures of 38. On the other hand, regional banks have a lower weight of 14% in Tokyo (around 25 to 30% in Osaka and Aichi). The data are as of the end of March 2007, with the denominator representing the sum of major banks, regional banks, credit association banks and credit unions. The data come from "Kin'yu Journal, extra issue 2008."

[10] FSA (Financial Services Agency) uses the loan amount for the denominator of nonperforming loan ratio. However, to mitigate impacts of fluctuations of the loan amount, this paper employs the total assets as the denominator. For more information on the definition of risk managed credit, see FSA's website (http://www.fsa.go.jp).

[11] The capital adequacy ratio is an important target variable for banking operations because it serves as the basic criteria for BIS's capital adequacy ratio requirements or the Japanese government's policy decision on prompt corrective actions. In many cases, financial institutions artificially sent up the ratio far beyond their actual soundness of the business operations through allocation of new shares to third parties, etc.

as a single indicator.[12]

The financial soundness indicator (iii) for this paper was prepared by extracting common components from principle component analysis on four variables, including the indicators (i) and (ii) as well as the capital adequacy ratio as a stock indicator and the expense ratio as a flow indicator.[13]

Let us briefly examine the actual trend of these indicators. After the bubble economy due to the Bank of Japan's long-term monetary relaxation since the late 1980s, the Japanese economy faced the bursting of asset bubbles of real estate prices and stock prices from 1989 to 1991. Real estate and construction firms that rapidly expanded their real estate-related businesses during the bubble era suddenly suffered from deteriorated business performance and serious financial problems. As a result, financial institutions that provided loans to these firms came to have massive amounts of nonperforming loans. As many financial institutions faced poor financial positions, the financial system became seriously unstable. In the early 2000s, this trend started to improve.[14] In particular, the soundness composite indicator hit bottom in 2001-2003, and it has taken a clear upward trend since then. This conforms to the common understanding of the situation in Japan.

Financial administration has also changed radically since the bursting of the bubble economy. The government took various policy actions to address nonperforming loan problems and reformed regulation/supervision program on financial institutions.[15] One of these major reforms is introduction of a system of prompt corrective action. Under this program, if a bank suffers a capital adequacy ratio lower than a certain level, the government will provide business improvement guidance in order to prevent bankruptcy of financial institutions. The government launched this program in 1998, but it started to apply this program to regional banks in 1999 as a preferential measure because most of them specialize in business operations only in the domestic market.

This paper employs the data from FY1999 to FY2006 when the financial system became unstable

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[12] The capital adequacy ratio in this contest is the domestic standard designated by FSA. For the definition of the ratio's domestic standards, see FSA's website as mentioned above. The capital adequacy ratio data are basically in accordance with the domestic standards, but the available data is used if banks engage in international business operations or only provide data on a consolidated basis.

[13] For practical purposes, it is common to measure the financial institution's business performance soundness with these four indicators. For example, as a part of IMF's missions, Sundararajan (2002) has developed a "Financial Soundness Indicator" for each country, and he also attaches importance to the indicators stated in this paper or other similar indicators as well. In Japan, some professional-use journals describe the soundness of individual financial institutions based on similar indicators. Hori and Kitaki (2003) conducted empirical analysis with the data available from Weekly Diamond "Financial Institutions Safety Ranking" (Extra issue published every December). As typical indicators for measuring the soundness of individual financial institutions, Crystal et al. (2001) pointed out (i) evaluation with the CAMEL system and (ii) grading by rating agencies, and developed new indicators of financial system soundness in Latin American nations by calculating a weighted average of the rating agency's grading with the financial institution's asset amount. The CAMEL system is a banking evaluation system introduced by the US federal banking supervisory authority in 1979, which evaluates banking soundness based on the bank's (i) capital, (ii) assets, (iii) management, (iv) earnings and (v) liquidity (and (vi) sensitivity to market risk has been added since 1997). The CAMEL system also employs similar indicators to this paper's as the main evaluation criteria.

[14] Cargrill et al. (1997, 2000) and some other researches describe the process of the emergence and bursting of the bubble economy in Japan in detail.

[15] See Ikeo (2010) and Shikano (2006) for more details on the situation at that time and the present situation in Japan.

and then started to recover to a stable level. The financial soundness in this period also saw large dispersion, depending on the region (Fig. 1). Fluctuations both in time series and cross section terms will make empirical analysis easier. The institutional framework on the financial system has continuity to a certain extent because it is after introduction of the system of prompt corrective action, which is a major turning point for Japan's financial administration.

[Figure 1. Trend of financial soundness indicators for regional banks]

4-2 Firms data and R&D activity indicators

Many researchers have proposed different ways of grasping corporate innovation activities, but there is broad consensus that R&D activity is a typical indicator. This paper also employs R&D-related indicators.

To be more specific, this paper uses METI's "Basic Survey of Business Structure and Activity." This is an annual survey that requests corporations to provide various data, such as their business operations, corporate organization, financial position, R&D activities, business transactions and IT programs, etc. As for industry categories, this paper employs data of secondary industries (manufacturing and construction industries) that are relatively aggressive about their R&D (the industry categories for some other data are in line with SNA). As for the mining industry or tertiary industries, such as wholesale and retail sectors, more than 90% of respondents did not answer or answered that they had no R&D expenditure.[16] The samples for this paper consist of firms that belong to secondary industries and are located in the aforementioned 44 prefectures.

We employ the following R&D-related indicators as dependent variables: (i) R&D expenditure and (ii) the number of R&D staff. See the appendix for more information on the definition. Taking into consideration independent variables, the data are available from 1,691 firms (4,469 observations) for R&D expenditure and 1,633 firms (4,443 observations) for the number of R&D staff (Table 2).

These indicators are distributed in a significantly right-skewed shape. Corporate data generally take a right-skewed shape, but they are right-skewed much more than, for example, the distribution of firm size data. In table 2, since the mean value is much larger than the median value, it looks like a long tail with its skirt expanding to the right side. Their skewness is partly because many firms answer that they make no R&D expenditure. This trend is outstanding among small-sized firms.

[Table 2. Summary statistics of R&D-related indicators]

[16] In the agriculture, forestry and fisheries sector, which belongs to primary industries, 10% of samples provided positive responses on R&D. However, since the sector's samples only account for a very low percentage of 0.04% of all the samples, these samples are excluded from estimation. Even if these samples were included, it would only pose negligible impacts on the analytical findings.

5. Empirical analysis

This section discusses the results of empirical analysis on the aforementioned data. The section first explains the basic relationship between regional financial soundness and R&D activities, then discusses the case that takes into consideration firm size, and finally shows analytical findings on several cases with different analytical methods or variables.

5-1 Financial soundness and R&D expenditure: The base case

First, regression analysis was conducted for the base case on the relationship between regional financial soundness and corporate R&D activities. The dependent variable is R&D expenditure, while independent variables include (i) the financial soundness indicator in the prefecture where the firm is located,[17] (ii) the economic activity level in the prefecture, (iii) innovation characteristics in the industry (appropriability, technological opportunity and industry's growth), (iv) the firm's internal finance (one-term lag), (v) firm's characteristics (size and age), and (vi) whether the prefecture has a nationalized bank (dummy variable) (See Table 3 for descriptive statistics for each variable, and refer to Table A-1 for definitions).

Supplementary explanations on (iii) are as follows: "Appropriability" means how much a firm is able to benefit from the outcomes of its innovation activities. "Technological opportunity" means innovation potential in the industry. Innovation activities will be encouraged if those two stand at higher levels. On the other hand, if demand for products and services is stronger, incentives for innovation will be enhanced. So, the analysis incorporates industrial growth potential as a proxy variable for market size growth. These three measures are recognized as orthodox factors among innovation researchers.

Corporate internal fund is incorporated as an independent variable because Himmerlberg and Petersen (1994) point out the relationship between internal financial restrictions and R&D investment. Assuming that R&D investments in the present term might depend on the internal finance in the preceding term, this paper employs the one-term lag of the internal fund. Firm age is uncertain to pose positive or negative impacts on an ad-hoc basis because younger firms tend to be more innovative, but older firms enjoy weaker financial restrictions than younger.

[Table 3. Descriptive statistics of dependent and independent variables]

[17] For the purpose of statistical design, the data is not based on the location of the corporation, but the location of its parent firm. However, since parent firms often provide business resources support, such as funds, as necessary, corporations might suffer some economic impacts resulting from the financial environment of the parent firm's location.

The most important independent variable is the financial soundness indicator. Using the ratio of nonperforming loans first, we conducted three types of regression, (i) OLS based on pooled data, (ii) random effect panel model, and (iii) fixed effect panel model. The linear panel models (ii) and (iii) employ a two-way model that incorporates firm's individual effects and time effects. Column (a) in Table 4 describes the estimation under these settings. The parameters of the nonperforming loan ratio take positive values for all cases, but they are not statistically significant. (As the sign of the nonperforming loan ratio is reversed in calculation, it is expected to take a positive value).

However, financial soundness is not so simple to be measured with such a single indicator as the nonperforming loan ratio. Thus, a similar estimation was conducted with other soundness indicators, as shown in Columns (b) and (c) of the said table. When using ROA, estimates take significant positive values in any case of the three estimation approaches. If using composite indicators, the parameters take significant positive values in the cases of OLS and random effect model. Generally speaking, the data show a certain trend.

However, from the result of the Hausman test, the fixed effect model is selected, rather than the random effect model. In the fixed effect random model, the indicators satisfy the sign condition, but only the ROA-based case is significant.

[Table 4. Results of regression analysis: Relationship between R&D expenditure and financial soundness]

5-2 Case of SMEs

This paper also puts focus on viewpoint of firm size, in particular situations surrounding SMEs. As mentioned earlier, preceding works, including Himmelberg and Petersen (1994), Herrera and Minetti (2007), Guiso et al. (2004), Benfratello et al. (2008), attach importance to financial restrictions on small-sized firms, in particular. In this paper, regression analysis was conducted after narrowing down the samples to SMEs with fewer than 500 workers.[18]

The analysis has revealed that financial soundness parameters in the linear panel model has increased by approximately 50% on average and become more statistically significant (Table 5). In particular, soundness composite indicators extracted as common elements from multiple indicators take statistically significant values in any of the three estimate approaches, including the fixed effect model. As for the estimate approach, the fixed effect model is selected according to the Hausman test also here. As for the said model, any of the three soundness indicators take statistically significant values in fixed effect models.

The fact that financial soundness parameters and their statistical significance generally increase

[18] Definitions of SMEs are different for each nation. As many countries use the criteria of less than 500 workers (Ayyagari et al., 2007), this paper also employs this criteria for international comparison purposes in the future.

suggests that SMEs are facing relatively strong financial restrictions. From now on, we focus on SME samples unless otherwise designated.

As dependent variables take logarithmic values, their coefficient approximates to their percentage of change. For example, 1% improvement in the nonperforming loan ratio will send up R&D expenditure by around 6% (in the SME samples, 1% change in the nonperforming loan ratio corresponds to 1.2 within-standard deviation).

Let us look at parameters of other independent variables. Generally speaking, the coefficients take signed values as expected. However, it is necessary to pay attention to some points. First, appropriability and technological opportunity might show multicollinearity because they are closely correlated. In addition, as the analysis here employs the data at a certain time point due to restriction of the statistics, the within variation is rather small (however, it may fluctuate because corporate characteristics (industry category) might change in some cases). For this reason, these variables do not have enough explanatory power especially in fixed effect models. Internal finance parameters are statistically significant in the case of OLS and random effect models, but it is less significant for fixed effect models. Since researchers have not formed consensus that this variable is appropriate as a proxy variable, it is necessary to pay careful attention when interpreting the coefficient. The nationalized bank dummy parameters take a positive value (but their statistical significance varies, depending on the model used). This suggests that, a nationalized bank that suffers a rather poor financial position is able to play financial intermediary roles to a certain extent, backed by intervention or support from the central government.

[Table 5. Regression results of SMEs]

5-3 Robustness check

From the results shown above, there seems to be a quite strong relationship between regional financial soundness and SMEs' R&D expenditure. This section examines robustness from several viewpoints. To be more specific, it additionally examines the data from the two perspectives: (i) causal relations and (ii) regional element controls.

5-3-1 Examination with instrumental variables

As for causal relations, financial soundness and real economic activity might have a two-way relationship. For example, good conditions in the regional economy should promote financial soundness in the region. As for causal relation, the local economy poses impacts on regional finance in this case. On the other hand, regional finance (soundness) is influenced by many other factors as well. This trend is significant since the bursting of the bubble economy in the 1990s. Financial

institutions that provided abundant loans to real estate and construction firms in urban areas and developers in other regions have suffered massive damages.[19] In addition, many banks attempted to quickly "improve" their financial position through increased capitalization. Thinking in this way, regional finance soundness is not influenced by the regional economy unilaterally, and a change in regional finance soundness might also pose some impacts on real economic activity.

In this context, regression analysis was conducted by using instrumental variables, taking into consideration the possibility that financial soundness might endogenously depend on real economic activity. The instrumental variables include the loan ratio to the "three industries" (construction, real estate and finance/insurance) in FY1996, the change in commercial land prices in the preceding year in the region, and the amount of deposit per capita (these data are all on a prefectural basis). [20] In his study on Japan, Watanabe (2007) employs the past loan ratio to problematic industries as an instrumental variable of the bank's financial indicator. [21]

The regression analysis has shown that, out of the three financial soundness indicators, the nonperforming loan ratio and the composite indicator take statistically significant values (Table 6). ROA is less significant, but keeps taking a positive value. In addition, Sargan test does not reject the null hypothesis of the over-identification restriction in any of these three indicators, suggesting that they are appropriate instrumental variables.

It should be noted that parameters take significantly higher values. There could be several reasons for this. For example, in order to avoid nonconformance to the financial authority's prudence policies, financial institutions might have made some efforts to improve high-visibility financial indicators beyond their actual business operations. If so, the financial soundness indicators used for this paper did not sufficiently reflect actual "soundness" attained under normal circumstances.

[Table 6. Regression results with instrumental variables]

5-3-2 Examination with prefectural-level dummies

This paper uses prefecture-level financial soundness indicators, which might include non-financial

[19] Stock prices have generally dropped since the bursting of the bubble economy. As financial institutions also have a high weight of stock and securities investment, their financial position became deteriorated.

[20] Regarding to the finance/insurance sector, much of loans to non-banks turned into nonperforming loans. At that time, construction, real estate and non-bank sectors were called the "three sectors" in which nonperforming loans concentrated. Some analysts replace non-banks with distribution sector. Taking into consideration the characteristics as instrumental variables, this paper employs the loan ratio to the three sectors including non-banks, which usually exist in urban areas.

[21] The financial soundness of financial institutions, of course, depends on local economic conditions, but loans to real estate and construction sectors, etc. served as influential factors during this period. These loans were not necessarily provided to local firms in the region. Financial institutions that provided such loans tend to suffer a significantly deteriorated financial position. For example, Hoshi (2001) and some other researches point out that financial institutions with massive amounts of loans to real estate firms have suffered large amounts of nonperforming loans. Their dependence on loans to problematic sectors is correlated with financial institution's financial position, but uncorrelated with firms' innovation in that region. For this reason, it has great potential as an instrumental variable.

regional factors. We also conducted a regression with prefectural dummies to represent other regional elements. The results are shown in Table 7, and financial soundness indicator parameters generally take statistically significant positive values. In this case, there remains a certain relationship, even with prefectural differentials being controlled with dummy variables.

[Table 7. Regression results with prefectural-level dummies]

5-4 Results of tobit model

One of the characteristics of the dependent variable R&D expenditure is that many respondents gave the value of zero. This is particularly significant among SMEs. Taking into consideration such situation, a panel-type tobit model was also used for analysis. Table 8 describes the analytical findings. As expected, parameters and statistical significance have both widely increased. SME's parameters generally took higher values than the cases incorporating all samples, and have additionally increased by 40% on average. For example, 1% improvement in the nonperforming loan ratio will send up R&D expenditure by approximately 7%.

[Table 8. Results of panel tobit model]

We have employed R&D expenditure as a variable of R&D activities so far, and a similar estimation has also been made based on the number of R&D staff. The estimation results are not explained in detail here because of limitations of space. To conclude, the estimation also shows a statistically significant relationship as a whole. Table 9 describes panel tobit estimation results that show this trend in the strongest manner.

But this indicator has some difference with R&D expenditure case. It shows a closer relationship with the financial soundness indicator in the preceding year, rather than that in the present year. Such feature is not observable in the case of R&D expenditure. In addition, even if we narrow down the sample to SMEs, parameters do not necessarily take larger values.

These factors suggest that firms are more careful about an increase/decrease in their R&D staff or face difficulties in quick personnel recruitment even if they want to do so. In particular, SMEs are supposed to have difficulties in increasing their R&D staff when needed.

[Table 9. Estimation results of the number of R&D staff: Panel tobit]

6. Conclusions

Using various indicators and approaches to analyze the relationships between regional financial soundness and R&D activities, the analysis reveals that as for firms, mainly SMEs, there exists a relationship between regional financial soundness and R&D activities. This trend is observable even with regional finance's endogeneity considered as well as prefecture-level effects other than financial factors.

In tobit model that takes into consideration that many SMEs answered they made no R&D expenditure, this relationship becomes stronger. Analytical findings suggest that regional finance plays important roles in revitalizing the regional economy through encouraging innovation. If that is the case, prudence policies for stabilizing the financial system might also contribute to development of the regional economy.

However, this paper's analysis is just one project based on limited data. In particular, as for the simultaneous nature of regional finance and innovation activities, it is necessary to accumulate analytical findings with more data, taking into consideration causal relationships between these two factors. The data analysis environment is improving, but data on corporate innovation activities, especially those in small-sized firms, are not sufficiently available yet. If these data become enhanced and accessible, data matching with individual financial institutions will be beneficial.

For the purpose of this paper, regional financial data were collected through regional banks, but it might be promising to collect information on regional financial structure in a more detailed manner from category perspectives of financial institutions (such as credit unions, credit association banks, city banks and government-affiliated financial institutions). As for corporate innovation activities, too, it is interesting to analyze non-R&D innovation activities, such as technological introduction and patent acquisition. Innovation activities generally have dynamic features which alter subsequent corporate business performance. It is also meaningful to employ an analytical framework with dynamic models.

Revitalization of the regional economy is an important policy agenda for many countries. Research projects on the relationships between regional finance and firms' innovation activities are significant not only to satisfy researcher's interest but for management of the actual economy.

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Appendix: Definitions of variables

R&D-related indicators used as dependent variables in this paper are (i) the amount of R&D expenditure and (ii) the number of R&D staff. The former is a firm's R&D expenses financed on its own, while the latter represents the sum of R&D staff serving at the headquarters and research centers. In order to mitigate extreme change resulting from the firm size gap and standardize data, the former is a natural logarithmic value of R&D expenditure plus one, while the latter is R&D staff as a percentage of the average number of employees during the period estimated. Definitions of variables, including independent variables, are shown in Table A-1.

As the nonperforming loan ratio takes the inverse sign added by 100 percent, an increase in value means improvement in financial soundness. The expense rate is used as the basic data for calculating soundness composite indicators. This rate is operating expenses divided by operational gross profit. Appropriability and technological opportunity are important variables for innovation analysis, but only a very limited statistics are available to directly collect these data. We employ "Report on the Japanese National Innovation Survey" released by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2004 and develops indicators in line with the approach of Goto et al. (2002) It should be noted that we grouped data for each industry as well as for each firm size (three categories: large, medium and small).

[Table A-1. List of dependent and independent variables]

[Bibliographies]

Ikeo, Kazuhito, *Gendai no Kin'yuu Nyuumon (Introduction to Modern Finance)*, new edition, Chikuma Shobo (2010)

Monthly Kinyu Journal, *Monthly Kinyu Journal, Extra Issue: Finance Sector Map* (2007)

Goto, Akira, Tadahisa Koga and Kazuyuki Suzuki, "Determinants of Industrial R & D in Japanese Manufacturing Industries (Wagakuni seizougyou ni okeru kenkyuukaihatsu-toushi no kettei-youin)," *The Economic Review (Keizai Kenkyuu)*, Vol.53, No.1 (2002)

Shikano, Yoshiaki, *Japan's Financial System (Nippon no Kinyuu Seido)*, second edition, Toyokeizai (2006)

Hori, Masahiro and Hideaki Kitaki, "Some Evidence on the Link between Bank Health and Regional Economies, Analysis with prefectural-level data (Kin'yū kikan no kenzensei to chiiki keizai: todōfukenbetsu dēta ni yoru kenshō)," *ESRI Discussion Paper Series No.38*, Economic and Social Research Institute, Cabinet Office (2003)

Acs, Z. and D. Audretsch, "Innovation and technological change," in Acs, Z. and D. Audretsch(ed.), *Handbook of Entrepreneurship Research*, Springer (2003)

Arrow, K.J., "Economic Welfare and the Allocation of Resources for Invention," in R.R.Nelson (ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton, Princeton Univ. Press (1962)

Audretsch, D.B. and J.A. Elston, "Does firm size matter? Evidence on the impact of liquidity constraints on firm investment behavior in Germany," *International Journal of Industrial Organization*, 20, pp.1-17 (2002)

Ayyagari, Meghana, Thorsten Beck and Asli Demirguc-Kunt, "Small and Medium Enterprises across the Globe," *Small Business Economics* , 29, pp415-434 (2007)

Beck, T. and A. Demirguc-Kunt, L. Laeven and R. Levine, "Finance, Firm Size, and Growth," *Journal of Money, Credit and Banking*, Vol.40 (7), pp.1379-1405 (2008)

Beck, T and R. Levine, "Industry Growth and Capital Allocation: Does Having a Market- or Bank-Based System Matter?" *Journal of Financial Economics*, 64, pp.147-180 (2002)

Benfratello L., F. Schiantarelli, and A. Sembenelli, "Banks and innovation: microeconometric evidence on Italian firms," *Journal of Financial Economics*, 90, pp197-217 (2008)

Berger, A. and G. F. Udell, "The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle," *Journal of Banking & Finance*, 22, pp613-673 (1998)

Bhattacharya, S. and J. Ritter, "Innovation and Communication: Signaling with Partial Disclosure," *Review of Economic Studies* (1985)

Bonaccorsi di Patti, E., and G. Dell'Ariccia, "Bank Competition and Firm Creation," *Journal of Money, Credit and Banking* (2004)

Cargill, T. F., Hutchison, M. M. and T. Ito, The Political Economy of Japanese Monetary Policy , The MIT Press (1997)

——, ——, ——, Financial Policy and Central Banking in Japan, The MIT Press (2000)

Carpenter, R.E. and B.C. Petersen, "Is the growth of small firms constrained by internal finance?" *Review of Economics and Statistics*, Vol.84, No.2, pp.298-309 (2002)

Crystal, J. S., B. G. Dages and L. S. Goldberg, "Does Foreign Ownership Contribute to Sounder Banks in Emerging Markets?: The Latin American Experience," *FRB of New York Staff Report No. 137* (2001)

Devereux, Michael, and Fabio Schiantarelli, "Investment, Financial Factors and Cash Flow: Evidence from U.K. Panel Data," in R. Glenn Hubbard (ed.), *Asymmetric Information, Corporate Finance, and Investment* (Chicago: University of Chicago Press (1989)

Fazzari, S., B. Petersen, and G. Hubbard, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activities*, (1) (1988) pp141-195

Gertler, M. and Simon Gilchrist, "Monetary Policy, Business Cycles, and the Behavior of Small Manufactruring Firms," *Quarterly Journal of Economics*, Vol.109, No.2, pp.309-340 (1994)

Guiso, L., P. Sapienza and L. Zingales, "Does local financial development matter?" *Quarterly Journal of Economics*, pp.929-969 (2004)

Goto, RIETI DP, "Regional Financial Stability and Firms' Innovation Activities", 2010

Hall, B, "Investment and Research and Development at the Firm Level: Does the Source of Financing Matter?" *NBER WP*, No.4096 (1992)

——, "The Financing of Innovation," mimeo (2005)

Harhoff, D., "Are There Financing Constraints for R&D and Investment in German Manufacturing Firms?" *Annales d'Economie et de Statistique* (1998)

Herrera, M. and R. Minetti, "Informed finance and technological change: Evidence from credit relationship," *Journal of Financial Economics*, 83, pp.223-269 (2007)

Himmelberg, Charles and Bruce Petersen, "R & D and Internal Finance: A Panel Study of Small Firms in High-Tech Industry," *The Review of Economics and Statistics*, Vol. 76, No. 1, pp38-51 (1994)

Hoshi, Takeo, "What Happened to Japanese Banks?" *Monetary and Economic Studies*, 19(1) pp1-29 (2001)

Hoshi, Takeo, Anil Kashyap, and David Scharfstein, "Corporate Structure, Liquidity and Investment," *Quarterly Journal of Economics* 106, pp33-60 (1991)

Kaplan, S. N. and L. Zingales, "Do Investment-cash Flow Sensitivities Provide Useful Measures of Financing Constraints?" *Quarterly Journal of Economics* 112 (1), pp169-215 (1997)

——, "Investment-cash Flow Sensitivities Are Not Valid Measures of Financing Constraints," *Quarterly Journal of Economics* 115 (1), pp707-712 (2000)

Lach, S. and M. Schankerman, "Dynamics of R&D and Investment in the Scientific Sector," *Journal of Political Economy* (1988)

Nelson, Richard, "The Simple Economics of Basic Scientific Research," *Journal of Political*

Economy, 49 (1959)

Oliveira, B. and A. Forturato, "Firm growth and liquidity constraints: a dynamic analysis," *Small Business Economics*, 27, pp.139-156 (2006)

Petersen, M, and R. Rajan, "The Effect of Credit Market Competition on Lending Relationships," *Quarterly Journal of Economics*, (1995)

Pugh, W., J. Jahera, and S. Oswald, "ESOPs, Takeover Protection, and Corporate Decision Making," *J. of Economics and Finance* (1999)

Rajan, R.G. and L. Zingales, "Financial Dependence and Growth," *American Economic Review*, Vol.88, No.3, pp.559-586 (1998)

Robinson, Joan, "The Generalization of the Generat Theory," *The Rate of Interest and Other Essays*, London, Macmillan (1952)

Schumpeter, Joseph, *A Theory of Economic Development*, Cambridge, Harvard Univ. Press (1911)

———, *Capitalism, Socialism, and Democracy*, New York, Harper and Row (1942)

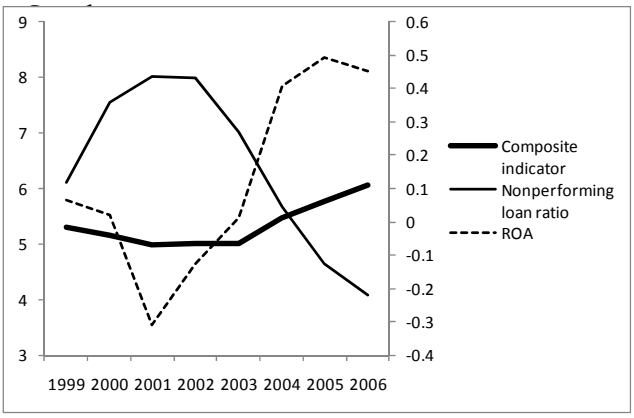
Sharma, Siddharth, "Financial development and innovation in small firms," *Policy Research Working Paper* 4350, World Bank (2007)

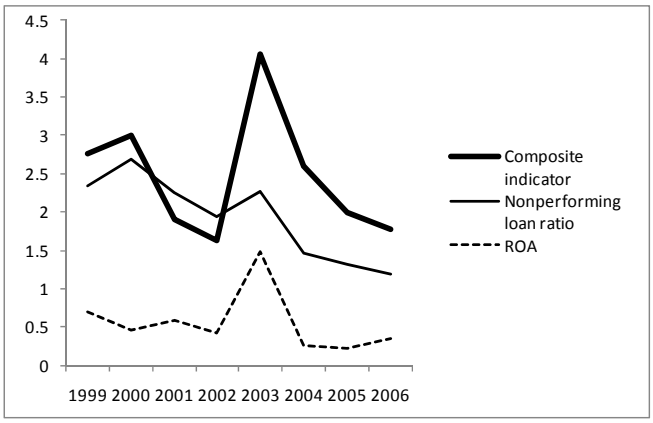
Sundararajan, V., C. Enoch, A. San Jose, P. Hilbers, R. Krueger, M. Moretti, and G. Slack, "Financial Soundness Indicators: Analytical Aspects and County Practices", *IMF Occasional Paper 212* (2002)

Szewczyk, S., G. Tsetsekos, and Z. Zantout, "The Valuation of Corporate R&D Expenditure: Evidence from Investment Opportunities and Free Cash Flow," *Financial Management* (1996)

Watanabe, Wako., "Prudential Regulation and the "Credit Crunch": Evidence from Japan," *Journal of Money, Credit and Banking*, 39, pp639-66 (2007)

[Figure 1. Trend of financial soundness indicators for regional banks]





Notes:

a. ROA is measured with the axis on the right side.

b. The data is on the percentage basis (%).

Source: The data is developed from annual security reports available from regional banks.

[Table 1. Studies on the relationship between financial elements and real economic elements]

		Real economic activity						
		Macroeconomic perspectives		Corporate activity perspectives				
		Economic growth	Growth of industries, etc.	R&D investment	Capacity investment	Firm growth	Innovation	Start-up and market entries
Financial elements	Financial development	Rajan and Zingales(1998)	Beck et al. (2008)					
	Financial structure		Beck and Levine (2002)	Sharma(2007)				
	Internal finance			Himmelberg and Petersen (1994)	Fazzari et al. (1988) Audretsch and Elston(2002)	Carpenter and Petersen(2002) Oliveira and Forturato(2006)		
	Relationships with financial institutions						Herrera and Minetti(2007)	
	Variety of financing methods					Berger and Udel (1998)		
	Regional finance						Benfratello et al. (2008)	Guiso et al. (2004)

[Table 2. Summary statistics of R&D-related indicators]

	unit	mean value	median value	standard deviation	minimum value	number of data samples	number of sample corporations	average number of times of response
R&D expenditures	1 million yen	207.47	14	839.83	0	4,469	1,691	2.64
SMEs	1 million yen	72.98	9	195.80	0	3,799	1,521	2.50
number of R&D staff	person	22.47	7	53.68	0	4,443	1,633	2.72
SMEs	person	12.27	6	20.75	0	3,821	1,467	2.60

Note: SMEs are defined as firms with fewer than 500 employees.

Source: micro data of METI, “Basic Survey of Business Structure and Activity”

[Table 3. Descriptive statistics of dependent and independent variables]

dependent variables	aggregation level	unit	average	standard deviation
R&D expenditure (RDE)	Micro data	ln (1 million yen)	2.79	2.34 2.16 0.73
Number of R&D staff (RDP)	Micro data	%	6.61	8.12 8.10 2.76

independent variables	aggregation level	unit	average	standard deviation
(i) Nonperforming loan ratio (BAD)	Prefecture	%	96.22	1.30 1.01 0.88
(ii) Return on asset (ROA)	Prefecture	%	0.26	0.47 0.30 0.37
(iii) Soundness composite indicator (PRIN)	Prefecture	—	59.23	1.90 1.50 1.18
(iv) Income level in the prefecture (GDP)	Prefecture	ln (1,000 yen/person)	8.23	0.11 0.10 0.03
(v) Appropriability (APPRO)	Industry × Firm size	%	81.53	10.02 10.54 2.86
(vi) Technological opportunity (INFO)	Industry × Firm size	%	89.01	7.40 7.34 1.94
(vii) Industry growth (I_GRTH)	Industry	First difference of logarithm	0.024	0.083 0.065 0.059
(viii) Internal finance (CASH)	Micro data	1 million yen/person	1.47	2.69 2.38 1.53
(ix) Firm size (SIZE)	Micro data	ln(person)	5.29	0.89 0.83 0.12
(x) Firm age (AGE)	Micro data	Years	33.19	17.31 16.64 3.23
(xi) Nationalized bank dummy (NTNL)	Prefecture	0 or 1	0.004	0.067 0.053 0.034

Notes:

a. The standard deviation section has three lines: The upper line for the overall samples, the middle line for the “between” cases, and the lower line for the “within” cases.

b. Except for RDP, these are sample’s descriptive statistics for the estimates with RDE as dependent variables (all firm sizes).

[Table 4. Results of regression analysis: Relationship between R&D expenditure and financial soundness]

[Pooled OLS]

	(a)				(b)				(c)			
Independent variables (name)	Coeff.	SE	p-value		Coeff.	SE	p-value		Coeff.	SE	p-value	
Nonperforming loan ratio （BAD）	0.057	0.041	0.164									
Return on asset （ROA）					0.161	0.080	0.044	**				
Soundness composite indicator （PRIN）									0.061	0.034	0.075	*
Income level in the prefecture （GDP）	1.178	0.482	0.015	**	1.136	0.482	0.019	**	1.068	0.481	0.027	**
Appropriability （APPRO）	0.023	0.005	0.000	***	0.023	0.005	0.000	***	0.023	0.005	0.000	***
Technological opportunity （INFO）	-0.007	0.008	0.371		-0.007	0.008	0.393		-0.007	0.008	0.384	
Industry growth （I_GRTH）	1.081	0.518	0.037	**	1.118	0.519	0.031	**	1.068	0.518	0.039	**
Internal finance: one-period lag （CASH）	0.055	0.019	0.004	***	0.057	0.019	0.003	***	0.055	0.019	0.004	***
Firm size （SIZE）	1.136	0.077	0.000	***	1.139	0.077	0.000	***	1.138	0.076	0.000	***
Firm age （AGE）	0.009	0.003	0.003	***	0.009	0.003	0.002	***	0.009	0.003	0.002	***
Nationalized bank dummy （NTNL）	0.255	0.548	0.642		0.244	0.529	0.644		0.997	0.708	0.159	
Constant	-19.892	5.952	0.001	***	-14.052	4.084	0.001	***	-17.145	4.472	0.000	***
R2		0.432				0.432				0.432		
# of observations		4,469				4,469				4,469		

[Random effect model]

Nonperforming loan ratio （BAD）	0.035	0.024	0.145									
Return on asset （ROA）					0.101	0.040	0.011	**				
Soundness composite indicator （PRIN）									0.038	0.019	0.049	**
Income level in the prefecture （GDP）	0.864	0.378	0.022	**	0.794	0.378	0.036	**	0.788	0.379	0.037	**
Appropriability （APPRO）	0.015	0.004	0.000	***	0.015	0.004	0.000	***	0.015	0.004	0.000	***
Technological opportunity （INFO）	0.005	0.006	0.413		0.005	0.006	0.389		0.005	0.006	0.404	
Industry growth （I_GRTH）	0.570	0.286	0.046	**	0.591	0.288	0.040	**	0.568	0.286	0.047	**
Internal finance: one-period lag （CASH）	0.020	0.011	0.063	*	0.021	0.011	0.057	*	0.020	0.011	0.061	*
Firm size （SIZE）	1.061	0.067	0.000	***	1.060	0.067	0.000	***	1.062	0.067	0.000	***
Firm age （AGE）	0.008	0.003	0.002	***	0.008	0.003	0.002	***	0.008	0.003	0.002	***
Nationalized bank dummy （NTNL）	0.203	0.306	0.507		0.253	0.304	0.404		0.675	0.422	0.110	
Constant	-15.627	4.031	0.000	***	-11.682	3.188	0.000	***	-13.877	3.302	0.000	***
R2		0.413				0.413				0.413		
# of observations		4,469				4,469				4,469		

[Fixed effect model]

Nonperforming loan ratio （BAD）	0.029	0.028	0.291									
Return on asset （ROA）					0.093	0.039	0.018	**				
Soundness composite indicator （PRIN）									0.033	0.022	0.126	
Income level in the prefecture （GDP）	0.857	0.850	0.314		0.703	0.848	0.407		0.827	0.846	0.328	
Appropriability （APPRO）	-0.005	0.006	0.457		-0.005	0.006	0.444		-0.005	0.006	0.444	
Technological opportunity （INFO）	0.007	0.010	0.510		0.007	0.010	0.501		0.007	0.010	0.504	
Industry growth （I_GRTH）	0.385	0.309	0.213		0.406	0.311	0.191		0.385	0.309	0.213	
Internal finance: one-period lag （CASH）	0.009	0.010	0.363		0.010	0.010	0.338		0.009	0.010	0.356	
Firm size （SIZE）	1.059	0.183	0.000	***	1.053	0.183	0.000	***	1.062	0.183	0.000	***
Firm age （AGE）	0.003	0.006	0.658		0.003	0.006	0.675		0.003	0.006	0.664	
Nationalized bank dummy （NTNL）	0.115	0.329	0.726		0.208	0.316	0.510		0.542	0.474	0.253	
Constant	-12.970	7.615	0.089	*	-8.857	7.046	0.209		-11.905	7.093	0.093	*
R2		0.371				0.371				0.371		
# of observations		4,469				4,469				4,469		

Notes:

a. The signs * , ** and *** represent 10%, 5%- and 1%-significance, respectively.

b. SE means cluster-robust standard errors.

c. Results of time effect are omitted.

[Table 5. Regression results on SMEs]

[Pooled OLS]

	(a)				(b)				(c)			
Independent variables (name)	Coeff.	SE	p-value		Coeff.	SE	p-value		Coeff.	SE	p-value	
Nonperforming loan ratio （BAD）	0.056	0.042	0.182									
Return on asset （ROA）					0.221	0.090	0.014	**				
Soundness composite indicator （PRIN)									0.060	0.034	0.078	*
Income level in the prefecture （GDP)	1.105	0.453	0.015	**	1.048	0.452	0.021	**	0.993	0.452	0.028	**
Appropriability （APPRO)	0.023	0.005	0.000	***	0.022	0.005	0.000	***	0.022	0.005	0.000	***
Technological opportunity （INFO)	-0.004	0.008	0.568		-0.004	0.008	0.602		-0.004	0.008	0.587	
Industry growth （I_GRTH）	0.741	0.549	0.177		0.767	0.548	0.161		0.737	0.549	0.179	
Internal finance: one-period lag （CASH）	0.057	0.020	0.005	***	0.058	0.020	0.004	***	0.056	0.020	0.005	***
Firm size （SIZE)	0.970	0.090	0.000	***	0.970	0.090	0.000	***	0.971	0.090	0.000	***
Firm age （AGE)	0.004	0.003	0.227		0.004	0.003	0.218		0.004	0.003	0.224	
Nationalized bank dummy （NTNL）	-0.099	0.615	0.873		-0.075	0.558	0.892		0.623	0.784	0.427	
Constant	-18.380	5.951	0.002	***	-12.528	3.811	0.001	***	-15.634	4.187	0.000	***
R2		0.340				0.341				0.341		
# of observations		3,799				3,799				3,799		

[Random effect model]

Nonperforming loan ratio （BAD）	0.058	0.027	0.032	**								
Return on asset （ROA）					0.119	0.046	0.010	***				
Soundness composite indicator （PRIN)									0.049	0.021	0.024	**
Income level in the prefecture （GDP)	0.831	0.373	0.026	**	0.743	0.372	0.046	**	0.723	0.372	0.052	*
Appropriability （APPRO)	0.015	0.004	0.000	***	0.015	0.004	0.000	***	0.015	0.004	0.000	***
Technological opportunity （INFO)	0.004	0.006	0.466		0.005	0.006	0.420		0.004	0.006	0.446	
Industry growth （I_GRTH）	0.388	0.308	0.207		0.428	0.310	0.167		0.398	0.308	0.196	
Internal finance: one-period lag （CASH）	0.021	0.012	0.072	*	0.022	0.012	0.063	*	0.021	0.012	0.069	*
Firm size （SIZE)	0.945	0.077	0.000	***	0.944	0.077	0.000	***	0.946	0.077	0.000	***
Firm age （AGE)	0.003	0.003	0.281		0.003	0.003	0.279		0.003	0.003	0.275	
Nationalized bank dummy （NTNL）	0.351	0.442	0.427		0.307	0.432	0.477		0.922	0.559	0.099	*
Constant	-16.859	4.226	0.000	***	-10.530	3.136	0.001	***	-13.250	3.297	0.000	***
R2		0.320				0.321				0.320		
# of observations		3,799				3,799				3,799		

[Fixed effect model]

Nonperforming loan ratio （BAD）	0.056	0.033	0.086	*								
Return on asset （ROA）					0.105	0.046	0.023	**				
Soundness composite indicator （PRIN)									0.051	0.026	0.049	**
Income level in the prefecture （GDP)	1.279	0.878	0.145		1.030	0.873	0.238		1.194	0.870	0.170	
Appropriability （APPRO)	-0.006	0.007	0.377		-0.006	0.007	0.353		-0.006	0.007	0.354	
Technological opportunity （INFO)	0.004	0.011	0.738		0.004	0.011	0.701		0.004	0.011	0.715	
Industry growth （I_GRTH）	0.281	0.333	0.398		0.319	0.335	0.341		0.287	0.332	0.388	
Internal finance: one-period lag （CASH）	0.009	0.010	0.344		0.010	0.010	0.319		0.009	0.010	0.338	
Firm size （SIZE)	1.093	0.194	0.000	***	1.083	0.194	0.000	***	1.094	0.194	0.000	***
Firm age （AGE)	-0.010	0.008	0.218		-0.009	0.008	0.242		-0.010	0.008	0.219	
Nationalized bank dummy （NTNL）	0.297	0.504	0.556		0.303	0.469	0.518		0.955	0.667	0.152	
Constant	-18.606	8.137	0.022	**	-11.078	7.289	0.129		-15.546	7.392	0.036	**
R2		0.233				0.235				0.234		
# of observations		3,799				3,799				3,799		

Notes:

a. The signs * , ** and *** represent 10%, 5%- and 1%-significance, respectively.

b. SE means cluster-robust standard errors.

c. Time effects are omitted.

[Table 6. Regression results with instrumental variables]

	(a)				(b)				(c)			
Independent variables (name)	Coeff.	SE	p-value		Coeff.	SE	p-value		Coeff.	SE	p-value	
Nonperforming loan ratio （BAD）	0.194	0.096	0.045	**								
Return on asset （ROA）					0.758	0.687	0.270					
Soundness composite indicator （PRIN）									0.175	0.084	0.037	**
Income level in the prefecture （GDP）	1.724	0.818	0.035	**	0.612	0.898	0.496		1.426	0.774	0.065	*
Appropriability （APPRO）	-0.006	0.006	0.336		-0.008	0.006	0.225		-0.007	0.006	0.260	
Technological opportunity （INFO）	0.003	0.009	0.765		0.005	0.010	0.596		0.004	0.009	0.671	
Industry growth （I_GRTH）	0.212	0.324	0.513		0.379	0.338	0.261		0.234	0.323	0.468	
Internal finance: one-period lag （CASH）	0.010	0.010	0.332		0.015	0.012	0.215		0.010	0.010	0.323	
Firm size （SIZE）	1.115	0.125	0.000	***	1.073	0.129	0.000	***	1.118	0.125	0.000	***
Firm age （AGE）	-0.011	0.008	0.178		-0.010	0.008	0.207		-0.011	0.008	0.175	
Nationalized bank dummy （NTNL）	0.686	0.567	0.226		1.335	1.201	0.266		2.917	1.421	0.040	**
Constant	-35.673	13.562	0.009	***	-7.802	7.416	0.293		-25.007	9.030	0.006	***
R2		0.223				0.215				0.221		
Sargan statistics		0.739				3.258				0.397		
p-value		0.691				0.196				0.820		
# of observations		3,799				3,799				3,799		

Note: Fixed effect model is employed.

[Table 7. Regression results with prefectural-level dummies]

[Random effect model]

	(a)				(b)				(c)			
Independent variables (name)	Coeff.	SE	p-value		Coeff.	SE	p-value		Coeff.	SE	p-value	
Nonperforming loan ratio （BAD）	0.067	0.031	0.032	**								
Return on asset （ROA）					0.116	0.044	0.009	***				
Soundness composite indicator （PRIN）									0.062	0.024	0.011	**
Income level in the prefecture （GDP）	1.880	1.139	0.099	*	1.633	1.130	0.148		1.861	1.134	0.101	
Appropriability （APPRO）	0.013	0.004	0.001	***	0.013	0.004	0.001	***	0.013	0.004	0.001	***
Technological opportunity （INFO）	0.006	0.006	0.320		0.006	0.006	0.292		0.006	0.006	0.302	
Industry growth （I_GRTH）	0.383	0.306	0.210		0.424	0.307	0.168		0.389	0.306	0.203	
Internal finance: one-period lag （CASH）	0.017	0.011	0.140		0.017	0.011	0.132		0.017	0.011	0.138	
Firm size （SIZE）	0.921	0.075	0.000	***	0.918	0.075	0.000	***	0.921	0.075	0.000	***
Firm age （AGE）	0.002	0.003	0.372		0.002	0.003	0.383		0.002	0.003	0.379	
Nationalized bank dummy （NTNL）	0.626	0.527	0.234		0.689	0.496	0.165		1.394	0.625	0.026	**
Constant	-16.859	4.226	0.000	***	-17.874	9.034	0.048	**	-13.250	3.297	0.000	***
R2		0.363				0.363				0.363		
# of observations		3,799				3,799				3,799		

[Fixed effect model]

Nonperforming loan ratio （BAD）	0.049	0.033	0.137									
Return on asset （ROA）					0.098	0.042	0.021	**				
Soundness composite indicator （PRIN）									0.044	0.026	0.087	*
Income level in the prefecture （GDP）	2.018	1.218	0.098	*	1.847	1.208	0.126		1.995	1.212	0.100	*
Appropriability （APPRO）	-0.006	0.007	0.388		-0.006	0.007	0.368		-0.006	0.007	0.368	
Technological opportunity （INFO）	0.003	0.011	0.766		0.004	0.011	0.735		0.004	0.011	0.745	
Industry growth （I_GRTH）	0.225	0.332	0.497		0.257	0.333	0.440		0.230	0.332	0.488	
Internal finance: one-period lag （CASH）	0.008	0.010	0.440		0.008	0.010	0.406		0.008	0.010	0.436	
Firm size （SIZE）	1.121	0.203	0.000	***	1.110	0.203	0.000	***	1.121	0.203	0.000	***
Firm age （AGE）	-0.009	0.008	0.227		-0.009	0.008	0.247		-0.009	0.008	0.227	
Nationalized bank dummy （NTNL）	0.636	0.689	0.356		0.731	0.612	0.232		1.212	0.781	0.121	
Constant	-23.004	10.919	0.035	**	-16.960	9.948	0.088	*	-20.804	10.249	0.043	**
R2		0.035				0.038				0.036		
# of observations		3,799				3,799				3,799		

Notes:

a. The signs * , ** and *** represent 10%, 5%- and 1%-significance, respectively.

b. SE means cluster-robust standard errors.

c. Results of time effects and prefectural dummies are omitted.

[Table 8. Results of panel tobit model]

[Random effect model]

	(a)				(b)				(c)			
Independent variables (name)	coeff.	SE	p-value		coeff.	SE	p-value		coeff.	SE	p-value	
Nonperforming loan ratio （BAD）	0.079	0.030	0.008	***								
Return on asset （ROA）					0.160	0.061	0.008	***				
Soundness composite indicator （PRIN）									0.069	0.024	0.004	***
Income level in the prefecture （GDP）	1.323	0.582	0.023	**	1.144	0.581	0.049	**	1.057	0.544	0.052	*
Appropriability （APPRO）	0.014	0.006	0.016	**	0.013	0.006	0.020	**	0.013	0.005	0.011	**
Technological opportunity （INFO）	0.006	0.008	0.437		0.007	0.008	0.401		0.008	0.008	0.289	
Industry growth （I_GRTH）	0.346	0.361	0.338		0.403	0.360	0.263		0.416	0.342	0.224	
Internal finance: one-period lag （CASH）	0.011	0.011	0.311		0.012	0.011	0.275		0.007	0.327	0.982	
Firm size （SIZE）	1.486	0.101	0.000	***	1.480	0.101	0.000	***	1.492	0.095	0.000	***
Firm age （AGE）	0.006	0.004	0.114		0.006	0.004	0.110		0.003	0.004	0.431	
Nationalized bank dummy （NTNL）	0.509	0.548	0.353		0.512	0.548	0.350		1.370	0.658	0.037	**
Constant	-26.942	5.835	0.000	***	-17.791	4.874	0.000	***	-21.195	4.749	0.000	***
Log-likelihood		-5607.1				-5607.2				-6206.1		
# of observations		3,799				3,799				3,799		

[Fixed effect model]

Nonperforming loan ratio （BAD）	0.069	0.025	0.006	***								
Return on asset （ROA）					0.156	0.049	0.002	***				
Soundness composite indicator （PRIN）									0.069	0.021	0.001	***
Income level in the prefecture （GDP）	1.642	0.702	0.019	**	1.322	0.698	0.058	*	1.539	0.698	0.028	**
Appropriability （APPRO）	-0.008	0.006	0.156		-0.008	0.006	0.129		-0.008	0.006	0.134	
Technological opportunity （INFO）	0.003	0.008	0.734		0.003	0.008	0.687		0.003	0.008	0.706	
Industry growth （I_GRTH）	0.263	0.292	0.368		0.314	0.291	0.282		0.267	0.292	0.360	
Internal finance: one-period lag （CASH）	0.006	0.009	0.510		0.007	0.009	0.453		0.006	0.009	0.496	
Firm size （SIZE）	1.391	0.120	0.000	***	1.373	0.120	0.000	***	1.396	0.120	0.000	***
Firm age （AGE）	-0.009	0.007	0.190		-0.009	0.007	0.191		-0.009	0.007	0.186	
Nationalized bank dummy （NTNL）	0.461	0.480	0.337		0.564	0.484	0.244		1.365	0.581	0.019	**
Log-likelihood		-3472.1				-3471.0				-3470.7		
# of observations		3,799				3,799				3,799		

Notes:

a. The signs * , ** and *** represent 10%, 5%- and 1%-significance, respectively.

b. Results of time effect are omitted.

[Table 9. Estimation results on the number of R&D staff: Panel tobit]

[Random effect model]

	(a)				(b)				(c)			
Independent variables (name)	coeff.	SE	p-value		coeff.	SE	p-value		coeff.	SE	p-value	
Nonperforming loan ratio （BAD）	0.139	0.072	0.054	*								
Return on asset （ROA）					0.354	0.142	0.013	**				
Soundness composite indicator （PRIN)									0.094	0.047	0.044	**
Income level in the prefecture （GDP)	2.027	2.256	0.369		2.269	2.258	0.315		2.007	2.255	0.373	
Appropriability （APPRO)	0.032	0.020	0.106		0.032	0.020	0.110		0.032	0.020	0.104	
Technological opportunity （INFO)	0.030	0.031	0.337		0.029	0.031	0.345		0.029	0.031	0.349	
Industry growth （I_GRTH）	-0.711	1.199	0.553		-0.651	1.199	0.587		-0.720	1.199	0.548	
Internal finance: one-period lag （CASH）	-0.009	0.037	0.818		-0.010	0.037	0.799		-0.009	0.037	0.802	
Firm size （SIZE)	5.134	0.398	0.000	***	5.128	0.397	0.000	***	5.143	0.398	0.000	***
Firm age （AGE)	-0.073	0.016	0.000	***	-0.073	0.016	0.000	***	-0.073	0.016	0.000	***
Nationalized bank dummy （NTNL）	1.486	1.729	0.390		2.219	1.774	0.211		2.077	1.782	0.244	
Constant	-55.532	20.510	0.007	***	-44.136	18.985	0.020	**	-47.563	19.270	0.014	**
Log-likelihood		-9880.6				-9879.3				-9880.4		
# of observations		3,821				3,821				3,821		

[Fixed effect model]

Nonperforming loan ratio （BAD）	0.198	0.060	0.001	***								
Return on asset （ROA）					0.371	0.117	0.002	***				
Soundness composite indicator （PRIN)									0.135	0.039	0.0005	***
Income level in the prefecture （GDP)	-2.395	2.462	0.331		-1.951	2.473	0.430		-2.252	2.463	0.3606	
Appropriability （APPRO)	-0.021	0.018	0.259		-0.021	0.018	0.254		-0.020	0.018	0.2718	
Technological opportunity （INFO)	0.050	0.029	0.093	*	0.049	0.029	0.096	*	0.048	0.029	0.1024	
Industry growth （I_GRTH）	-1.295	0.965	0.180		-1.241	0.965	0.199		-1.309	0.965	0.1750	
Internal finance: one-period lag （CASH）	-0.907	0.734	0.216		-0.908	0.734	0.216		-0.939	0.734	0.2006	
Firm size （SIZE)	7.104	0.414	0.000	***	7.075	0.414	0.000	***	7.113	0.414	0.0000	***
Firm age （AGE)	-0.050	0.024	0.039	**	-0.050	0.024	0.040	**	-0.050	0.024	0.0393	**
Nationalized bank dummy （NTNL）	0.898	1.460	0.539		1.626	1.501	0.279		1.717	1.498	0.2518	
Log-likelihood		-7550.5				-7551.3				-7550.1		
# of observations		3,821				3,821				3,821		

Notes:

a. The signs * , ** and *** represent 10%, 5%- and 1%-significance, respectively.

b. Results of time effect are omitted.

[Table A-1. List of dependent and independent variables]

(Dependent variables)

variables	definition	aggregation level	unit	data source
R&D expenditure (RDE)	Logarithmic value of (R&D expenditure + 1)	Micro data	ln(1 million yen)	METI, "Basic Survey of Business Structure and Activity"
Number of R&D staff (RDP)	Number of R&D staff serving the headquarters or research institutes as a percentage of the number of employees during the period estimated	Micro data	%	Same as above

（Independent variables）

variables	definition	aggregation level	unit	data source
(i) Nonperforming loan ratio (BAD)	・100 minus nonperforming loan ratio (an increase means improvement in financial soundness) ・Nonperforming loan ratio = Regional bank's risk-management loans divided by total assets for each prefecture	Prefecture (44)	%	Annual securities report of regional banks
(ii) Return on asset (ROA)	Regional bank's ROA = Current profit divided by total assets	Prefecture (44)	%	Same as above
(iii) Soundness composite indicator (PRIN)	The primary major component of principal component analysis on the aforementioned two indicators, capital adequacy ratio, and expense rate	Prefecture (44)	－	Calculated by the author.
(iv) Income level in the prefecture (GDP)	Income per capita in the prefecture	Prefecture (44)	1,000 yen/person	Cabinet Office, "Annual Report on Prefectural Accounts"
(v) Appropriability (APPRO)	The maximum percentage of respondent firms capable of benefiting from their "product innovation" among innovative firms (comparison of 9 methods)	Industry (25)× Firm size (3)	%	MEXT, "Japanese National Innovation Survey"
(vi) Technological opportunity (INFO)	The maximum percentage of respondent firms having used information from a "new innovation information source" among innovative firms (comparison of 15 information sources)	Industry (25)× Firm size (3)	%	Same as above
(vii) Industry growth (I_GRTH)	First difference of logarithm of Gross Domestic Product classified by Economic Activities (SNA basis)	Industry（14）	First difference of logarithm	Cabinet Office, "Annual Report on National Accounts"
(viii) Internal finance (CASH)	(Current profit + depreciation) / number of employees	Micro data	1 million yen/person	METI, "Basic Survey of Business Structure and Activity"
(ix) Firm size (SIZE)	Logarithm of the number of employees	Micro data	ln(person)	Same as above
(x) Firm age (AGE)	Number of years since the firm was established	Micro data	Year	Same as above
(xi) Nationalized bank dummy (NTNL)	1 (if there is any nationalized regional bank in the prefecture) or 0 (if the prefecture does not have such banks)	Prefecture (44)	0 or 1	Developed by the author.