R&D Investment Smoothing and Corporate Diversification

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Abstract

We estimate dynamic R&D investment models in publicly traded Japanese manufacturing firms over 2001-2009. Splitting into two subsamples by the degree of corporate diversification, we provide evidence that less-diversified firms have an increased tendency to smooth R&D but more-diversified firms don't do it. To clarify the causes behind corporate diversification, we also turn our eyes on the effect of financial liquidity or share ownership structure, showing that financially unconstrained firms tend to smooth R&D investment. We, furthermore, provide evidence that corporate diversification doesn't improve financial liquidity in financially constrained firms, but deteriorates financial liquidity in some financially unconstrained firms.

Keywords: corporate diversification; R&D; investment smoothing; financial liquidity; share ownership structure

JEL classification: G31;G32

I. Introduction

Recently, the amount of R&D investments on publicly traded US firms has been increasing sharply (Brown, Fazzari, and Petersen (2009), Brown and Petersen (2011)). Although R&D investments in Japanese firms do not increase as remarkably as those of US firms, it has been increasing gradually. In Figure 1, we use the database of *Nikkei Needs Financial Quest* to estimate the sum of physical investment (excluding lands) and R&D investment expenditures per a listed firm, which belongs to manufacturing industry. We find that the former has increased a little from 8.37 billion yen (fiscal year 2001) to 9.02 billion yen (fiscal year 2009), while the latter has increased from 5.01 billion yen to 6.85 billion yen. Now we confirm that the amount of R&D expenditures is close to the amount of physical investment.

In this way, R&D investment is not a mere derivation of physical investment any longer. Similar to physical investment, that is, R&D investment is one of the most interesting concerns for not only researchers but also managers. There are only a few empirical studies on R&D investment in Japan, US, UK, and so on. There are many studies on physical investment, however.

Insert Figure 1

The most important features of R&D investment are to require consecutive and stable expenses and to take long time to obtain fruits from the project (Cooper and Haltiwanger (2006)). As seen in Figure 1, therefore, R&D expenditures in Japanese manufacturing firms are not volatile but independent of business cycles relative to physical investments. In other words, Japanese firms have a tendency to smooth R&D investments, unlikely to physical investments. Besides, most firms are apt to utilize internal funds rather than external funds to finance R&D investments. For example, Hall (2002) reported that firms with high R&D expenditures are less likely to utilize debt financing. Furthermore, since R&D investments are more likely to be a riskier project than physical investments and are likely to have an asymmetric information problem between managers and investors. This implies that firms are more prone to face the financial constraints in carrying out R&D investments, relative to physical investments. Indeed, Brown, Fazzari, and Petersen (2009), Brown and Petersen (2011) examined the influence of financial liquidity on R&D investment or R&D investment smoothing in U.S firms to show that it is related to firm's financial liquidity.

As illustrated by Brown, Fazzari, and Petersen (2009), it is young firms not but mature firms that have been more engaged in R&D investment in US. In Japan, on the other hand, mature firms which have led the growth of Japanese economy since 1960s mainly carry out R&D investment at the present. Therefore, R&D expenditures in Japanese manufacturing firms are likely to be more stable than those of US. On the other hands, since the late 1990s, the Japanese economy has experienced the depreciation of the business quality of the banking sector and released a number of deregulations in the capital markets. Consequently, R&D investments of Japanese firms may be subject to financial constraints because of a lack of a financial support of the so-called main bank[1]. More importantly, with

[1] Main banks are defined as banks which establish a close relationship with firms. For

entering into new business lines and actively making use of M&A activities internationally rather than domestically, Japanese firms have been carrying out stable R&D investments for a decade. In this way, we expect that it is interesting for us to clarify the relationship between R&D investments and corporate diversification (financial liquidity or corporate governance system) in Japanese firms.

In our paper we pay attention to the role of corporate diversification on R&D investment smoothing. We present some economic implications of corporate diversification which are closely related to financial liquidity. In particular, we focus on the effect of debt coinsurance and efficient internal capital markets in our paper. The former is that diversifying business segments declines the firm's overall cash flow volatility, resulting to the lessening of expected bankruptcy cost. The latter is that combining the cash flows of multiple business segments makes it possible for firms to allocate their funds into profitable projects through exchanges across the divisions' internal funds. Thus, we expect that diversified firms can improve financial liquidity through both effects, and then they

example, see Aoki and Patrick (1994), Hoshi and Kashyap (2001), and so on.

will carry out desirable level of R&D investment without any financial constraints, that is, to smooth R&D investment.

Using the panel data of publicly traded Japanese manufacturing firms from 2001 to 2009, we examine the effect of corporate diversification on the smoothness of R&D investment. According to Lang and Stulz (1994) and Berger and Ofek (1995), first of all, we use the number of business segments or the Herfindahl-Hirschman index across segments to calculate the degree of corporate diversification. We then estimate the speed of adjustment (SOA) of R&D investment in the dynamic R&D investment model for each of the subsamples divided by the degree of corporate diversification, and compare the difference of SOA across subsamples. Our reduced form equation for R&D investment resembles that of Fazzari, Hubbard, and Petersen (1988), but a lagged R&D term are included in their equation in order to captures the degree of R&D's smoothness

What is interesting about our paper is that we attempt to relate R&D smoothness to corporate diversification. Many studies examine the effect of the financially constraint on R&D and physical investments. Similarly, many studies examine why firms attempt to diversify their business. It, however, seems that we have never argued two studies simultaneously. Our research is to find out a causal nexus between investments and corporate diversification. To our knowledge, no study relates the smooth path of R&D investment to corporate diversification. By clarifying the effects of corporate diversification, we not only provide a solution to the relation between R&D smoothing and corporate diversification but also may cast a new light on an empirical puzzle on corporate diversification — "diversification discount" — which has been questioned so far.

Our study is closely related to the study of Brown and Petersen (2011). Similar to our study, Brown and Petersen (2011) examined the smoothing of R&D investment. Following Brown *et al.* (2009), they distinguished young firms and mature firms to estimate the Euler equation for R&D investment in each subsample. They presume the Euler equation with which we incorporate the changes of cash holdings as additional explanatory variables. They also examined the effect of the accumulated changes of cash holdings on R&D investment. According to their study, young firms, which are likely to be financially constrained firms, have a positive sensitivity on the changes of cash holdings to R&D

investment, while mature firms, which are financially unconstrained firms, do not have such sensitivity. This implies that a lack of financial liquidity may intercept the smoothness of R&D investment. In contrast, we formulate the reduced R&D equation with the dynamic structure, that is, the partial adjustment model. By explicitly incorporating the degree of smoothness in the model, which is represented by "1 - SOA", we can evaluate the smoothness of R&D investment.

Our main results are as follows. First of all, estimating the dynamic R&D investment models for subsamples; more-diversified firms and less-diversified firms, we compare the estimated coefficient on the lagged R&D ratio across subsamples. It is predicted that, under the hypothesis that the benefits of corporate diversification exceed its costs, in particular, when the benefits from debt coinsurance and efficient internal capital markets are overwhelming, the (positive) coefficient on the lagged R&D ratio is large in more-diversified firms. According to our results, however, less-diversified firms tend to smooth R&D more, irrespective of our diversification measures. This is inconsistent with the above hypothesis, that is, the effectiveness of debt coinsurance or efficient internal capital markets.

Next, we paid attention to the relationships between corporate diversification and financial liquidity or between corporate diversification and share ownership structure in order to clarify the causes of our unexpected results. Similar to the case of corporate diversification, we segregated our sample into two subsamples, according to the degree of financial liquidity or share ownership structure. We then examined the differences of SOA between the two subsamples. We found that financially unconstrained firms are likely to smooth R&D investment while financially constrained firms do not have this predisposition. We also divided our sample into two subsamples according to some share ownership types to examine the differences of SOA between the two subsamples. However, we could not find that there are some differences between the two subsamples. These imply that corporate diversification is, if anything, negatively related to financial liquidity, that is, corporate diversification may lead firms to be financially constrained.

Finally, in order to examine more directly the relationship between corporate diversification and financial liquidity, we examined the effect of corporate diversification on the smoothing of R&D investment in financially constrained firms and financially unconstrained firms, respectively. If corporate diversification improves financial liquidity through debt coinsurance and efficient internal capital markets, financially constrained firms but not financially unconstrained firms will have the effect of corporate diversification on the smoothness of R&D investment. In our study, we cannot provide evidence that corporate diversification improves the financial liquidity in financially constrained firms. Rather, we show that corporate diversification deteriorates the financial liquidity in financially unconstrained firms.

Our evidence does not support the advantages of corporate diversification, for example, the effectiveness of debt coinsurance or the efficient internal capital market in Japanese manufacturing industries. This implies that, when most of R&D investments are led by mature firms such as Japan, corporate diversification does not necessarily lead to the improvement of financial liquidity.

The remainder of our study proceeds as follows. The next section proposes R&D investment, corporate diversification, and some predictions pertaining to R&D smoothing with corporate diversification. Section Ⅲ shows the dynamic R&D investment model, the methodology of estimation, and the hypotheses to be tested. Section Ⅳ provides an explanation of the data utilized in our analysis. We, in particular, argue some of the characteristics of our measures of corporate diversification and the descriptive statistics of our sample. Section Ⅴ presents the main results, that is, that corporate diversification is negatively linked to R&D smoothing. Section Ⅵ presents more supportive evidence on the negative relationship between corporate diversification and R&D smoothing. Section Ⅶ also examines the smoothness of physical investment and cash holdings. Section Ⅷ summarizes our paper.

II. R&D Investment and Corporate Diversification

A. R&D investment

It has been known that firms go on involving consecutive and stable expenses for long periods in R&D investments (e.g., Himmelberg and Petersen (1994), Hall (2002)). In fact, as argued by Hamermesh and Pfann (1996) and Brown and Petersen (2011), most of R&D expenditures consist of wage payments to highly trained scientists, engineers, and other skilled technology workers who often require a great deal of firm-specific training. Thus, if managers make a decision to cut R&D expenditures, these proficient workers will have to be laid off. Even if this retrenchment is temporary, such as due to financial shocks, new workers need to be hired in the future, and thus creating additional hiring and training costs. If, furthermore, rival firms hire these laid off R&D workers, some critical proprietary information obtained through R&D activities may flow out to rivals. Therefore, in general, firms attempt to avoid these risks which they cannot immediately respond to by maintaining a smooth path of R&D investment as much as possible. This tendency in R&D investment appears to be more prominent than in physical investment (See Cooper and Haltiwanger (2006)).

A second important feature of R&D investments is that equity finance is the main source of R&D financings. For example, Hall (2002) reported that firms with high R&D

expenditures are less likely to utilize debt financing. R&D investment is likely to be a riskier project than physical investment because it takes time to obtain the fruits of the project. It is obvious that, as far as there are no conflicts between the management and shareholders, a large number of R&D expenditures surely increase the expected return of shareholders. However, they do not necessarily lead to an increase in the expected return of debtors due to risk-shifting, hence creating agency costs of debt. Thus, the agency costs of debt make it difficult to use debt for financing an R&D investment. Besides, in comparing internal equity finance with external equity finance, as pubic stock issues incur sizeable floating costs and asymmetric information problems, internal equity finance has an advantage over external equity finance. Therefore, it is expected that, in financing funds for R&D investment, most firms attempt to utilize internal equity finance rather than external equity finance or debt finance. It is also expected that firms with accessibility to external finance can smooth R&D expenditure. For example, Brown and Petersen (2011) found that young firms which would be severe financially constrained tend less to smooth R&D expenditures in the US manufacturing industry.

B. Corporate Diversification

So far a number of studies have examined the economic implications of corporate diversification for a long time (for example, see surveys by Martin and Sayrak (2003), Maksimovic and Phillips (2007))[2]. As we will see, we show that some implications of corporate diversification are closely related to financial liquidity, which we have explained in the above. In our study, therefore, we attempt to have access to the effect of corporate diversification rather than financial liquidity on R&D smoothing. In order to do so, we

[2] Following the excellent survey papers of Martin and Sayrak (2003), Maksimovic and Phillips (2007), the benefits of corporate diversification are illustrated by (1) Debt coinsurance (Lewllen (1971)), (2) Internal capital markets (Stein (1997), Matsusaka and Nanda (2002)), (3) Value maximizing behavior of the firm (Matsusaka (2001), Gomes and Livdan (2004)), and (4) Economies of scope (Teece (1980, 1982)). In contrast, the costs of corporate diversification are related to (1) Agency problem between managers and shareholders (Stulz (1990), Shleifer and Vishny (1989)), and (2) Intra-firm conflicts (Scharfstein (1998), Scharfstein and Stein (2000), Rajan, Servaes, and Zingales (2000)).

have to provide the benefits and the costs of corporate diversification in the following.

First of all, let us explain the benefits of corporate diversification.[3] As advocated by Lewellen (1971), Stein (1997), Matsusaka and Nanda (2002), and others, corporate diversification has the potential benefit of insulating firms from the rationing and costs of external capital markets through the coinsurance of debt and the workings of internal capital markets. Lewellen (1971) found that corporate diversification reduces the firm's overall cash flow volatility by combining the cash flows of multiple business segments. This implies the reduction of expected bankruptcy cost, leading to the reduction of the agency costs of debt. For example, Aivazian, Qiu, and Rahaman (2011) found that diversified firms have lower bank loan spread, which is defined as the loan rate minus the London Inter-bank Offered Rate, compared to the portfolio of stand-alone firms.

[3] As the benefits we focus on debt coinsurance and internal capital markets. As far value maximizing behavior of the firm, its focus is firm's diversifying behavior but not investment decision in itself. In addition, as seen later, our diversification measure focuses on the degree of diversification not within some industry but across different industries. Therefore, it is considered that the benefit of the economies of scope would be small.

Stein (1997) and Matsusaka and Nanda (2002) showed that diversifying business segments not only makes cash flow more stable but also enables firms to allocate funds into profitable projects through transfers across the segments' internal funds. Compared with stand-alone firms, diversified firms can reduce the precautionary demand for corporate liquidity, so that they can transform from liquidity assets (such as cash holdings) to assets that have a more positive net present value. Therefore, the investments of more-diversified firms are free from financial constraints.

Unfortunately, all effects of corporate diversification aren't benefits. Some studies show that there are some costs. These are directly related to the conflicts or the agency problems among stakeholders. The one is the conflicts between managers and shareholders (Stulz (1990), Shleifer and Vishny (1989)). The other is the conflicts between headquarters and segment managers (Scharfstein (1998), Scharfstein and Stein (2000), Rajan, Servaes, and Zingales (2000)).

As far conflicts between managers and shareholders, some of shareholders, for example, individual shareholders, intend to hold shares in order to obtain the short-term capital gains. So, R&D investments are not desirable for them, because it take a long time for these shareholders to obtain the fruits of R&D investments. Therefore, even if firms have a tendency to carry out R&D investments, the conflict between managers and shareholders will disturb the efficient execution of R&D, so that these firms may be unable to smooth R&D. Indeed, more-diversified firms are large firms and issue a large number of shares. So they may face this kind of problem.

The conflicts between headquarters and segment managers are intra-firm problems. As a firm diversifies business segments, the headquarters cannot monitor the behavior of firm's segment managers accurately, because headquarters don't have more information about business segments than their segment managers. So these conflicts also lead to the inefficient execution of R&D, so that diversified firms may be unable to smooth R&D.

In this way, both benefits of corporate diversification are closely related to financial liquidity. For example, Duchin (2010) examined the relation between financial liquidity and diversification to find evidence that diversified firms hold significantly less cash than stand-alone firms do. Similarly, both costs of corporate diversification are closely related to the corporate governance structure. In particular, the former is related to the time horizon of shareholders which have an influence on manager's decision. The latter is related to a monitoring ability of headquarters, that is, a monitoring ability of shareholders, because headquarters (managers) are elected by shareholders.

C. The relation between smoothness of R&D investment and corporate diversification

The arguments outlined above on R&D investment provide us with some predictions in our empirical study. Due to the coinsurance of debt and the efficiency of internal capital markets, corporate diversification makes it easy for firms to finance more funds for R&D investment. Thus, as far as these benefits surpass the other costs of corporate diversification, since diversified firms are able to prevail over imperfections that there exist in external capital markets, they will be able to smooth R&D investment easily. On the other hand, when the benefits of corporate diversification are so trivial that the costs can be rather large, less-diversified firms will be able to smooth R&D investment.

Therefore, we posit the following predictions:

P1-a: More-diversified firms have a tendency to smooth R&D investment.

P1-b: Less-diversified firms have a tendency to smooth R&D investment.

These two predictions are mutually exclusive. We can say that, if the benefits surpass the costs of corporate diversification, there should be a positive relation between corporate diversification and the smoothness of R&D investment. If, conversely, the costs surpass the benefits, there should be a negative relation. Finally, if neither of these predictions holds, the smoothness of R&D investment has nothing to do with corporate diversification. In the later section, we will investigate which of the above predictions is true of Japanese manufacturing firms.

Next, we look into the underlying causes that support our empirical result. As seen in Section Ⅱ.B, we aim at the relation between corporate diversification and financial liquidity and between corporate diversification and share ownership structure. Then, we shall consider the effect of financial liquidity in the place of corporate diversification on the smoothness of R&D investment. For example, Brown and *et al.* (2009) and Brown and Petersen (2011) showed evidence that R&D smoothing is related to a firm's financial liquidity. We, therefore, expect firms that are less financially constrained to be more capable of smoothing R&D investment. At the same time, we also look into the effect of an alternative issue – the share ownership structure – on the smoothness of R&D investment. Since it takes time for firms to yield gains from R&D, firms have to attract shareholders who have a long-term time horizon in order to smooth R&D investment. In addition, by attracting informed shareholders who have a monitoring ability, such as financial institutional investors, firms can have an easy and stable access to capital markets. Because revealing the fact that some of firm's shares are held by the informed shareholders conveys a useful signal to uninformed investors, it contributes to loosen financial difficulties, so that firms can easily smooth R&D investment.[4] Taken together, we

[4] Allen, Bernardo, and Welch (2000) showed that, when firms suffer from a disadvantage

have the following predictions:

P2: Financially unconstrained firms have a tendency to smooth R&D investment.

P3: Firms that are held by shareholders who have a long-term horizon or with a monitoring ability have a tendency to smooth R&D investment.

Now we can suggest a conclusion: that, when P1-a is supported and P2 holds, corporate diversification moderates financial liquidity and then encourages firms to smooth R&D investment. Similarly, we can conclude that, when P1-a is supported and P3 holds, corporate diversification attracts shareholders with long-term horizon or with monitoring skills, which in turn encourages firms to smooth R&D investment. Conversely, the evidence that P2 or P3 holds, but P1-b is supported, implies that corporate diversification due to asymmetric information between managers and investors about current or future cash flows, firms increase dividend payments to attract financial institutional investors in order to resolve the informational disadvantage.

makes firms financially constrained or that diversified firms fall from favor from such shareholders and therefore that they would be unable to smooth R&D investment. Finally, if none of the cases above holds, this implies that corporate diversification is unrelated to a firm's financial liquidity or share ownership structure.

III.Model and Hypothesis

A. Model

We adopt Tobin's Q reduced model of physical investment (Hayashi and Inoue (1991), Gilchrist and Himmelberg (1995)) to R&D investment. Thus, we will specify desired R&D investment $R\&D^{*}_{i,t}$ as follows:

$$R\&D^{*}_{i,t}/Assets_{i,t-1} = \beta_0 + \beta_1 Tobin's\ Q_{it} + \gamma_1\ CF_{i,t}/Assets_{i,t-1} \quad (1)$$

where $R\&D^{*}_{i,t}/Assets_{i,t-1}$ denote the ratio of desired R&D investment to the total assets, $Tobin's\ Q_{it}$ denotes the ratio of market value to book value of total assets, and $CF_{i,t}/Assets_{i,t-1}$ denotes the cash flow ratio. In frictionless financial markets and competitive product markets, we know that R&D investments as well as physical investments depend only on Tobin's Q. However, we also know that Tobin's Q has a poor explanatory power for investment behaviors. Therefore, we add the cash flow ratio to the explanatory variables into Eq. (1). In our paper, we do not discuss the so-called cash-flow sensitivity γ_1 because γ_1 in itself is not our main interest.[4]

[4] As we know, a number of studies have questioned the hypothesis that firms with greater cash-flow sensitivity is subject to severe constraints. On the empirical side, Kaplan and Zingales (1997) and Cleary (1999) provided evidence that cash-flow sensitivity need not identify liquidity constrained firms, because sensitivity is not monotonic in the degree of constraints. Furthermore, Erickson and Whited (2000) and Bond and Cummins (2001) demonstrated that observed differential cash-flow sensitivity is explained across groups of firms by the measurement error in Tobin's Q. On the theoretical side, Gomes (2001) simulated a dynamic investment model, demonstrating that cash-flow sensitivity does not identify liquidity constrained firms. In Japanese empirical studies, Ogawa and Suzuki (1998) and Ogawa and Kitasaka (1999) reported the importance of the land stock as a

As seen in Section II.A, unlike to physical investment, firms attempt to smooth R&D investment more in order to avoid instantaneously unexpected shocks. We make use of a target adjustment model to evaluate the effect of R&D smoothing, which is the speed of adjustment (SOA) of R&D investment, depending on the different degrees of corporate diversification. This model is as follows:

$$\mathrm{R\&}D_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}} - \mathrm{R\&}D_{\mathrm{i,t-1}}/\mathrm{Assets}_{\mathrm{i,t-2}} = \alpha\left(\mathrm{R\&}D^{*}_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}} - \mathrm{R\&}D_{\mathrm{i,t-1}}/\mathrm{Assets}_{\mathrm{i,t-2}}\right) + \varepsilon_{\mathrm{it}}, \quad (2)$$

$$\varepsilon_{\mathrm{it}} = \mu_{\mathrm{i}} + \mathrm{u}_{\mathrm{it}},$$

where $\mathrm{R\&}D_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}}$ denotes the ratio of R&D investment to the total assets. The disturbance term $\varepsilon_{\mathrm{it}}$ has two orthogonal components: firm-specific term μ_{i} and observation-specific term u_{it}. The coefficient which we have an interest in is the speed of adjustment (SOA): α. This coefficient α lies in (0 , 1).

Using Eq. (1), Eq. (2) can be written as follows:

collateral rather than cash flow in financially constrained firms.

$$\mathrm{R\&}D_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}} = \alpha\beta_0 + \alpha\beta_1 \mathrm{Tobin's\ Q}_{\mathrm{it}} + \alpha\gamma_1\, \mathrm{CF}_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}} + (1-\alpha)\, \mathrm{R\&}D_{\mathrm{i,t-1}}/\mathrm{Assets}_{\mathrm{i,t-2}} + \mu_{\mathrm{i}} + \mathrm{u}_{\mathrm{it}} \quad (3)$$

In Eq. (3), $\mathrm{Tobin's\ Q}_{\mathrm{it}}$ includes a lagged variable as well as a contemporaneous variable since the specification of only a contemporaneous variable has poorly fitted in the various specifications. Furthermore, we assume weak exogeneity on cash flow to use the lagged cash flow ratio but not the contemporaneous cash flow ratio.[5] Finally, the estimation includes yearly dummies YD to control for aggregate changes that could affect the demand for R&D. As a result, our estimated specification is as follows:

[5] As similar to Tobin's Q, the cash flow ratio may be a contemporaneous variable. In fact, even if we assume the endogeneity of cash flow, that is, when we use the specification with the contemporaneous cash flow ratio, we can obtain similar results for the coefficient on SOA. However, we have gotten into the difficulty that the orthogonal condition (Hansen's J test) is more likely to be rejected in some spitted samples under most sets of instruments.

$$\mathrm{R\&}D_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}} = \delta_1 \mathrm{Tobin's\ Q_{it}} + \delta_2 \mathrm{Tobin's\ Q_{it-1}} + \delta_3\, \mathrm{CF_{i,t-1}}/\mathrm{Assets}_{\mathrm{i,t-1}}$$

$$+\delta_4\, \mathrm{R\&}D_{\mathrm{i,t-1}}/\mathrm{Assets}_{\mathrm{i,t-2}} + \sum\nolimits_{\mathrm{t}}^{\mathrm{T}} \theta_{\mathrm{t}} \mathrm{YD_t} + \mu_{\mathrm{i}} + \mathrm{u_{it}} \quad (4)$$

where δ_i for $i = 1,2,3,4$ and θ_t are parameters to be estimated. We focus on the following parameter: coefficient of SOA, that is, $\alpha = 1 - \delta_4$. The low value of α , that is, δ_4 becomes the large value, at least larger than zero, when firms attempt to smooth R&D investment. However, if a firm cannot maintain smoothing an R&D investment due to some reasons, δ_4 will have a low value. Through large effects of debt coinsurance and efficient internal capital market, diversified firms attempt to smooth R&D investment because corporate diversification makes it possible for them to be free from financial constraints. Hence, we expect that δ_4 in diversified firms should be at least greater than zero.

We estimate Eq. (4) by referring to Arellano and Bond's (1991) estimation. This methodology is based on the GMM estimation with the difference equation in Eq. (4), and hence we can remove firm specific term μ_i. In performing the GMM estimation, we use the lagged $\mathrm{R\&}D_{\mathrm{i,t}}/\mathrm{Assets}_{\mathrm{i,t-1}}$dated t-2 to t-5, the lagged Tobin's Q_{it} dated t-2 to t-3, the lagged

$CF_{i,t-1}/Assets_{i,t-1}$, and yearly dummies as instrumental variables. To assess the validity of the instruments, we use Hansen's J-test on over-identifying restrictions. In addition, we also use Arellano and Bond's M-2 test for second-order autocorrelation in the first-differenced residuals, which, if present, could lead to a biased GMM estimator.

We show coefficient estimates and standard errors in the tables that follow. Referring to Arellano and Bond (1991), we use one-step GMM estimates for inference. The standard errors are robust to heteroskedasticity and within-firm serial correlation. They are also adjusted by the finite-sample correction, according to Windmeijer (2005). In addition to the estimates on δ_i for $i = 1,2,3,4$, we also report statistical significances of Tobin's Q and cash flow ratio on R&D investment in a steady state. The former is calculated as $(\delta_1 + \delta_2)/(1 - \delta_4) = \beta_1 + \beta_2$, and the latter is as $\delta_3/(1 - \delta_4) = \gamma_1$. Finally, we report the results of the joint significance test on yearly dummies, although we have to omit reporting their coefficients for want of space.

B. Hypothesis

As seen in Section Ⅲ.A, we focus on the coefficient on lagged R&D investment $\delta_4 (= 1 - \alpha)$ in Eq. (4). In other words, δ_4 represents a large value, at least larger than zero, when firms attempt to smooth R&D investment. In contrast, if a firm cannot maintain the smoothing of an R&D investment, δ_4 will have a low value. Then, our predictions which have been derived in Section Ⅱ.C are able to be rewritten by the hypotheses with regarding δ_4. First of all, in order to argue P1-a or P1-b in Section Ⅱ.C, we perform the following test:

H1-a: Under debt coinsurance and efficient internal capital markets, δ_4 is greater than zero for more-diversified firms. On the other hand, δ_4 is indeterminate for less-diversified firms.

H1-b: Under no debt coinsurance and inefficient internal capital markets, δ_4 is greater than zero for less-diversified firms. On the other hand, δ_4 is indeterminate for more-diversified firms.

We also pay attention to the degree of financial liquidity and share ownership structure in order to shed light on factors behind corporate diversification. Thus, in order to argue P2 or P3 in Section Ⅱ.C we perform the following test:

H2: When the smoothness of R&D investment depends on a firm's financial liquidity, δ_4 is at least greater than zero for financially unconstrained firms. On the other hand, δ_4 is indeterminate for financially constrained firms.

H3: When the smoothness of R&D investment depends on a firm's share ownership structure, δ_4 is at least greater than zero for firms with shareholders with the long-term time horizon or with the high monitoring ability. On the other hand, δ_4 is indeterminate for firms without such shareholders.

IV. Data

Most of the variables needed for our empirical analysis are constructed from databases contained in the *Nikkei NEEDS-Financial Quest* 's *Corporate Financials Database*, the *Corporate Attribute Database*, and the *Segment Database*. With regard to share prices, we use closing prices of a firm's settlement term in the *Nikkei Needs Portfolio Master's Database*. We select manufacturing firms listed in Japanese security markets for the period from the fiscal years 2001 to 2009, because accurate R&D expenditure's data have been available since 2001. The reason why we focus on manufacturing firms is that R&D expenditures in manufacturing firms far surpassed those in nonmanufacturing firms. [6]

A. Diversification measures

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[6] The amount of R&D expenditures per listed firms belonging to manufacturing industries is about 6.05 billion yen for 2001 – 2009, while that in nonmanufacturing industries is about 0.43 billion yen. In addition, the mean physical investment expenditures excluding for lands in manufacturing (nonmanufacturing) firms is about 8.86 (5.94) billion yen.

The *Segment Database* in the *Nikkei NEEDS-Financial Quest* provides miscellaneous information about business segments which firms hold (segment's name, code, sales, operating profits, operating costs, total assets, and so on). The first two numbers of the four-digit segment code, which is provided according to business segment, presents a board industry segment as a component of the firm that is engaged in providing products or services primarily to customers for profit. The board industry segment covers 93 different industries. We call this classification "segment broad classification."

Segment broad classification is not in accordance with industrial classification due to the Nikkei industry code, which is popular to the Japanese empirical researches. Since the Nikkei industrial classification categorizes 36 industries, the segment broad classification is approximately considered to be more subdivided. For example, the segment code 2700 represents the information and communication segment, 2800 the electric machinery segment, and 2900 the electronic components and devices segment. It is considered that these three segments are summarized as the electric machinery industry in the Nikkei industrial classification. Furthermore, each industrial segment is subdivided into other related industry segments by the last two numbers as much as possible. For example, 2710 represents the electric machinery segment for generation, transmission, transformation, and industrial use. Following our segment broad classification, we identify the number of business segments (**N-segment**) which is reported by each firm as a measure of corporate diversification. However, this measure might be a crude proxy for diversification. For example, while a diversified firm may concentrate most of their resources on a core segment, the other might not have a core segment and instead allocate resources to all the segments uniformly. In this case, we may judge that the former is less diversified than the latter. In order to allow for this possibility, we utilize the Herfindahl-Hirschman index (**HHI-segment**) calculated based on the ratio of segment assets to total assets as a complementary measure of diversification.

Before showing our detailed empirical results, it is necessary for us to keep some characteristics of these measures in mind. First of all, although our measures are based on segment broad classification, these values represent the degree of diversification not across divided segments within a given board segment but across different board segments (industries). It, therefore, seems that these are close to the "diversification across unrelated industries." Secondly, the **HHI-segment** is constructed from the lines of total assets per segment. Some studies construct this measure based on the assets reported in each segment, while some utilize the one based on the sales per segment. Our **HHI-segment** is its less susceptibility to biases brought about by customer demand. Furthermore, most studies show that asset-based HHI measure and sale-based HHI measure are similar. Therefore, our study utilizes asset-based HHI measure.

Table I provides the numerical characteristics of our corporate diversification measures in Japanese manufacturing industries. As seen in Panel A, the number of firm-year observations that we have collected is 7,066. The maximum value of **N-segment** is eight in our sample. It is observed that the distribution of the **N-segment** is right-skewed, that is, the proportion of **N-segment** = 1 or 2 is 0.13 = 901/7,066 or 0.42 = 2,995/7,066 and the sum of these two proportions is almost 0.50. Panel A of Table I also shows the mean and the median of **HHI-segment** by **N-segment**. Apparently, the **HHI-segment** tends to decrease as the **N-segment** increases. Panel B of Table I reports the correlation coefficient between the **N-segment** and the **HHI-segment**. Its value is -0.72 and is significant at 1 %, indicating that there is a negative and liner relation between the **N-segment** and the **HHI-segment**. Finally, Panel C of Table I provides the progresses of the **N-segment** and the **HHI-segment** for the period of 2001 to 2009. Judging from the mean of the **N-segment** and the **HHI-segment**, the degree of corporate diversification remains to be stable, or slightly decreasing.

Insert Table I

B. Sample selection

In order to obtain reliable results in the GMM estimation of the dynamic panel models, we have to select a clean sample. First, we restrict the sample by deleting any firm-year observations with missing data.[7] In addition, due to reporting errors in the data file or incorrectly consolidated data, there are a few substantial outliers in our sample. Hence, we exclude any observations for which total assets, **N-segment**, or **HHI-segment** are zero or negative. Furthermore, we exclude any observations if the **HHI-segment** is larger than one. We also exclude observations with a ratio of market-to-book value of total assets (**Tobin's Q**), of which the value is larger than 5.0, and with a cash flow divided by total assets (**CF / Assets**), of which the value is smaller than -0.5. Here, **Tobin's Q** is measured as the market value of the firm's total assets divided by the book value of the firm's total assets. The market value is measured as the total number of outstanding shares of a common stock multiplied by the stock's closing price at the fiscal year-end plus the book value of total debt. **CF** is defined as the sum of before-tax operating income, interest receivable and

[7] The number of firm-year observations without missing values is 9,919 in the *Nikkei NEEDS-Financial Quest* 's *Corporate Financials Database*. In merging this sample and segment data in *Segment Database*, unfortunately, we experienced that approximately one third of these observations lack segment information. However, characteristics of our final sample are quite similar to those of the sample before deleting observations.

discount premium, interest on securities, and depreciation expense in the current year. Finally, we trim the data by deleting the observations above the 99th percentile for R&D expenditures, divided by total assets at of the beginning of the year (**R&D / Assets**).

In order to examine the effect of corporate diversification on the smoothness of R&D investment, we use the beginning-of-period value of **N-segment** to split into subsamples: single-segment firms (**N-segment** = 1), two-segment firms (**N-segment** = 2), three-segment firms (**N-segment** = 3), and four-or-more-segment firms (**N-segment** ≥ 4). Occasionally, we call firms in **N-segment** = 1 or 2 "less-diversified firms," and firms in **N-segment** > 3 "more-diversified firms." In the same way, we use **HHI-Segment** to split into two or four subsamples by its median or quartile values.

C. Summary of statistics

Table II provides summary statistics for the total sample and for the subsamples.[8] Column

[8] The statistics are based on firm-year observations.

(A) presents the statistics of the total sample, and column (B) presents the statistics of four subsamples. Column (A) of Table II documents that the mean (median) value of **R&D / Assets** in Japanese manufacturing firms is 0.022 (0.016), indicating that its value is considerably lower than that reflected in the US, as stated by Brown and Petersen (2011). The mean (median) values of **R&D / Assets** in US manufacturing young or mature firms during 1994 -2006 is 0.15 (0.082) or 0.05 (0.027), respectively. The mean (median) value of the ratio of physical investment to the total assets (**Investment / Assets**)[9] is 0.034 (0.027) and is about 1.5 times as large as that of **R&D / Assets** in our sample. Similar to **R&D / Assets, Investment / Assets, Tobin's Q,** and **CF / Assets** in Japanese manufacturing firms are also lower than in the US, as reported by Brown and Petersen (2011).

Insert Table II

[9] **Investment** is defined as the change of net capital stock plus the accounting depreciation in the current year.

In column (B) of Table Ⅱ, we show that the mean (median) values of **R&D / Assets** in single-segment firms, two-segment firms, three-segment firms, and four-or-more-segment firms are 0.029 (0.025), 0.023 (0.018), 0.020 (0.014), and 0.019 (0.012), indicating that **R&D / Assets** decrease as the number of business segments increases. In column (C), we provide the differences and its p-values, which we perform the rank test, of **R&D / Assets** between less-diversified and more-diversified firms or between firms with Segment = 1 and those with Segment = 4. No matter what separation standards we adopt, the difference of **R&D / Assets** is significant at 1 %. These results imply that corporate diversification leads to decreases in **R&D / Assets**. A similar pattern is more or less observed in **Investment / Assets** and **CF / Assets**. It, however, seems that, as far as **Tobin's Q** is concerned, there are no significant differences among any two subsamples.

Table Ⅱ also provides information on the firms' attributes in order to capture the characteristics of corporate diversification. These are composed of the logarithm of real total assets (**Firm Size**), the ratio of cash to the total assets (**Cash / Assets**), the debt to asset ratio (**Debt / Assets**), the cash dividend payments per equity (**Dividends / Equities**), and the ratio of shares held by various shareholders (**Large Shareholders**, **Financial Institutions**, and **Foreign Shareholders**).[10] As seen in Section Ⅱ.C, these variables are related to financial liquidity or corporate governance that is behind corporate diversification.[11,12] **Firm Size** is defined as the logarithm of total assets divided by the GDP deflator. **Cash** is defined as the sum of cash and short-term securities. **Debt** is the sum of debt in current liabilities and long-term debt. **Dividends** is calculated as the sum of any

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[10] **Equities**, **Cash**, **Debt**, **Dividend**, **Large Shareholders, Financial Institutions**, and **Foreign Shareholders** are used at the beginning of the fiscal year.

[11] Since there are various arguments about what is an appropriate measure for financial liquidity, most studies divided their sample on the basis of some standard in order to a priori classify firms into groups more or less likely to face financing constraints (e.g., Fazzari et al. (1988), Hoshi, Kashyap, and Scharfstein (1991), Ogawa and Suzuki (1998), Ogawa and Kitasaka (1999), Hatakeda (2002), Honda and Suzuki (2006), Almeid, Campello, and Weisbach (2004), Brown and Petersen (2011), and so on).

[12] Most empirical studies on US firms available from Compustat's files make use of the governance measure advocated by Gompers, Ishii, and Metrick (2003), the so-called GIM index. Unfortunately, such a comprehensive and objective measure is not available for Japanese firms.

cash dividend payments.[13] **Large Shareholders**, **Financial Institutions**, and **Foreign Shareholders** denote the ratio of shares held by the top 10 largest shareholders, domestic financial institutions, and foreign (financial) investors, respectively.

Firm Size, **Cash / Assets**, **Debt / Assets**, and **Dividends / Equities** are often utilized as one of the proxy variables for the degree of financial liquidity. In general, it seems that small-sized firms or firms with low cash ratio, high debt ratio, or low dividend payout ratio are subject to face some financial constraints or credit rationing. As seen in column (B), the mean (median) values of **Firm Size** and **Debt / Assets** increase when the number of **N-segment** increases. In column (C), the differences on the **Firm Size** and **Debt / Assets** median values between less-diversified and more-diversified firms or between firms with Segment = 1 and with Segment = 4 are statistically significant at 1 %. In contrast, the mean (median) values of **Cash / Assets** decrease as the number of **N-segment** increases and the differences of **Cash / Assets** are statistically significant at 1 %. However, the mean

[13] Cash dividends occupy the most part of total payout rather than share repurchases or stock dividends in Japanese firms. Therefore, **Dividend** can be regarded as a proxy of total payout in our study (See Hatakeda (2011)).

(median) **Dividends / Equities** values are similar irrespective of the degree of corporate diversification. Indeed there are no statistical differences across segment groups.

Regarding **Firm Size**, this finding may indicate that diversified firms are likely to be financially unconstrained firms. It is consistent with the prediction that corporate diversification enables firms to be free from financing-related difficulties through debt coinsurances and efficient internal capital markets. However, the positive relation between corporate diversification and firm size may also be explained by ideas other than financial liquidity, such as scale economies. On the other hand, the findings on **Cash / Assets** and **Debt / Assets** show that diversified firms are financially constrained firms. These findings contradict theories pertaining to corporate diversification and financial liquidity through debt coinsurances and efficient internal capital markets. These findings, however, may suggest that corporate diversification encourages the reduction of cash holdings and the increase of debts (e.g. Duchin (2010)).

Large Shareholders, **Financial Institutions**, and **Foreign Shareholders** signify the strength of corporate governance due to capital markets.[15] Since it takes time for firms to yield gains in R&D, they have to attract shareholders with a long-term time horizon in order to finance stable and long-term funds for R&D investment. We use **Large Shareholders**, **Financial Institutions**, and **Foreign Shareholders** to capture the investors' time preference for investment. Furthermore, by attracting informed shareholders with a monitoring ability such as **Financial Institutions** and **Foreign Shareholders**, firms can have an easy and stable access to capital markets. It is because the fact that firm's shares

[15] As the existence of cross-shareholders contributes to the prevention of transient shareholders from intervening the in firm's excessive management, management with long-term time horizon is possible. Cross-shareholders, however, monitor less actively than financial institutions or foreign (financial) investors, because they have an interest in maintaining a stable relationship with the customers but not in letting managers follow the demands as shareholders. In Japan, most **Large Shareholders** consist of corporate shareholders such as cross-shareholders and keirestu (See Aoki, Patrick, and Sheard (1994), Hoshi and Kashyap (2001)). **Financial Institutions** such as Japanese commercial banks and insurance companies may be cross-shareholders and keirestu. However, some financial institutions, especially, foreign financial investors (**Foreign Shareholders**) have an interest in acquiring dividends and capital gains, so that they have an incentive to monitor the firm's management aggressively.

are held by the informed shareholders can implicitly implies that the firm has no asymmetric information or agency problems.

In Table Ⅱ, we see that diversified firms are likely to have low **Large Shareholders** and high **Financial Institutions** as shareholders. Hence, it seems that diversified firms have shareholders with a short-term time horizon; however, they have shareholders with a superior monitoring ability. In column (B), the mean (median) value of **Large Shareholders** decreases as the number of **N-segment** increases. The differences on the **Large Shareholders** values are statistically significant at 1 % in any cases. On the other hand, the mean (median) value of **Financial Institutions** increases with the number of **N-segment**. The differences of **Financial Institutions** are statistically significant at 1 % in any cases. However, the value of **Foreign Shareholders** is ambiguous. The difference between less-diversified firms and more-diversified firms is significantly negative, while the difference between firms with **Segment = 1** and with **Segment = 4** is significantly positive.

V. Results

A. Main results

Table Ⅲ provides estimates of dynamic R&D regression (Eq. (4)) for total samples and for two types of subsamples according to the degree of corporate diversification. In the total regression of the sample (column (A)), the coefficient on **lagged R&D / Assets** is positive and significant at 1 %. The coefficient on **lagged R&D / Assets** indicates that the speed of adjustment (SOA) is 0.507 (= 1 - 0.493). It appears that average firms in Japanese manufacturing industries tend to smooth the path of R&D investment. The coefficient on current **Tobin's Q** is positive and insignificant, the coefficient for **lagged Tobin's Q** is negative and significant, and the steady-state effect of Tobin's Q on R&D investment is -0.007 (= (0.002 -0.005) / (1 - 0.493)), of which the Wald test (see the bottom of table) does not reject the null hypothesis that the effect is equal to zero. The low value of the effect indicates that the marginal adjustment costs of R&D investment may be very expensive. In contrast, the coefficient on **CF / Assets** is positive and significant, wherein the steady-state effect of cash flow on R&D investment is 0.055 (= 0.028 / (1 - 0.493)). The Wald test of the cash flow effect rejects the null hypothesis that the effect is equal to zero, indicating that high cash flow leads to an increase in R&D investment. The results showing that the explanatory power of Tobin's Q is poor and that the coefficient on cash flow ratio is significant are consistent with Brown, *et al.* (2009) and Brown and Petersen (2011). These are also common empirical results on the literature about physical investment (e.g., Fazzari *et al.* (1988), Hayashi and Inoue (1991), Ogawa and Kitasaka (1999), and others). The model specification is appropriate, judging from the Hansen's J test for over-identifying restrictions and the Arellano and Bond's M 2 test for second-order autocorrelation in the first-differenced residuals. Finally, the joint zero test of yearly dummies is rejected, given a statistical significance of 1%.

Insert Table III

The columns (B) and (C) of Table III provide estimates for more-diversified firms

(**N-Segment** > 2) and less-diversified firms (**N-Segment** ≤ 2) and for more-diversified firms (**HHI-Segment** ≤ 0.7) and less-diversified firms (**HHI-Segment** > 0.7). The coefficients on **lagged R&D / Assets** in more-diversified firms are 0.146 in Panel B and 0.149 in Panel C, and both coefficients are insignificant. In contrast, the coefficients on **lagged R&D / Assets** in less-diversified firms are 0.450 in column (B) and 0.563 in column (C), and both are statistically significant at 1 %. In both columns, the coefficient on **lagged R&D / Assets** in less-diversified firms is more than three times as that of more-diversified firms. Empirical results indicate that less-diversified firms can smooth R&D investment but more-diversified firms cannot. Hence, we can conclude that the evidence supports the hypothesis: H1-b in Section Ⅲ.B. The steady state effects of Tobin's Q and cash flow are positive and significant in more-diversified firms. On the other hand, the steady state effects of Tobin's Q are negative and insignificant, while the coefficients on **CF / Assets** are significant in less-diversified firms. Finally, these models are appropriate irrespective of subsamples.

In order to obtain more solid confidence, we estimate for parts broken into degrees of corporate diversification. Table Ⅳ A and B provide estimates through the **N-Segment** (**N-Segment** = 1, **N-Segment** = 2, **N-Segment** = 3 and **N-Segment** ≥ 4) or the quartiles of the **HHI-segment** (the first quartile, the second quartile, the third quartile, and the fourth quartile groups). The coefficients on **lagged R&D / Assets** are positive and significant in **N-Segment** = 1 and 2 in Panel A and in the third and fourth quartiles in Panel B. On the other hand, the coefficients on **lagged R&D / Assets** are positive and insignificant in **N-Segment** = 3 and ≥ 4 and they are negative and insignificant in the first and second quartiles.

To summarize, the results in Panel A and B of Table Ⅳ are almost analogous to those in Table Ⅲ. That is, our results indicate that less-diversified firms tend to smooth R&D investment while more-diversified firms cannot smooth R&D investment. Thus, these results are supportive of the first prediction P1-b, or the hypothesis H1-b. This indicates that corporate diversification would make firms unable to finance R&D expenditures through debt coinsurance and efficient internal capital markets.

Insert Table IV

It is not necessarily surprising that our evidence does not support the claimed advantages of corporate diversification. Some studies cast doubt on corporate diversification from different viewpoints. For example, Lang and Stulz (1994), Berger and Ofek (1995), Lins and Servaes (1999), and others provide evidence that corporate diversification destroys firm value – a "diversification discount." Our evidence may support the view that "diversification discount" has been going on in Japanese manufacturing industries since the 2000s.

However, our results do not necessarily deny the benefits of corporate diversification. Among less-diversified firms, quite diversified firms (**N-Segment** = 2 or the third quartile) tend to have a larger smoothing effect than stand-alone firms or more concentrated firms (**N-Segment = 1** or the fourth quartile). Thus, this suggests the possibility that, as long as corporate diversification is moderate, corporate diversification contributes to R&D smoothing.

B. Sample splits due to financial liquidity

Next, we look into the underlying causes behind the results in Table Ⅲ and Table Ⅳ. As already seen in Table Ⅱ, we found that more-diversified firms have low cash ratio, and high debt ratio, although they are large-sized firms relative to less-diversified firms. To sum these findings in Table Ⅱ and the results in Table Ⅲ and Table Ⅳ, more-diversified firms cannot smooth R&D investment because corporate diversification tightens firms' financial liquidity. In this respect, it is necessary for us to examine whether or not a firm's financial liquidity contribute to the smoothness of R&D investment.

We focus on financial liquidity in place of corporate diversification to estimate the effect of it on the smoothness of R&D investment. Following the previous studies, we split our sample into two subsamples according to some proxy variables for firms' financial liquidity: **Firm Size**, **Cash / Assets**, **Debt / Assets**, and **Dividends / Equities**. These variables are popularly utilized as proxies in various researches. We, thereby, treat these variables as criterion variables for financial liquidity.

When splitting the sample into two subsamples by using these criterion variables, we have to clearly define what percentile of our sample should be divided. For each criterion variable, we obey a rule to determine the percentile to divide our sample. First, we calculate the sum of the Hansen's J tests for two subsamples divided by each five-stride percentile from the 25th percentile to the 75th percentile. Second, we choose the percentile with the minimum value as the appropriate percentile (threshold point) of the variable.

Table V reports the appropriate percentile selected through the above procedure in each proxy variable. The appropriate percentile for **Firm Size**, **Cash / Assets**, **Debt / Assets**, or **Dividends / Equities** is 25th, 65th, 40th, or 35th, respectively. As far as **Firm size** is concerned, three fourths of our sample consist of large-size firms because our sample has already been collected from publicly listed firms. Based on the percentile of each variable, we divide our sample into two subsamples and report the estimation results in each subsample.

Insert Table V

In Table VI, we consider the estimation results for the two subsamples depending on criterion variables for financial liquidity. The results for the **Firm Size** partition show that the coefficients on **lagged R&D / Assets** are positive and significant irrespective of subsamples. The coefficient in large-sized firms, with a value of 0.490, is a little larger than that in small-sized firms, the value of which is 0.339. The results for the **Cash / Assets** and the **Debt / Assets** partitions are remarkable. The coefficient on **lagged R&D / Assets** in firms with low cash holdings is positive but insignificant – that is, 0.118, while that in firms with high cash holdings is positive and significant at 1% level – that is, 0.461. The magnitude of the coefficient in firms with high cash holdings is about four times as large as that in firms with low cash holdings. Similarly, the coefficient on **lagged R&D / Assets** in firms with low debt ratio is positive and significant at 1% level – that is, 0.431, while the coefficient in firms with high debt ratio is insignificant – that is, 0.235. The magnitude of the coefficient in the former firms is about twice as large as that in the latter firms. Finally, the results for the **Dividends / Equities** partition show that the coefficients on **lagged R&D / Assets** are positive and significant irrespective of subsamples. The coefficient in firms with high **Dividends / Equities** is about twice as large as that in firms with low **Dividends / Equities**.

Insert Table VI

These results approximately indicate that financially unconstrained firms attempt to smooth R&D investment while financially constrained firms cannot smooth R&D investment, which is consistent with our prediction P2, or the hypothesis H2.

C. Sample splits due to share ownership structure

Following the similar approach on the effect of financial liquidity, we also look into the effect of share ownership structure on the smoothness of R&D investment. In order to smooth R&D investment, firms are required to have shareholders with long-term horizon or with a monitoring ability. Similar to the approach in Section Ⅴ. B, we split our sample into two subsamples by using shareholder ownership ratios on which we focus on the following as criterion variables: **Large Shareholders**, **Financial Shareholders**, and **Foreign Shareholders.** And then we apply the GMM estimation in each subsample. In Table Ⅴ, we show the appropriate percentile selected in these three variables. The appropriate percentiles for **Large Shareholders**, **Financial Shareholders**, and **Foreign Shareholders** are 65th, 70th, and 65th, respectively.

Table Ⅶ provides estimates for the three types of subsamples. The results for the **Large Shareholders** partition show that the coefficients on **lagged R&D / Assets** are positive and significant in firms with both high and low large shareholders ratios. The coefficient in firms with high large shareholders ratio is higher than that in firms with low large shareholder ratio, but it appears that the coefficient difference is not so large. In the same way, the coefficients on **lagged R&D / Assets** for the **Financial Shareholders**, or the **Foreign Shareholders** are positive and significant in any subsample, but the coefficient on

lagged R&D / Assets in firms with high **Financial Shareholders** is marginally significant. The coefficients on **lagged R&D / Assets** in firms with low **Financial Shareholders** or **Foreign Shareholders** are almost the same as the coefficients in firms with high **Financial Shareholders** or **Foreign Shareholders**.

Insert Table Ⅶ

To summarize, these results suggest that the smoothness of R&D investment is observed even if firms are categorized according to the type of shareholders. These results are not consistent with prediction P3 or hypothesis H3. Although firms held by shareholders with long-term horizon more or less have a tendency to smooth R&D investment, the existence of shareholders with monitoring ability does not lead firms to smooth R&D investment.

Judging from the results in Table Ⅲ, Table Ⅳ, and Table Ⅵ, we can conclude that more diversified firms are likely to be financially constrained firms. From the results in

Table Ⅶ, on the other hand, we can insist that corporate diversification is unrelated to share ownership structure in Japan.

VI. Does Corporate Diversification Deteriorate Financial Liquidity?

In Section Ⅴ, we concluded that more diversified firms are likely to be financially constrained firms, and therefore they cannot smooth R&D investment. In this section, we will investigate the possibility that corporate diversification deteriorates firm's financial liquidity. Using the subsamples in Section Ⅴ. B, that is, financially constrained firms and financially unconstrained firms, we directly examine the effect of corporate diversification on smoothing R&D investment in each subsample. If corporate diversification contributes to increase the financial liquidity, the R&D smoothing effect of corporate diversification is more likely to be observed in financially constrained firms, while it is less likely to be observed in financially unconstrained firms. On the other hand, if corporate diversification deteriorates firm's financial liquidity, the off-smoothing effect of corporate diversification is more likely to be observed in financially unconstrained firms.

In order to examine this possibility, we explicitly presume that corporate diversification directly has a linear relation to the SOA in the dynamic R&D model, Eq. (2), that is α.

$$\alpha = \alpha_0 + \alpha_1 \mathrm{D(DIV)}_{i,t-1} \tag{5}$$

where $\mathrm{D(DIV)}_{i,t-1}$ denotes the degree of corporate diversification as of the previous year. The large value of $\mathrm{D(DIV)}_{i,t-1}$ implies that the firm's segments are diversified. α_0 and α_1 are parameters. In particular, α_1 denotes the marginal effect of corporate diversification on SOA. If α_1 has a negative (positive) value, corporate diversification will lead to decrease (increase) the SOA. In other words, it means that corporate diversification encourages (discourages) firms to smooth R&D investment.

Using Eq. (5), we can rewrite Eq. (4) as follows:

$\mathrm{R\&}D_{i,t}/\mathrm{Assets}_{i,t-1}$

$$
\begin{aligned}
= \ & \delta_1 \text{Tobin's } Q_{it} + \delta_2 \text{Tobin's } Q_{it-1} + \delta_3 \ CF_{i,t-1}/Assets_{i,t-1} + \delta_4 R\&D_{i,t-1}/Assets_{i,t-2} \\
& + \delta_5 D(DIV)_{it-1} \cdot \text{Tobin's } Q_{it} + \delta_6 D(DIV)_{it-1} \cdot \text{Tobin's } Q_{it-1} + \delta_7 \ D(DIV)_{it-1} \cdot CF_{i,t-1}/Assets_{i,t-1} \\
& + \ \delta_8 D(DIV)_{it-1} \cdot R\&D_{i,t-1}/Assets_{i,t-2} + \ \textstyle\sum_t^T \theta_t YD_t + \mu_i + u_{it} \qquad (6)
\end{aligned}
$$

where δ_i for $i = 1, \cdots, 8$ and θ_t are parameters to be estimated. The parameter on which we focus is the coefficient on δ_8 $(= -\alpha_1)$ in order to examine the marginal effect of corporate diversification on SOA. If corporate diversification leads to increase the smoothness of R&D investment, δ_8 should have a positive value. We, in particular, expect that this positive effect is more remarkable in financially constrained firms than that in financially unconstrained firms under the situation that debt coinsurance or efficient internal capital markets is effective. On the other hand, we expect that, if corporate diversification deteriorates R&D smoothing, δ_8 should have a negative value. We, in particular, expect that this positive effect is more remarkable in financially unconstrained firms.

Using **N-Segment** or **HHI-Segment**, we define two types of D(DIV)s, which denote whether or not firms are more diversified:

$$D(DIV)_{i,t-1} = \begin{cases} 0 & \text{if N} - \text{Segment}_{i,t-1} < 2 \\ 1 & \text{if N} - \text{Segment}_{i,t-1} \geq 2 \end{cases} \tag{7}$$

or

$$D(DIV)_{i,t-1} = \begin{cases} 0 & \text{if HHI} - \text{Segment}_{i,t-1} > 0.7 \\ 1 & \text{if HHI} - \text{Segment}_{i,t-1} \leq 0.7 \end{cases} \tag{8}$$

The above thresholds are the same as the ones used in Table Ⅲ. Besides, in splitting the sample into two subsamples, we use the percentile reported in Table Ⅴ. Thus, the threshold percentile for **Firm Size**, **Cash / Assets**, **Debt / Assets**, or **Dividends / Equities** is 25th, 65th, 40th, or 35th, respectively. We estimate Eq. (6) with the GMM estimation in each subsample. We now use the **lagged** $\mathbf{R\&D_{i,t}/Assets_{i,t-1}}$ dated t-2 to t-5, the $\mathbf{Tobin's\ Q_{it}}$ dated t-2 to t-3, the $\mathbf{CF_{i,t-1}/Assets_{i,t-1}}$, the $\mathbf{D(DIV)_{it-1}}$ · **lagged** $\mathbf{R\&D_{i,t}/Assets_{i,t-1}}$ dated t-2 to t-5, the $\mathbf{D(DIV)_{it-1} \cdot Tobin's\ Q_{it}}$ dated t-2 to t-3, the $\mathbf{D(DIV)_{it-1} \cdot CF_{i,t-1}/Assets_{i,t-1}}$, and yearly dummies as instrumental variables.

Table Ⅷ provides estimates for three types of subsamples. Panel A presents estimates for **D(DIV)**, based the degree of corporate diversification on **N-Segment**, while Panel B presents estimates for **D(DIV)** on **HHI-Segment**. Both coefficients on **lagged R&D / Assets** reported in Panel A and Panel B are similar to those on **lagged R&D / Assets** in Table VI. Its coefficients are statistically significant at 1% level or 5% in both low- and high- **Firm Size**, high- **Cash / Assets**, low- **Debt / Assets**, and high- **Dividends / Equities**. In Panel A, all of the coefficients on **D(DIV) × Lagged R&D / Assets** indicate a negative sign, and its coefficients in high- **Cash / Assets** and low- **Debt / Assets** are significant at 5% level (the coefficient in high- **Dividends / Equities** is significant in high at 10% level). These suggest that corporate diversification makes it difficult for financially unconstrained firms to smooth R&D investment. Similar results are obtained in Panel B, though some of coefficients are a little lack of clarity. In seven out of eight subsamples, however, the coefficients on **D(DIV) × Lagged R&D / Assets** have a negative sign, and its coefficients in low- **Debt / Assets** and low- **Dividends / Equities** are significant at 5% level.

Except for **D(DIV) × Lagged R&D / Assets**, all of the coefficients on **D(DIV) × Tobin's Q**, **D(DIV) × Lagged Tobin's Q**, and **D(DIV) × Lagged Cash Flow / Assets** are insignificant in all subsamples in Panel A. In Panel B, most of coefficients except for some are also insignificant.

Insert Table Ⅷ

To sum, the above results suggest that corporate diversification in financially constrained firms does not lead to the improvement in the smoothness of R&D investment. In some cases, if anything, we can observe that corporate diversification in financially unconstrained firms should deteriorate the smoothness of R&D investment. More-diversified firms have low cash ratio and high debt ratio, even if they are large-sized (See Table Ⅱ). It, therefore, seems that corporate diversification reduces a firm's financial liquidity.

VII. Smoothness Path of Physical Investment and Cash Holding

Finally, we consider whether the effect of corporate diversification is related to the smoothness of physical investment or cash holdings with a specification that mirrors Eq. (4). Similar to R&D investment, we apply Eq. (4) with physical investment or cash holdings for GMM estimation in more-diversified firms and less-diversified firms. Before performing our estimation, we trim the data by deleting the observations above the 99th percentile for physical investment or cash holdings in place of R&D expenditures, divided by total assets at the beginning of the year, which are dependent variables (**Investment / Assets** or **Cash / Assets**).

Table IX provides estimates of dynamic physical investment regression for two types of subsamples according to the degree of corporate diversification. Similar to results for R&D investment, the coefficient on **lagged Investment / Assets** in less-diversified firms is positive and significant at 1 % irrespective of diversification measures, while its value is insignificant in more-diversified firms irrespective of diversification measures. This indicates that less-diversified firms are likely to smooth physical investment. Thus, it seems that our discussion so far is true of physical investment. However, it is worth noting that the SOA of physical investment is smaller than that of R&D investment. The SOA of physical investment in less-diversified firms is 0.85 (= 1 − 0.15), based on **N-Segment**, or 0.82, based on **N-Segment**, while the SOA of R&D investment is 0.450 or 0.563, which are shown in Table III. This is because physical investment is not required to be so consecutive and stable expenses as R&D investment. In addition, the steady state effect of Tobin's Q lies in a range between 0.08 and 0.13 and is significant at 1% in all subsamples. The steady state effect of cash flow lies in a range between 0.16 and 0.24 and is also significant at 1% in all subsamples. These effects on physical investment are much larger than those on R&D investment. These are consistent with the assertion that R&D investment, in general, has high marginal adjustment costs because the coefficient(s) on Tobin's Q is the inverse of the marginal adjustment costs (See Gilchrist and Himmelberg (1995)).

Insert Table IX

Table X provides estimates of dynamic cash holdings regression. In contrast to results for R&D investment and physical investment, the coefficient on **lagged Cash / Assets** is positive and significant in all subsamples while its magnitude in more-diversified firms is a little larger than in less-diversified firms. As far as **Cash / Assets** are concerned, all firms are more or less likely to smooth cash holdings. However, more-diversified firms are more likely to smooth cash holdings. Using the **HHI-Segment**, its coefficient on **lagged Cash / Assets** in highly diversified firms is twice as large as that in less-diversified firms. However, the SOA of cash holdings is smaller than that of R&D investment but larger than that of physical investment. Finally, the steady state effect of Tobin's Q lies in a range between 0.08 and 0.10 and is significant at 1% in all subsamples, while the steady state effect of cash flow is insignificant in all subsamples.

Insert Table X

VIII. Conclusion[16]

[16] The findings we presented are robust to the results of some alternative estimates. In particular, we re-estimated Eq. (4) using two-step GMM. Though the two-step estimator is more efficient relative to a one-step GMM, the standard errors from the two-step GMM are

Recently, R&D investment in Japanese manufacturing firms has been increasing gradually and the total sum of R&D expenditure has been close to the total sum of physical investment. Unlike physical investment, R&D investment requires to be consecutive and stable expenses for some periods in order to obtain the fruits of the project. Therefore, in general, firms attempt to smooth R&D investment as much as possible. In addition, firms are likely to be subject to some financial constraints in raising funds for R&D projects. Financial constraints make it difficult for firms to smooth R&D investment.

We paid attention into the role of corporate diversification. When debt coinsurance and efficient internal capital markets work well, corporate diversification loosen the firm's financial constraints and then encourage firms to invest in profitable projects. Our paper,

downward biased in small samples (e.g., Arellano and Bond (1991)). We address this downward bias by employing the finite-sample correction suggested by Windmeijer (2005). The two-step estimates are very similar in almost all respects to the results in all tables. In particular, we continue to find strong evidence of smoothing with R&D investment for financially constrained firms divided by **Firm Size**.

therefore, explored the effect of corporate diversification on R&D smoothing using panel data for publicly traded Japanese manufacturing firms over the period of 2001 to 2009.

One of the interesting points in our paper is our attempt to approach R&D smoothness from the angle of corporate diversification. We utilized information on the firms' business segments reported by them to segregate our sample into two subsamples: more-diversified firms and less-diversified firms. By comparing the speed of adjustment (SOA) in the dynamic R&D investment regression across subsamples, we can know the effect of corporate diversification on R&D investment. We showed evidence that less-diversified firms are more likely to smooth R&D irrespective of diversification measures.

In order to clarify the causes behind the above result, we paid attention to the relationship between corporate diversification and financial liquidity or between corporate diversification and share ownership structure. Our results showed that financially unconstrained firms are likely to smooth R&D investment but that share ownership structure does not characterize the smoothness of R&D investment. This evidence implies that corporate diversification is negatively related to financial liquidity. Furthermore, we examined an effect of corporate diversification on smoothing R&D investment in financial constrained firms and in financial unconstrained firms. However, we could not show the evidence that corporate diversification improves firm's financial liquidity in both types of firms, in particular, financial constrained firms. Rather, we showed evidence that corporate diversification deteriorated the financial liquidity of the financially unconstrained firms in our sample.

In general, we expect that corporate diversification has advantages in raising funds through debt coinsurance and efficient internal capital markets. Our results cast doubt on the effectiveness of corporate diversification in smoothing R&D investment. Rather, Japanese diversified firms may exhaust corporate liquidity through diversifying their business segments, so that they may not afford to preserve the large volume of R&D expenditures required. In other words, corporate diversification deteriorates financial liquidity, even for firms with high financial liquidity. This may be consistent with the assertions of Lang and Stulz (1994), Berger and Ofek (1995), Lins and Servaes (1999), and others on "diversification discount."

There are a number of studies about internal capital markets in corporate diversification. Some of the reasons why internal capital markets do not work efficiently are agency problems between managers and shareholders (Jensen (1986), Stulz (1990), Shleifer and Vishny (1989)) and rent-seeking activity as forms of power struggle within a firm (Scharfstein (1998), Stein (2000), and Rajan *et al.* (2000)). Unfortunately, our study does not treat these issues more directly. These are subjects for future research.

Data Appendix: Variable Definitions

Most of variables needed for our empirical analysis are constructed from databases contained in the *Nikkei NEEDS-Financial Quest* 's *Corporate Financials Database*, the *Corporate Attribute Database*, and *Segment Database*. With regard to share prices, we use the close prices in a firm's settlement term in the *Nikkei Needs Portfolio Master's*

Database.

[1] **N-Segment** : Number of business segments reported by each firm. Segment classification is based on the first two numbers of 4-digit segment code at the beginning of period t.

[2] **HHI-Segment** : Herfindahl-Hirschman index calculated on the basis of the ratio of segment assets to total assets.

[3] **R&D / Assets** : Research and development expenses in period t, divided by the book value of total assets at the beginning of period t.

[4] **Investment / Assets** : The change of net capital stock plus the accounting depreciation in period t, divided by the book value of total assets at the beginning of period t.

[5] **Tobin's Q** : Market value of assets at the end of period t divided by the book value of total assets at the beginning of period t, where market value of assets is equal to the market value of equity (the total number of outstanding shares of common stock multiplied by the share price at the end of period t) plus the book value of assets minus

the book value of equity.

[6] **CF / Assets** : Sum of before-tax operating income, interest receivable and discount premium, interest on securities, and depreciation expense and amortization in period t-1, divided by the book value of total assets at the beginning of period t.

[7] **Firm size** : Natural logarithm of the book value of total assets at the beginning of period t, divided by the GDP deflator at period t.

[8] **Cash / Assets** : Cash and short-term securities at the beginning of period t, divided by the book value of total assets at the beginning of period t.

[9] **Debt / Assets** : Sum of debt in current liabilities and long-term debt at the beginning of period t, divided by the book value of total assets at the beginning of period t.

[10] **Dividends / Equities** : Sum of any cash dividend payments at the period t -1, divided by the book value of equities at the beginning of period t.

[11] **Large Shareholders** : Number of shares held by the top 10 largest shareholders at the beginning of period t, divided the number of total shares at the beginning of period t.

[12] **Financial Institutions**：Number of shares held by domestic financial institutions at the beginning of period t, divided the number of total shares at the beginning of period t.

[13] **Foreign Shareholders**：Number of shares held by foreign (financial) investors at the beginning of period t, divided the number of total shares at the beginning of period t.

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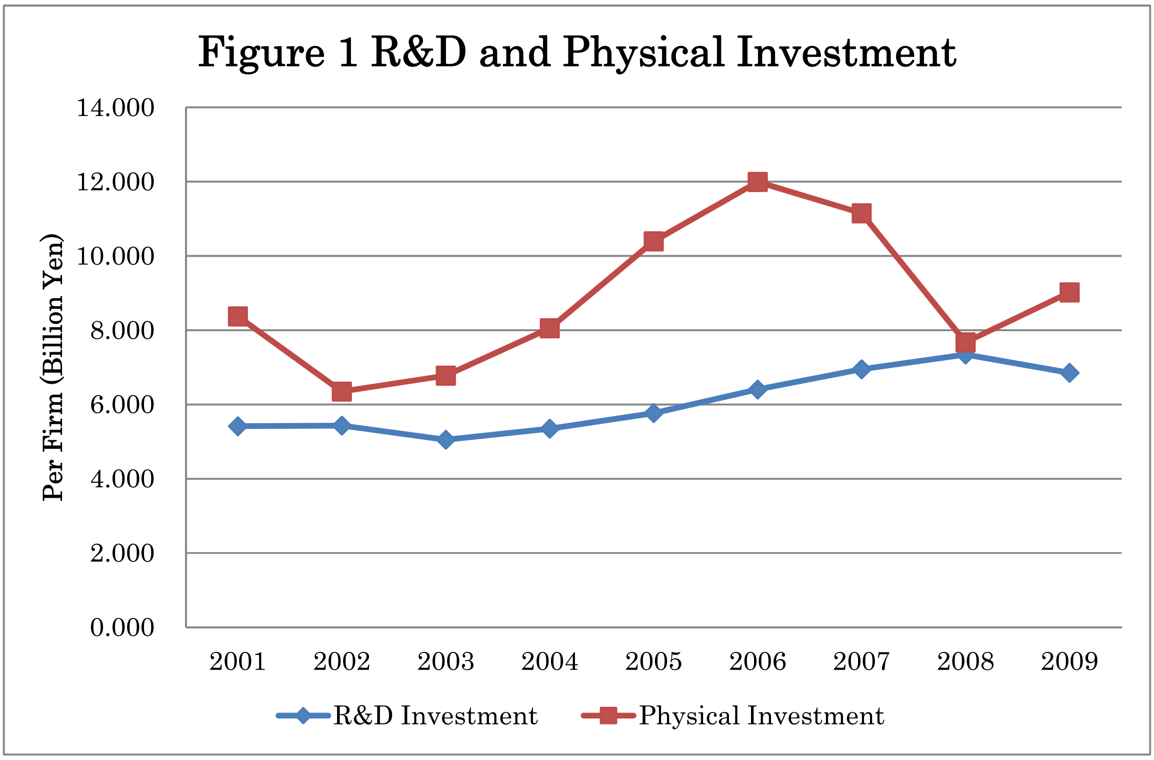
Figure 1 R&D and Physical Investment
Per Firm (Billion Yen)
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
2001
2002
2003
2004
2005
2006
2007
2008
2009
R&D Investment
Physical Investment

Table I Characteristics of Corporate Diversificatin Measures

Panel A: Distribution				
N-Segment		HHI-Segment		
Number	Observations	Mean	Median	S.D
1	901	1.000	1.000	0.000
2	2,995	0.749	0.767	0.153
3	2,135	0.591	0.567	0.155
4	727	0.447	0.413	0.129
5	204	0.389	0.370	0.120
6	80	0.360	0.299	0.161
7	21	0.516	0.285	0.301
8	3	0.241	0.263	0.040
Total	7,066	0.686	0.685	0.216

Notes: N-segment denotes the number of business segments reported by each firm. Segment classification is based on the first two numbers of 4-digit segment code. HHI-segment is Herfindahl-Hirschman index calculated on the basis of the ratio of segment assets to total assets.

Panel B: Correlation Coefficients		
	N-Segment	HHI-Segment
N-Segement	1.000	
HHI-Segment	-0.720 ***	1.000

Notes: Significance at 1%, 5%, and 10% is denoted with ***,**, and *, respectively.

Panel C: Time Series				
Fiscal Year	Observations	N-Segment		
		Mean	Median	S.D
2001	805	2.493	2.000	1.009
2002	800	2.533	2.000	1.042
2003	784	2.522	2.000	1.042
2004	788	2.524	2.000	1.054
2005	791	2.512	2.000	1.041
2006	784	2.546	2.000	1.064
2007	779	2.538	2.000	1.058
2008	773	2.545	2.000	1.053
2009	762	2.558	2.000	1.043
Total	7066	2.530	2.000	1.045
Fiscal Year	Observations	HHI-Segment		
		Mean	Median	S.D
2001	805	0.679	0.674	0.217
2002	800	0.677	0.667	0.217
2003	784	0.679	0.673	0.217
2004	788	0.683	0.680	0.216
2005	791	0.687	0.684	0.216
2006	784	0.689	0.690	0.217
2007	779	0.695	0.705	0.216
2008	773	0.697	0.699	0.213
2009	762	0.693	0.699	0.214
Total	7066	0.686	0.685	0.216

Table II Summary of Statistics

N-Segment		(A) Total Sample	(B) Less-diversified N-segment = 1	(B) Less-diversified N-segment = 2	(B) More-diversified N-segment = 3	(B) More-diversified N-segment ≥ 3	(C) Difference LD v.s MD		(C) Difference = 1 v.s ≥ 3	
R&D / Assets	Mean	0.022	0.029	0.023	0.020	0.019				
	Median	0.016	0.025	0.018	0.014	0.012	0.006	***	0.013	***
	S.D	0.020	0.022	0.020	0.019	0.019				
Investment / Assets	Mean	0.034	0.036	0.036	0.033	0.032				
	Median	0.027	0.028	0.028	0.026	0.028	0.002	***	0.000	
	S.D	0.039	0.032	0.042	0.037	0.039				
Tobin's Q	Mean	1.070	1.112	1.062	1.050	1.097				
	Median	0.979	1.008	0.966	0.971	1.017	-0.009		-0.010	
	S.D	0.427	0.418	0.435	0.414	0.437				
CF / Assets	Mean	0.081	0.089	0.081	0.078	0.081				
	Median	0.078	0.085	0.077	0.075	0.077	0.003	**	0.007	***
	S.D	0.050	0.049	0.052	0.047	0.049				
Firm Size	Mean	11.327	11.174	11.081	11.412	11.965				
	Median	11.117	10.913	10.956	11.091	11.773	-0.386	***	-0.860	***
	S.D	1.396	1.263	1.275	1.431	1.527				
Cash / Assets	Mean	0.123	0.131	0.127	0.121	0.107				
	Median	0.100	0.104	0.103	0.103	0.080	0.008	***	0.024	***
	S.D	0.093	0.104	0.093	0.086	0.093				
Debt / Assets	Mean	0.549	0.527	0.529	0.557	0.604				
	Median	0.562	0.533	0.545	0.565	0.612	-0.042	***	-0.080	***
	S.D	0.190	0.200	0.198	0.183	0.161				
Dividends / Equities	Mean	0.014	0.014	0.014	0.015	0.014				
	Median	0.014	0.014	0.014	0.014	0.014	0.000		0.000	
	S.D	0.011	0.009	0.010	0.011	0.011				
Large Shareholders	Mean	0.179	0.195	0.185	0.175	0.159				
	Median	0.163	0.181	0.174	0.158	0.144	0.022	***	0.037	***
	S.D	0.084	0.091	0.083	0.084	0.076				
Financial Institutions	Mean	0.108	0.104	0.101	0.110	0.126				
	Median	0.093	0.093	0.083	0.097	0.113	-0.016	***	-0.021	***
	S.D	0.071	0.068	0.072	0.069	0.071				

Table II Summary of Statistics Continued).

N-Segment		(A) Total Sample	(B) Less-diversified N-segment = 1	(B) Less-diversified N-segment = 2	(B) More-diversified N-segment = 3	(B) More-diversified N-segment ≥ 3	(C) Difference LD v.s MD		(C) Difference = 1 v.s ≥ 3	
Foreign Shareholders	Mean	0.037	0.038	0.034	0.037	0.043				
	Median	0.018	0.018	0.015	0.017	0.030	-0.006	***	0.008	***
	S.D	0.051	0.051	0.051	0.056	0.043				
Observations		6,532	805	2,731	2,021	975				

Notes: Four subsamples are divided into by the number of N-segment as of the beginning of the fiscal year. The column (A) presents the statistics for the total sample, and the column (B) presents the statistics for four subsamples: single-segment firms (N-segment = 1), two-segment firms (N-segment = 2), three-segment firms (N-segment = 3), and four-or-more-segment firms (N-segment ≥ 4). The statistics are based on firm-year observations. R&D/Assets denotes research and development expenses in period t, divided by the book value of total assets at the beginning of period t. Investment/Assets denotes the change of net capital stock plus the accounting depreciation in period t, divided by the book value of total assets at the beginning of period t. Tobin's Q denotes the market value of assets at the end of period t, divided by the book value of total assets at the beginning of period t. CF/Assets denotes the sum of before-tax operating income, interest receivable and discount premium, interest on securities, and depreciation expense and amortization divided by the book value of total assets at the beginning of period t. Firm size denotes the natural logarithm of the book value of total assets at the beginning of period t, divided by the GDP deflator at period t. Cash/Assets denotes cash and short-term securities divided by the book value of total assets at the beginning of period t. Debt/Assets denotes the sum of debt in current liabilities and long-term debt divided by the book value of total assets at the beginning of period t. Dividends/Equities denotes the sum of any cash dividend payments divided by the book value of equities at the beginning of period t. Large Shareholders, Financial Institutions and Foreign Shareholders denote the number of shares held by the top 10 largest shareholders, the number of shares held by domestic financial institutions divided the number of total shares, and foreign (financial) investors divided the number of total shares at the beginning of period t. Difference in the column (C) denotes the difference of median among two subsapmles and the signicicance of the runk-sum test: Less-diversified firms v.s More-diversified firms or N-Segment = 1 v.s N-Segment ≥ 4. Significance at 1%, 5%, and 10% is denoted with ***,**, and *, respectively.

Table III Result for Dynamic R&D Regressions: Corporate Diversification

Variable	(A)		(B)				(C)			
			Diversification Measure: N-segment				Diversification Measure: HHI-segment			
	Total sample		More-diversified > 2		Less-diversified ≤ 2		More-diversified < 0.70		Less-diversified ≥ 0.70	
Lagged R&D / Assets	0.493	***	0.146		0.450	***	0.149		0.563	***
	(0.150)		(0.115)		(0.153)		(0.117)		(0.196)	
Tobin's Q	0.002		0.008	***	-0.001		0.007	***	0.000	
	(0.003)		(0.002)		(0.004)		(0.002)		(0.004)	
Lagged Tobin's Q	-0.005	***	0.000		-0.005	**	-0.002		-0.007	**
	(0.002)		(0.002)		(0.002)		(0.002)		(0.003)	
Lagged Cash Flow / Assets	0.028	***	0.019	***	0.024	***	0.026	***	0.023	***
	(0.006)		(0.005)		(0.009)		(0.006)		(0.009)	
Steady State Effects										
Sum of Tobin's Q / (1 - Lagged R&D / Assets)	-0.007		0.009	***	-0.011		0.006	**	-0.014	
CF / Assets / (1 - Lagged R&D / Assets)	0.055	***	0.023	***	0.043	**	0.031	***	0.053	
Model Specification										
Yearly Dummies [p-value]	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
Hansen's J test [p-value]	0.145		0.217		0.697		0.127		0.414	
M test for AR(2) in first differences [p-value]	0.548		0.109		0.485		0.139		0.412	
Observations	6373		2932		3441		3352		3021	

Note: Using Arellano and Bond's (1991) estimation techique, we estimate Eq. (4) for each sample. One-step GMM coefficient estimates and standard errors are reported in the tables. Standard errors are in parentheses. Standard errors are robust to heteroskedasticity. Yearly dummies are included in all regressions. Significance at 1%, 5%, and 10% is denoted with ***,**, and *, respectively.

Table IV Result for Dynamic R&D Regressions: Corporate Diversification

Panel A:	Diversification Measure: N-Segment							
Variable	≥ 4		= 3		= 2		= 1	
Lagged R&D / Assets	0.132		0.026		0.466	**	0.281	**
	(0.136)		(0.160)		(0.190)		(0.129)	
Tobin's Q	0.006	**	0.009	***	0.002		0.004	
	(0.003)		(0.002)		(0.003)		(0.004)	
Lagged Tobin's Q	0.002		-0.001		-0.003		-0.007	**
	(0.002)		(0.002)		(0.002)		(0.003)	
Lagged Cash Flow / Assets	0.023	**	0.015	**	0.020	**	0.040	***
	(0.010)		(0.007)		(0.008)		(0.013)	
Steady State Effects								
Sum of Tobin's Q / (1 - Lagged R&D / Assets)	0.009	**	0.008	***	-0.002		-0.005	
CF / Assets / (1 - Lagged R&D / Assets)	0.026	**	0.016	*	0.037	*	0.055	**
Model Specification								
Yearly Dummies [p-value]	0.272		0.011	**	0.001	***	0.006	***
Hansen's J test [p-value]	0.586		0.133		0.525		0.106	
M test for AR(2) in first differences [p-value]	0.221		0.205		0.643		0.080	*
Observations	957		1975		2660		781	

Table IV Result for Dynamic R&D Regressions: Corporate Diversification (Continued).

Panel B:	Diversification Measure: HHI-Segment							
Variable	The first		The second		The third		The fourth	
Lagged R&D / Assets	-0.182		0.000		0.670	**	0.400	***
	(0.164)		(0.266)		(0.333)		(0.126)	
Tobin's Q	0.008	***	0.005	*	0.002		0.001	
	(0.003)		(0.003)		(0.005)		(0.002)	
Lagged Tobin's Q	0.001		-0.001		-0.008		-0.008	**
	(0.002)		(0.003)		(0.005)		(0.004)	
Lagged Cash Flow / Assets	0.018	**	0.023	**	0.031		0.027	***
	(0.008)		(0.011)		(0.019)		(0.009)	
Steady State Effects								
Sum of Tobin's Q / (1 - Lagged R&D / Assets)	0.008	***	0.004		-0.017		-0.013	
CF / Assets / (1 - Lagged R&D / Assets)	0.015	**	0.023		0.094		0.045	**
Model Specification								
Yearly Dummies [p-value]	0.002	***	0.011	**	0.322		0.000	***
Hansen's J test [p-value]	0.358		0.142		0.514		0.323	
M test for AR(2) in first differences [p-value]	0.032	**	0.382		0.644		0.278	
Observations	1591		1599		1586		1597	

Note: See Note in Table Ⅲ.

Table V Appropriate Percentile

Criterion Variables	Minimum Percentile
Financial Liquidity	
Firm Size	25.0
Cash	65.0
Debt	40.0
Dividends	35.0
Share Ownership Structure	
Large shareholders	65.0
Financial Institutions	70.0
Foreign Shareholders	65.0

Table VI Result for Dynamic R&D Regressions: Financial Liquidity

Variable	Firm Size Low		Firm Size High		Cash / Assets Low		Cash / Assets High	
Lagged R&D / Assets	0.336	**	0.490	***	0.118		0.461	***
	(0.149)		(0.138)		(0.132)		(0.176)	
Tobin Q	0.001		0.007	***	0.006	**	0.003	
	(0.005)		(0.002)		(0.003)		(0.004)	
Lagged Tobin's Q	-0.002		-0.006	***	-0.003		-0.002	*
	(0.002)		(0.002)		(0.003)		(0.001)	
Lagged Cash Flow / Assets	0.018	**	0.030	***	0.024	***	0.020	***
	(0.008)		(0.007)		(0.008)		(0.007)	
Steady State Effects								
Sum of Tobin's Q / (1 - Lagged R&D / Assets)	-0.002		0.002		0.004		0.001	
CF / Assets / (1 - Lagged R&D / Assets)	0.026	*	0.058	**	0.027	**	0.038	**
Model Specification								
Yearly Dummies [p-value]	0.105		0.000	***	0.000	***	0.001	***
Hansen's J test [p-value]	0.891		0.053	*	0.363		0.372	
M test for AR(2) in first differences [p-value]	0.905		0.982		0.384		0.709	
Number of Observations	1550		4823		4162		2211	
Variable	**Debt / Assets Low**		**Debt / Assets High**		**Dividends / Equities Low**		**Dividends / Equities High**	
Lagged R&D / Assets	0.431	***	0.235		0.336	***	0.679	***
	(0.110)		(0.172)		(0.130)		(0.260)	
Tobin Q	0.002		0.009	***	-0.004		0.001	
	(0.002)		(0.003)		(0.007)		(0.003)	
Lagged Tobin's Q	-0.005	**	-0.002		-0.008		-0.004	**
	(0.002)		(0.002)		(0.005)		(0.002)	
Lagged Cash Flow / Assets	0.020	**	0.028	***	0.025	**	0.025	***
	(0.008)		(0.007)		(0.011)		(0.007)	
Steady State Effects								
Sum of Tobin's Q / (1 - Lagged R&D / Assets)	-0.005		0.010	***	-0.017		-0.009	
CF / Assets / (1 - Lagged R&D / Assets)	0.036	**	0.036	***	0.069	*	0.078	
Model Specification								
Yearly Dummies [p-value]	0.001	***	0.000	***	0.072	*	0.000	***
Hansen's J test [p-value]	0.919		0.028	**	0.564		0.361	
M test for AR(2) in first differences [p-value]	0.171		0.130		0.766		0.443	
Number of Observations	2559		3814		2215		4158	

Note: See Note in Table Ⅲ.

Table VII Result for Dynamic R&D Regressions: Share Ownership Structure

Variable	Large Shareholders				Financial Institutions				Foreign Shareholders			
	Low		High		Low		High		Low		High	
Lagged R&D / Assets	0.361	**	0.492	***	0.409	***	0.371	*	0.324	***	0.312	**
	(0.183)		(0.127)		(0.108)		(0.214)		(0.122)		(0.126)	
Tobin Q	0.003		0.004		0.004		0.005	**	0.005		0.007	***
	(0.003)		(0.003)		(0.003)		(0.002)		(0.003)		(0.002)	
Lagged Tobin's Q	-0.003	*	-0.005	*	-0.003	**	-0.007	**	-0.003		-0.004	
	(0.002)		(0.003)		(0.002)		(0.003)		(0.002)		(0.002)	
Lagged Cash Flow / Assets	0.023	***	0.028	***	0.025	***	0.030	*	0.018	***	0.035	***
	(0.006)		(0.010)		(0.005)		(0.016)		(0.006)		(0.009)	
Steady State Effects												
Sum of Tobin's Q / (1 - Lagged R&D / Assets)	-0.001		-0.003		0.001		-0.003		0.003		0.004	
CF / Assets / (1 - Lagged R&D / Assets)	0.035	**	0.055	**	0.042	***	0.048		0.027	**	0.051	***
Model Specification												
Yearly Dummies [p-value]	0.000	***	0.001	***	0.000	***	0.000	***	0.000	***	0.000	***
Hansen's J test [p-value]	0.486		0.161		0.389		0.511		0.249		0.473	
M test for AR(2) in first differences [p-value]	0.217		0.285		0.808		0.687		0.249		0.660	
Number of Observations	4143		2230		4429		1944		4115		2258	

Note: See Note in Table Ⅲ.

Table VIII Result for Dynamic R&D Regressions: Corporate Diversification and Financial Liquidity

Panel A： D(DIV) = 1 if N-Segment > 2, D(DIV) = 0 otherwise.

Variable	Firm Size				Cash / Assets			
	Low		High		Low		High	
Lagged R&D / Assets	0.400	***	0.446	***	0.094		0.506	***
	(0.139)		(0.104)		(0.113)		(0.146)	
Tobin's Q	-0.001		0.006	***	0.005	**	0.002	
	(0.003)		(0.002)		(0.002)		(0.003)	
Lagged Tobin's Q	-0.002		-0.006	***	-0.002		-0.001	
	(0.002)		(0.002)		(0.002)		(0.002)	
Lagged Cash Flow / Assets	0.009		0.031	***	0.021	***	0.013	
	(0.009)		(0.009)		(0.007)		(0.009)	
D(DIV) × Lagged R&D / Assets	-0.147		-0.091		-0.005		-0.220	**
	(0.106)		(0.091)		(0.104)		(0.108)	
D(DIV) × Tobin's Q	0.001		0.002		0.001		0.003	
	(0.002)		(0.001)		(0.001)		(0.002)	
D(DIV) × Lagged Tobin's Q	0.001		0.001		0.000		0.000	
	(0.002)		(0.002)		(0.002)		(0.002)	
D(DIV) × Lagged Cash Flow / Assets	0.018		-0.007		0.002		0.012	
	(0.015)		(0.009)		(0.009)		(0.011)	
Model Specification								
Yearly Dummies [p-value]	0.095	*	0.077	*	0.305		0.106	
Hansen's J test [p-value]	70.280		71.694		60.856		69.517	
M test for AR(2) in first differences [p-value]	0.906		0.829		0.358		0.604	
Observations	1550		4823		4162		2211	

Panel A (Continued).								
Variable	Debt / Assets				Dividends / Equities			
	Low		High		Low		High	
Lagged R&D / Assets	0.438	***	0.284		0.303	***	0.601	***
	(0.103)		(0.190)		(0.112)		(0.214)	
Tobin's Q	0.002		0.008	***	0.003		0.003	
	(0.002)		(0.003)		(0.003)		(0.002)	
Lagged Tobin's Q	-0.005	**	-0.001		-0.002		-0.003	*
	(0.002)		(0.002)		(0.002)		(0.002)	
Lagged Cash Flow / Assets	0.013		0.025	***	0.016	*	0.020	**
	(0.010)		(0.008)		(0.009)		(0.009)	
D(DIV) × Lagged R&D / Assets	-0.204	**	-0.167		-0.224		-0.164	*
	(0.098)		(0.122)		(0.190)		(0.092)	
D(DIV) × Tobin's Q	0.002		0.003		0.000		0.002	
	(0.002)		(0.002)		(0.002)		(0.001)	
D(DIV) × Lagged Tobin's Q	0.001		0.000		0.005		0.000	
	(0.002)		(0.002)		(0.004)		(0.002)	
D(DIV) × Lagged Cash Flow / Assets	0.013		0.002		-0.002		0.008	
	(0.011)		(0.010)		(0.011)		(0.011)	
Model Specification								
Yearly Dummies [p-value]	0.557		0.065	*	0.069	*	0.209	
Hansen's J test [p-value]	53.835		72.817		72.431		64.278	
M test for AR(2) in first differences [p-value]	0.212		0.096	*	0.070	*	0.544	
Observations	2559		3814		2215		4158	

Note: See Note in Table Ⅲ.

Panel B： D(DIV) = 1 if HHI-Segment ≤ 0.70, D(DIV) = 0 otherwise.								
Variable	Firm Size				Cash / Assets			
	Low		High		Low		High	
Lagged R&D / Assets	0.302	**	0.474	***	0.147		0.501	***
	(0.129)		(0.129)		(0.120)		(0.135)	
Tobin's Q	0.004		0.007	***	0.007	***	0.001	
	(0.003)		(0.002)		(0.003)		(0.004)	
Lagged Tobin's Q	0.001		-0.006	***	-0.002		-0.003	
	(0.003)		(0.002)		(0.002)		(0.002)	
Lagged Cash Flow / Assets	-0.010		0.025	***	0.010		0.012	
	(0.014)		(0.008)		(0.006)		(0.011)	
D(DIV) × Lagged R&D / Assets	-0.083		-0.169		-0.046		-0.181	
	(0.160)		(0.120)		(0.096)		(0.121)	
D(DIV) × Tobin's Q	0.002		0.000		-0.003	**	0.003	
	(0.003)		(0.002)		(0.001)		(0.002)	
D(DIV) × Lagged Tobin's Q	-0.002		0.004	**	0.002		0.001	
	(0.003)		(0.002)		(0.002)		(0.002)	
D(DIV) × Lagged Cash Flow / Assets	0.041	**	-0.001		0.020	**	0.014	
	(0.016)		(0.010)		(0.010)		(0.015)	
Model Specification								
Yearly Dummies [p-value]	0.356		0.086	*	0.066	*	0.051	*
Hansen's J test [p-value]	58.271		69.845		71.589		73.203	
M test for AR(2) in first differences [p-value]	0.294		0.967		0.187		0.884	
Observations	1550		4823		4162		2211	

Panel B (Continued).								
Variable	Debt / Assets				Dividends / Equities			
	Low		High		Low		High	
Lagged R&D / Assets	0.531	***	0.235		0.383	***	0.594	***
	(0.106)		(0.177)		(0.136)		(0.209)	
Tobin's Q	0.001		0.010	***	0.004		0.004	*
	(0.003)		(0.003)		(0.003)		(0.002)	
Lagged Tobin's Q	-0.006	***	-0.002		-0.007	*	-0.005	**
	(0.002)		(0.002)		(0.004)		(0.002)	
Lagged Cash Flow / Assets	0.015		0.021	**	0.011		0.026	***
	(0.012)		(0.009)		(0.013)		(0.008)	
D(DIV) × Lagged R&D / Assets	-0.219	***	0.038		-0.257	**	-0.073	
	(0.069)		(0.097)		(0.105)		(0.112)	
D(DIV) × Tobin's Q	0.001		-0.002		-0.002		0.000	
	(0.002)		(0.002)		(0.003)		(0.002)	
D(DIV) × Lagged Tobin's Q	0.003		0.000		0.005		0.002	
	(0.002)		(0.002)		(0.003)		(0.002)	
D(DIV) × Lagged Cash Flow / Assets	0.010		0.017		0.018		-0.002	
	(0.012)		(0.012)		(0.013)		(0.012)	
Model Specification								
Yearly Dummies [p-value]	0.584		0.020	**	0.087	*	0.185	
Hansen's J test [p-value]	52.159		78.634		69.765		64.203	
M test for AR(2) in first differences [p-value]	0.324		0.164		0.324		0.547	
Observations	2559		3814		2215		4158	

Note: See Note in Table III.

Table IX Result for Dynamic Physical Investment Regressions

Variable	Diversification Measure: N-Segment				Diversification Measure: HHI-Segment			
	More-diversified > 2		Less-diversified ≤ 2		More-diversified < 0.70		Less-diversified ≥ 0.70	
Lagged Investment / Assets	0.047		0.151	***	0.011		0.183	***
	(0.038)		(0.038)		(0.034)		(0.038)	
Tobin's Q	0.094	***	0.103	***	0.076	***	0.118	***
	(0.010)		(0.030)		(0.009)		(0.030)	
Lagged Tobin's Q	-0.010	*	-0.011	*	-0.008	*	-0.012	*
	(0.006)		(0.006)		(0.004)		(0.007)	
Lagged Cash Flow / Assets	0.159	***	0.191	***	0.154	***	0.199	***
	(0.046)		(0.061)		(0.040)		(0.059)	
Steady State Effects								
Sum of Tobin's Q / (1 - Lagged Investment / Assets)	0.088	***	0.108	***	0.069	***	0.130	***
CF / Assets / (1 - Lagged Investment / Assets)	0.167	***	0.225	***	0.156	***	0.243	***
Model Specification								
Yearly Dummies [p-value]	0.000	***	0.000	***	0.000	***	0.000	***
Hansen's J test [p-value]	0.662		0.190		0.239		0.365	
M test for AR(2) in first differences [p-value]	0.171		0.019	**	0.434		0.179	
Number of Observations	2884		3360		3312		2932	

Note: See Note in Table III.

Table X Result for Dynamic Cash Holdings Regressions

Variable	Diversification Measure: N-Segment				Diversification Measure: HHI-Segment			
	More-diversified > 2		Less-diversified ≤ 2		More-diversified < 0.70		Less-diversified ≥ 0.70	
Lagged Cash / Assets	0.256	***	0.201	***	0.307	***	0.141	**
	(0.064)		(0.059)		(0.065)		(0.063)	
Tobin's Q	0.094	***	0.110	***	0.102	***	0.099	***
	(0.014)		(0.012)		(0.015)		(0.012)	
Lagged Tobin's Q	-0.035	***	-0.029	***	-0.044	***	-0.023	**
	(0.008)		(0.010)		(0.009)		(0.009)	
Lagged Cash Flow / Assets	0.056		0.087	*	0.087	*	0.080	*
	(0.047)		(0.051)		(0.051)		(0.048)	
Steady State Effects								
Sum of Tobin's Q / (1 - Lagged Cash / Assets)	0.079	***	0.101	***	0.084	***	0.089	***
CF / Assets / (1 - Lagged Cash / Assets)	0.075		0.109		0.126		0.093	
Model Specification								
Yearly Dummies [p-value]	0.000	***	0.000	***	0.000	***	0.000	***
Hansen's J test [p-value]	0.105		0.310		0.199		0.122	
M test for AR(2) in first differences [p-value]	0.211		0.759		0.344		0.482	
Number of Observations	2882		3350		3313		2919	

Note: See Note in Table III.

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