How Do We Account for the Relationship between Investment and Uncertainty?

Takashi Hatakeda*

Nihon University College of Economics, 1-3-2, Misaki, Chiyoda, Tokyo, 101-8360, Japan

Abstract

In this paper, we examine the relationship between investment and uncertainty by investigating not only the configuration of marginal q but also the imperfections of the capital market. We find that the relationship is negative for medium-to-small firms and high-leverage firms. This implies that the negative relationship is accounted for by the imperfections of the capital market. Our finding, furthermore, is that it is negative for firms having a close relationship with a particular bank, indicating that these firms, especially large firms, are likely to face more severe hold-up problems.

Keyword: investment, uncertainty, imperfections of the capital market, hold-up.

JEF Classification Number: D92.

---

* Tel.:+81-3-3219-3447; Fax:+81-43-273-5471.
E-*mail address*: hatakeda@eco.nihon-u.ac.jp (T. Hatakeda)

1. Introduction

The study of investment decisions has been a central topic on the economic research agenda for a long time. For example, Yoshikawa (1980) shows that, in the presence of convex adjustment costs, investment is an increasing function of the marginal profitability of capital—that is, marginal q. Hayashi (1982) demonstrates that, under constant-returns-to-scale and price-taking assumptions, marginal q is equal to average q. Contrary to these sophisticated theoretical studies, however, a large body of recent empirical research reports that investment is not as obviously related to q as previously expected. In order to clarify the ambiguous relationship, the investment literature of the last two decades has focused on two issues: capital market imperfections and uncertainty.

In the presence of capital market imperfections, the investment decisions of firms depend on not only marginal q but also financial variables such as cash flow and leverage. A number of studies also show that the more constrained the access to capital markets, the greater the sensitivity of investment to financial variables.[1]

On the other hand, the effect of uncertainty on investment is considered according to two different approaches. The first approach associates the uncertainty over future profitability with the imperfections of capital markets. Greenwald, Stiglitz and Weiss (1990) and Greenwald and Stiglitz (1990) examine a model of credit and equity rationing to demonstrate that an increase in uncertainty increases the default risk of investment projects, and that the increased default risk makes firms less eager to invest.[2]

1 See, for example, the survey of Hubbard (1998).
2 Appelbaum and Katz (1986), Zeira (1990), and Nakamura (1999) illustrate the negative relationship between investment and uncertainty in the light of risk aversion.

The second approach considers the effect of uncertainty in relation to the configuration of marginal q. According to Hartman (1972) and Abel (1983), given certain conditions, marginal q is a convex function of the stochastic variable that characterizes uncertainty. An increase in uncertainty, therefore, increases marginal q, according to Jensen's inequality, and the increased marginal q has the effect of making firms eager to invest more. On the other hand, Dixit and Pindyck (1994) show that the irreversibility of investment makes marginal q become a concave function so that an increase in uncertainty makes firms eager to invest more.

Recently, a number of empirical studies have been done on the relationship between investment and uncertainty.[3] Most of them report a negative relationship. They, however, focus on only the configuration of marginal q and, therefore, support the conclusion that the presence of irreversibility makes firms decrease investment when uncertainty increases. Unfortunately, most of the previous studies do not completely answer the question of how uncertainty affects the firm's decision rule for investment.[4]

We use panel data for Japanese firms over the period 1983–1993 to examine the relationship by considering not only the configuration of marginal q but also the

3 For aggregate or disaggregate macro empirical studies of the investment–uncertainty relationship, see Driver and Moreton (1991), Price (1995, 1996), Carruth, Dickerson, and Henley (1998), Ferderer (1993a, 1993b), and Calcagnini and Saltari (2000). For these empirical studies of cross-sectional or panel data, see Huizinga (1993), Ghosal and Loungani (1996, 2000), Leahy and White (1996), Bell and Campa (1997), Pattillo (1998), Guiso and Parigi (1999), Kalckreuth (2000), Bo and Lensink (2000), and Lensink, Steen, and Sterken (1999, 2000). Most of these studies report a negative relationship to emphasize the importance of the irreversibility. Also, Aizenman and Marion (1993, 1996, 1999), Ramey and Ramey (1995), Lensink (1998), Lensink, Bo, and Sterken (1998), and Lensink (2000) report a negative relationship between investment (economic growth) and uncertainty in developing or developed countries.
4 For empirical studies of Japanese manufacturing firms, we can cite Matsubayashi (1995), Ogawa and Suzuki (2000), and Honda and Suzuki (2000). A series of studies interprets the negative sensitivity of investment to uncertainty as evidence that irreversibility of investment induces a firm to refrain from investment in response to an increase in uncertainty. Suzuki (2001) makes a suggestion that the negative sensitivity

imperfections of the capital market. We then attempt to clarify the channel of uncertainty on investment in the light of these results.

Our basic strategy is to estimate the reduced q models with an uncertainty variable and to examine the sign of the uncertainty coefficient. If the coefficient is positive, we interpret this result as evidence that the investment–uncertainty relationship is attributed to the convexity of marginal q. The negative sign, on the other hand, is accounted for not only by the concavity of marginal q but also by the imperfections of capital markets. Unfortunately, we cannot yet identify which of the two arguments has greater explanatory power. With regard to our empirical evidence, indeed, we find that the sensitivity of investment to uncertainty is negative for the entire sample of Japanese manufacturing firms.

In order to solve this difficulty, we divide the sample of firms into two groups depending on some criteria that characterize the configuration of marginal q and the imperfections of the capital markets. We then infer a dominant argument from the differences in the sensitivity of uncertainty to investment across groups.

This approach is adopted by only a few empirical studies: Guiso and Parigi (1999), Lensink, Steen, and Sterken (1999), Ghosal and Loungani (1996), and Ghosal and Loungani (2000).[5] These studies report different empirical findings across countries.

---

may have relevance to capital market imperfections.

5 Guiso and Parigi (1999), Lensink, Steen, and Sterken (1999) distinguish between firms according to the price–cost margin ratio. The former analyzes a sample of Italian manufacturing firms, the latter uses a sample of Dutch firms, and both find that the impact of uncertainty on investment is larger among large firms with greater market power. On the contrary, Ghosal and Loungani (1996) and Ghosal and Loungani (2000) utilize firm size as a criterion to split the sample of U.S. manufacturing firms into two, and find that an increase in uncertainty makes it difficult for small and medium-sized firms to invest more. Furthermore, Minton and Schrand (1999) provide empirical evidence that an increase in uncertainty over cash flow increases the cost of capital and reduces investment in capital expenditures, R&D, and advertising.

There is thus no consensus about the channel of uncertainty on investment. It is surprising and interesting that there are very few studies conducted for Japan.

We find that the investment–uncertainty relationship is negative for medium-to-small firms and high-leverage firms, while the relationship is ambiguous for large and low-leverage firms. This finding is consistent with the argument that the negative relationship is attributed to imperfections of capital markets. Thus, our finding contradicts an explanation that the previous empirical studies have given for the negative relationship.

Unlike the previous empirical studies, we attempt to examine a role that banks play in the investment–uncertainty relationship. Recently, a large number of empirical studies have rekindled the discussion over the role that financial intermediaries—in particular, banks—play in the investment decisions of firms.[6]

In our paper, we begin by presuming that banks have two opposing effects on the decision rule of firms for investment. One is that a bank–firm relationship makes it possible to lower agency costs of external financing through the information production and monitoring activities of banks (see, for example, Diamond (1984, 1991), Fama (1985), and Berlin and Loeys (1988)). The other is that its relationship leads to an increase in agency costs since a bank may exploit its privileged position to hold up and demand additional rents from firms (see, for example, Sharpe (1990), Rajan (1992), and Diamond (1993)).

Another purpose of our paper is to clarify whether or not a close bank–firm relationship lowers agency costs. We estimate the sensitivity of investment to

---

6 See the empirical studies, Petersen and Rajan (1994), Houston and James (1996), Weinstein and Yafeh (1995, 1998), Anderson and Makhija (1999), and Detragiache, Garella, and Guiso (2000).

uncertainty across two groups into which the sample firms are split, according to the bond-to-debt ratio and the main-bank-loan ratio. We then discuss the role of a (main) bank from the differences in the sensitivity of uncertainty to investment across groups.

Consistent with the notion that firms are likely to cope with more severe hold-up problems, we find that firms with access to multiple banking relationships and public debt markets have less negative impact of uncertainty on investment. It is antithetical to a number of the existing papers in the literature, which emphasize that Japanese banks have mitigated agency costs (see, for example, Hoshi, Kashyap, and Scharfstein (1990, 1991), Prowse (1990), Kaplan and Minton (1994), and Anderson and Makhija (1999)). In particular, we find that large firms are likely to face more severe hold-up problems than small-to-medium firms.

The remainder of our study is organized as follows. Section 2 provides a brief review of the theoretical studies on a relationship between investment and uncertainty. Section 3 provides some hypotheses that we construct on the basis of these theories. Section 4 describes the procedures for measuring uncertainty. Section 5 presents the empirical model and the methods of estimation for the model. Section 6 presents the empirical results for the model. Finally, Section 7 concludes with a summary of our main findings.

2. Literature Review

There are various conflicts of interest between creditors and shareholders (or managers who are trusted entirely by shareholders) concerning the returns of firms. Under limited liability, a firm has an incentive to opt for excessively risky investment projects, because the expected payoff for shareholders is positively associated with a default risk—that is, the volatility of a firm's return. In contrast, the expected payoff for creditors decreases with an increase in uncertainty, and creditors who correctly anticipate a firm's behavior demand a premium on the debt they purchase or bond covenants that restrict the firm's future use of debt. For example, a high interest payment prevents a firm from investing in some projects that would normally have been undertaken. The costs that are caused by these conflicts are called agency costs,[7] and they result in increasing the cost of capital. In this way, an increase in uncertainty makes firms less eager to invest.

In addition to conflicts of interest on a firm's future prospects, there exist some information asymmetries between creditors and the firm. Information asymmetries make it difficult for an individual creditor or a financial intermediary to assess investment projects.[8] Creditors demand higher interest payments from the borrowing firm to make up for the costly tasks of screening and monitoring. In other words, information asymmetries generate alternative agency costs. Consequently, an increase in uncertainty over a firm's future profitability makes firms less eager to invest. In particular, it is expected that the negative relationship is large for firms with a higher dependence on external financing because they are more likely to face serious information problems (See, for example, Greenwald, Stiglitz, and Weiss (1984) and Greenwald and Stiglitz (1990)).

In contrast to these arguments that emphasize imperfections of the capital markets, the alternative is to focus on the configuration of the marginal profitability of capital—that is, marginal q. According to the alternative arguments, there are two

7 In our paper, we restrict our attention to agency costs of debt and do not discuss agency costs of equity.
8 See, for example, Stulz (1990).

opposing effects of uncertainty on marginal q: a positive one and a negative one. As Hartman (1972) and Abel (1983, 1986) have shown, under the combination of perfect competition, reversibility, and a constant-returns-to-scale technology, marginal q is a convex function of the stochastic variable such as an output price or an input price. Abel and Eberly (1994) show that, given that competition is perfect and that technology is constant-returns-to-scale, the above argument is held regardless of the irreversibility of investment. In addition, Lee and Shin (2000) show that the existence of input variables makes marginal q more convex. In all cases, an increase in uncertainty increases the value of marginal q, according to Jensen's inequality, and stimulates a firm to invest more. In this paper, the effect of uncertainty is called the convexity effect.

In contrast, McDonald and Siegel (1986) and Dixit and Pindyck (1994) show that, in a monopolistic setting, irreversibility of investment bestows a value on the option of waiting for new information, and that irreversibility of investment induces a firm to postpone (or decrease) investment in response to an increase in uncertainty. Caballero (1991) and Sakellaris (1994) show that the combination of imperfect competition, a constant-returns-to-scale technology, and irreversibility of investment causes marginal q to be a concave function. This effect of uncertainty is called the irreversibility effect.

The overall effect of uncertainty on irreversible investment—whether the convexity effect dominates the irreversibility effect or not—is, in principle, ambiguous. Caballero (1991) and Sakellaris (1994) focus on the role of the price elasticity of demand, which is negatively related to the degree of imperfect competition. Following both studies, given that investment is irreversible and that a firm has a constant-returns-to-scale technology, when demand is inelastic, the irreversibility effect dominates the convexity effect. That is, the marginal profitability becomes so concave that an increase in uncertainty makes firms less eager to invest. When, on the other hand, demand is elastic, the marginal profitability becomes so convex that an increase in uncertainty makes firms more eager to invest.

Furthermore, Metcalf and Hassett (1995), Abel and Eberly (1999), Bar-Ilan and Strange (1999), and Sarkar (2000) show that, under the combination of the price inelasticity of demand, irreversibility, and a constant-returns-to-scale technology, the investment–uncertainty relationship is not monotonic. In particular, Abel and Eberly (1999) show that the relationship is characterized by an inverted U-curve—that is, when uncertainty is sufficiently small, the convexity effect is dominant; otherwise, the irreversibility effect is dominant.

3. Approaches for Empirical Analysis

In our paper, we examine the relationship by considering not only the configuration of marginal q but also the imperfections of the capital market. We divide the sample of firms into two subsamples depending on the factors that are attributed to marginal q or to the imperfections of the capital market. We examine the investment–uncertainty relationship across subsamples.

Throughout our paper, we presume that investment is irreversible[9] and that a firm's technology is constant-returns-to-scale. If the investment–uncertainty relationship is attributed to the configuration of marginal q, the relationship is negative and large in terms of the absolute value for firms with a monopoly right to invest. Alternatively, if the

9 Ogawa and Suzuki (2000) provide empirical evidence that investment is irreversible in

relationship is attributed to capital market imperfections, it is negative and large for firms facing liquidity constraints.

Furthermore, it is a more interesting issue to explore the role that banks have in the investment–uncertainty relationship. The presence of capital market imperfections generates various agency costs depending on external financing. We focus on debt financing among the variety of external financing alternatives and then divide it into two: arm's-length debt financing (bond financing) and monitored-debt financing (bank financing), which typically is supplied by commercial banks. The advantage of bank financing is in the reduction of some agency costs that arise from conflicts and information asymmetries between firms (shareholders) and creditors. In contrast, the disadvantage is that an ongoing relationship with a bank may create hold-up problems.

It is expected that, as far as the advantage of bank financing exceeds the disadvantage, the negative effect of uncertainty on investment becomes small in absolute value for firms with close financial ties to a (main) bank. In contrast, it is expected that, under the situation that there exists a severe hold-up problem associated with borrowing from a particular bank, the negative effect becomes small for firms with access to pubic bond markets or multiple banking relationships.

Finally, we examine whether there are some differences in the role that a (main) bank plays across firm classes. Medium-to-small firms or the liquidity-constrained firms are likely to be subject to serious problems owing to capital market imperfections. Consequently, it is expected that the advantages of bank financing exceed the disadvantages for these firms and that the main-bank relationship makes it possible to lessen the negative effect of uncertainty on investment. However, the advantage of bank

---

the Japanese manufacturing sector.

financing is restrictive for large firms or the non-liquidity-constrained firms. If anything, it is expected that the main-bank relationship leads to increasing the negative relationship of uncertainty to investment.

4. Measuring Uncertainty

A large number of previous empirical studies have used the volatilities of sales, costs, profits, output prices, input prices, stock returns, and so on, as uncertainty proxy variables.[10] Unfortunately, there is no consensus about what is the most appropriate for an uncertainty variable in the existing empirical literature.

In addition, there are several ways of measuring an uncertainty proxy. The first is to calculate the standard deviation of a variable X that is believed to influence the profit of firms. The second is to estimate a statistical model of the process that a variable X follows and then to calculate the standard deviation of the residuals.[11]

In our paper, following Pindyck and Solimano (1993), Honda and Suzuki (2000),

---

10 For example, Bell and Campa (1997) examine the sensitivities of investment to uncertainty proxies of the exchange rates, input prices, and product demands, and report that exchange rate uncertainty has a negative and significant impact on investment by chemical manufacturing firms in the European Union. Leahy and Whited (1996) examine the sensitivities of investment to the stock return uncertainty and report a negative relationship for U.S. manufacturing firms. Kalckreuth (2000) examines the sensitivities of investment to the sales and cost uncertainty indicators and reports that both uncertainty indicators have a negative and significant impact on investment in the German manufacturing sector. Ogawa and Suzuki (2000) examine the sensitivities of investment to the individual-specific and industry-wide uncertainty indicators of sales, and report that industry-wide uncertainty has a negative and significant impact on investment in the Japanese manufacturing sector.

11 Guiso and Parigi (1996) use information on each firm's subjective assessment of the evolution of its product demand one and three years ahead in order to construct a measure of uncertainty.

and Suzuki (2001), we adopt the volatility of marginal q as an uncertainty proxy. In order to ensure robustness of our empirical results, we use two different procedures that depend on the year-overlapping periods over which we construct our uncertainty proxy.

The first procedure is to calculate the standard deviations of marginal q based on the popular formula using the past three or five years of information. In other words, our measure of uncertainty, $\left(UC(1,q)_{i,t}, q = 3\, or\, 5\right)$, is calculated as follows:

(1) $UC(1,q)_{i,t} = \sqrt{\left(\sum_{k=t-q}^{t-1}\left(X_{i,k} - X_i^{*q}\right)^2\right)/q} \quad q = 3 \text{ or } 5$,

(2) $X_i^{*q} = \left(\sum_{k=t-q}^{t-1} X_{i,k}\right)/q$,

where i , t , and q denote the firm, period, and the year-period over which we construct our uncertainty proxy, respectively; and $X_{i,k}$ denotes marginal q.

Following Ghosal and Loungani (2000), the second procedure estimates the individual firm's profit-forecasting equation, and then calculates the standard deviation of the residuals. We assume that the individual firm's profit-forecasting equation is as follows:

(3) $X_{i,t} = \lambda_0 + \lambda_1 X_{i,t-1} + \lambda_2 AX_{l,t-1} + v_{i,t}$,

(4) $AX_{l,t-1} = \left(\sum_{i=1}^{n_{l,t-1}} X_{i,t-1}\right)/n_{l,t-1}$,

where $AX_{l,t-1}$ denotes marginal q in the l-th industry to which the i-th firm belongs (where $l=1$ for the machinery industry, $l=2$ for the electrical machinery and equipment industry, and $l=3$ for the transportation equipment industry) in year $t-1$; $n_{l,t-1}$ denotes the number of firms in the l-th industry in year $t-1$; and $v_{i,t}$ denotes the error term of the forecasting equation.

For each individual firm, we estimate Equation (3) over the entire sample period 1978–1992. We then use the standard deviation of the residuals over the past three- or five-year period, $(UC(2,q)_{i,t}, q = 3\ or\ 5)$, as an uncertainty proxy. By incorporating Equation (3) into $AX_{l,t-1}$, we remove the influences of industry-wide fluctuations in business cycles. In other words, $UC(1,q)_{i,t}$ encompasses both the individual-specific uncertainty and the industry-wide uncertainty of marginal q, while $UC(2,q)_{i,t}$ mainly captures the individual-specific uncertainty of marginal q.

5. Empirical Specification and Data

Following Leahy and Whited (1996) and Suzuki (2001), the basic investment function we adopt for estimation is the q-type investment function with an uncertainty proxy variable, $UC(m,q)_{i,t}$, $m = 1\ or\ 2$, $q = 3\ or\ 5$, and financial variables, $FIN_{i,t-1}$ and $LK_{i,t-1}$. Thus the estimated model is written as follows:

$$(5)\quad I_{i,t}/K_{i,t-1} = \alpha_1 MRQ_{i,t} + \alpha_2 FIN_{i,t-1} + \alpha_3 LK_{i,t-1} + \alpha_4 UC(m,q)_{i,t} + z_i + d_t + u_{i,t}.$$

Furthermore, in order to test the existence of the inverted-U uncertainty effect, which is illustrated by Abel and Eberly (1999), we estimate the model that adds the square of uncertainty, $\left(UC(m,q)_{i,t}\right)^2$, to explanatory variables in Equation (5):

$$(6)\quad I_{i,t}/K_{i,t-1} = \alpha_1 MRQ_{i,t} + \alpha_2 FIN_{i,t-1} + \alpha_3 LK_{i,t-1} + \alpha_4 UC(m,q)_{i,t} + \alpha_5 \left(UC(m,q)_{i,t}\right)^2 + z_i + d_t + u_{i,t}$$

Here $I_{i,t}$ is real gross investment, $K_{i,t-1}$ is the real capital stock, $MRQ_{i,t}$ is the proxy variable of marginal q, $FIN_{i,t-1}$ is the liquidity financial asset ratio, $LK_{i,t-1}$ is the land-to-capital ratio, z_i is the unobservable firm effect, d_t is the unobservable year effect, and $u_{i,t}$ is the disturbance term. All stocks denote end-of-period values.[12] In estimating Equation (5) or Equation (6), the two-way, fixed-effects model is chosen because of the results of Hausman's specification test.[13]

$FIN_{i,t-1}$ and $LK_{i,t-1}$ are the so-called financial proxies that express the intensity of financial liquidity. Since the study of Fazzari, Hubbard, and Petersen (1988), a number of empirical studies have used cash flow as a proxy for financial liquidity. Kaplan and Zingales (1997), however, provide both theoretical reasons and empirical evidence for the conclusion that a greater sensitivity of investment to cash flow is not a reliable measure of the degree of financial liquidity. Therefore, as in Gilchrist and Himmelberg (1999), we adopt the liquidity–asset ratio as a proxy for a firm's financial liquidity[14] in order to avoid a criticism that has been directed at Kaplan and Zingales (1997). In addition, we adopt the land-to-capital ratio, $LK_{i,t-1}$, as another proxy for financial liquidity. The reason for introducing $LK_{i,t-1}$ is that for Japanese firms, land assets have

12 See the appendix for further details about the data and variable definitions.
13 See Baltagi (1995) for a further discussion of Hausman's specification test.
14 According to Suzuki (2001), we used the capital–asset ratio as an alternative to financial liquidity, but there were insignificant changes in the qualitative results.

played an important role as collateral since land prices kept rising in the post-war period until they collapsed in the early 1990s.[15]

The data on which our empirical analysis is based come mostly from the database of the Japan Development Bank. The total number of firms in our sample is 245. All the sample firms belong to one of three manufacturing industries, namely machinery, electrical machinery and equipment, and transportation equipment industries. We delete sample firms with missing or inconsistent data or those that were involved in large mergers and acquisitions during the sample period. The sample period is from 1983 to 1993.

We use the instrument-variable method to estimate Equations (5) and (6) in order to avoid the problem of the endogeneity of the regressors. Instruments that we utilize to estimate Equation (5) are the first and second lags of the rate of investment, $I_{i,t}/K_{i,t-1}$, marginal q, $MRQ_{i,t}$, two beginning-of-period financial variables, $FIN_{i,t-1}, LK_{i,t-1}$, current measured uncertainty, $UC(m,q)_{i,t}$, firm dummies, z_i, and time dummies, d_t. Also, in estimating Equation (6), we add the square of current measured uncertainty, $\left(UC(m,q)_{i,t}\right)^2$, to the set of instruments in Equation (5). There are a few substantial outliers in the sample. Since their inclusion may bias the estimation, we further trimmed the data by deleting the observations below the 0.5th percentile and above the 99.5th percentile for $I_{i,t}/K_{i,t-1}$ and $MRQ_{i,t}$.

Table 1 reports summary statistics for the full sample and the various sample splits. As described in the next section, we undertake an in-depth analysis of whether or not there are differences in the sensitivity of investment to uncertainty across subsamples depending on firm characteristics.

---

[15] See, for example, Ogawa and Kitasaka (1998).

6. Empirical Results

A. The Negative and Linear Relationship

We first examine the relationship between uncertainty and investment for the entire sample of firms. In Table 2 we present the empirical results obtained by using four different uncertainty measures, for Equation (5), in which the relationship between investment and uncertainty is assumed to be linear, and Equation (6), in which the relationship is assumed to be non-linear. We report the results obtained for Equation (5) in the first and third columns of Part 1 and Part 2, and the results obtained for Equation (6) in the second and fourth columns of Part 1 and Part 2. If the inverted U-curve relationship exists, as Abel and Eberly (1999) have documented, we expect the coefficient of $UC(m,q)_{i,t}$ to be is positive and the coefficient of $(UC(m,q)_{i,t})^2$ to be negative.

The coefficients of $MRQ_{i,t}$, $FIN_{i,t-1}$, and $LK_{i,t-1}$ are positive and statistically significant, irrespective of the uncertainty measures. These empirical results are similar to those of Ogawa et al. (1994). These are consistent with the widespread notion that a firm's investment decision depends not only on the investment opportunity itself but also on financial variables that represent the degree of liquidity constraint.

The chief concern in our paper is the sign of the estimates of the uncertainty coefficients. First, we discuss the results of the investment function with a linear relationship to uncertainty. Of the four uncertainty measures, three uncertainty coefficients are negative and statistically significant at the 5% level, and the other one is significant at the 10% level. From these results, we cannot support the hypothesis that marginal q is convex—that is, that an increase in uncertainty increases the value of marginal q and encourages a firm to invest more.

Second, irrespective of the various uncertainty measures, the uncertainty coefficients are essentially similar in their values. This finding suggests that the main source of uncertainty that affects a firm's investment decision is firm-specific uncertainty rather than industry-wide uncertainty.

With regard to the results of the investment function with a non-linear relationship to uncertainty, the uncertainty coefficients do not satisfy the condition: $\alpha_4 > 0$ and $\alpha_5 < 0$. Consequently, there is no inverted U-curve relationship between investment and uncertainty.[16]

B. The Importance of Capital Market Imperfections

As has been illustrated, the negative sign of the uncertainty coefficient is explained by the concavity of marginal q and by imperfections of the capital markets. In the former case, the uncertainty coefficients are negative and large in absolute value for large firms and for firms with high market share, both of which enjoy a monopoly right to invest and rule out the possibility of other firms entering in competition. In the latter case, in contrast, the uncertainty coefficients are negative and large for the medium-to-small firms and firms with high debt ratios, which are both likely to be subject to the liquidity

16 In our empirical analyses, which are reported below, the results do not support the existence of an inverted U-curve relationship. We therefore omit the results of Equation (6) from our tables in order to avoid troublesome arguments.

constraint. To test these predictions, we split the sample into two subsamples according to firm size, market-share ratio, and debt ratio.

In Table 3, we present the empirical results of our investment equations that are estimated for the subsamples of medium-to-small firms and large firms. According to the magnitude of capital stock at end-of-fiscal-year 1993, we divide the sample of firms into two: medium-to-small firms, of which the observations are below the 40th percentile of the full sample, and large firms, of which the observations are above the 60th percentile. The uncertainty coefficients for medium-to-small firms are negative and significant at the 5% level, irrespective of the uncertainty measures, while the coefficients for large firms are insignificant or marginally significant (but positive) at the 10% level. Also, the magnitudes of the uncertainty coefficients are statistically different between medium-to-small and large firms at the 5% significance level except for the case of the uncertainty measure $UC(1,5)$.

In Table 4, we present the empirical results for the two subsamples on the basis of the market-share ratio. According to the magnitude of the average price–cost margin[17] for 1983–1993 (PCM) as the market-share ratio, we divide the sample of firms into the low-PCM firm and the high-PCM firm subsamples.[18] The uncertainty coefficients for low-PCM firms are negative and significant at the 5% level, except for the case of $UC(1,3)$, while the coefficients for high-PCM firms are insignificant in the all cases. Also, these magnitudes are statistically different between low-PCM and high-PCM firms at the 1%

---

17 Following Domowitz, Hubbard, and Petersen (1986), we calculate PCM as:

$$\text{PCM} = \frac{\text{Value of Sales} + \Delta\text{Inventories} - \text{Payroll} - \text{Cost of Materials}}{\text{Value of Sales} + \Delta\text{Inventories}}.$$

We then compute the average PCM for 1983–1993 for each individual firm.

18 We identify low-PCM firms as those in the lower 40th percentile and high-PCM firms as those in the higher 60th percentile of the sample.

significance level in the cases of the firm-specific uncertainty measures, $UC(2,3)$ and $UC(2,5)$.

In Table 5, we present empirical results for the two subsamples on the basis of the debt ratio. According to the magnitude of the average debt ratio[19] for 1983–1993 (D/A), we divide the sample of firms into subsamples of the low-D/A firms and the high-D/A firms.[20] All the uncertainty coefficients for low-D/A firms are positive values and two of the four are marginally significant at the 10% level. In contrast, all the uncertainty coefficients for high-D/A firms are negative, and three of the four are significant at the 5% level and the other is marginally significant at the 10% level. Also, these magnitudes are statistically different between low-D/A and high-D/A firms at the 5% significance level, irrespective of the uncertainty measures.

To summarize, our results are reasonably consistent with the argument that the negative relationship between investment and uncertainty is explained not by the concavity of marginal q but by the imperfections of the capital markets for Japanese manufacturing firms.

C. The Role of Banks

In the light of the above results, it is interesting to examine what role banks have in the relationship between investment and uncertainty. There are some differences in agency

---

19 Here we calculate the debt ratio as:

$$\text{D/A} = \frac{\text{Book Value of Debt Outstanding}\begin{pmatrix}\text{Short-Term Loans and Long-Term Loans} + \text{Straight Bonds}\\ + \text{Convertible Bonds} + \text{Warrant Bonds}\end{pmatrix}}{\text{Book Value of Debt Outstanding} + \text{Market Value of Equity}}$$

We then compute the average D/A for 1983–1993 for each individual firm.

20 We identify low-D/A firms as those in the lower 40th percentile and high-D/A firms as those in the higher 60th percentile of the sample.

costs across external financing of firms, and there are therefore some differences in the sensitivity of investment to uncertainty across the external financing of firms. We now focus on bank financing and bond financing as external forms of debt financing.

As a whole, bank financing can mitigate some agency costs that arise from conflicts and information asymmetry problems, while an ongoing relationship with a bank may create hold-up problems. As Rajan (1992) and Diamond (1993) argue, in situations where firms face severe hold-up problems, multiple banking relationships and public debt issues can limit the bargaining power that banks have in a loan contract and can thus mitigate underinvestment problems. The sensitivity of investment to uncertainty, therefore, is expected to be smaller for firms with multiple banking relationships or bond financing. To test this prediction, we estimate the sensitivity of investment to uncertainty across two groups into which the sample firms are split, according to the bond-to-debt or the main-bank-loan ratios.

First, Table 6 presents the empirical results for the two groups according to the magnitude of the average bond-to-total-debt ratio for 1983–1993 (B/D).[21] The two groups are defined as follows: one is the low-B/D firms and the other is the high-B/D firms.[22] All the uncertainty coefficients for the low-B/D firms are negative and three are significant at the 5% level. In contrast, all the coefficients for the high-B/D firms are statistically insignificant. Also, the magnitudes of the uncertainty coefficients are statistically different between the low-B/D and the high-B/D firms at the 5% level significance,

---

21 Here we calculate the bond-to-total-debt ratio as:

$$\text{B/D} = \frac{\text{Bond Outstanding}\left(\text{Straight Bonds} + \text{Convertible Bonds} + \text{Warrant Bonds}\right)}{\text{Debt Outstanding}}.$$

We then compute the average B/D for 1983–1993 for each individual firm.

22 We identify low-B/D firms as those in the lower 40th percentile and high-B/D firms as those in the higher 60th percentile of the sample.

except for the case of $UC(1,3)$.

Second, Table 7 presents the results for the two groups according to the magnitude of the average main-bank-loan-to-total-loan ratio for 1983–1993 (MB/L).[23] One group is defined as low-MB/L firms and other as high-MB/L firms.[24] All the uncertainty coefficients for the low-MB/L firms are statistically insignificant, while all the coefficients for the high-MB/L firms are negative and significant at the 5% level. Also, the magnitudes of the uncertainty coefficients are statistically different between the low-MB/L and the high-MB/L firms at the 5% level.

In summary, these results support the argument that a firm's investment decision is constrained by the hold-up behavior of their main bank that has an information monopoly. Consistent with Rajan (1992) and Diamond (1993), the higher the dependence on a main bank, the more difficult it is for these firms to raise funds by bond financing and by borrowing from other banks and to invest in their projects with an increase in uncertainty.

The effect of a main bank on uncertainty in investment is expected to vary according to the kind of firm. Medium-to-small firms are likely experience severe problems of information asymmetry (moral hazard and adverse selection) between the borrowing

---

23 Here we calculate the main-bank-loan ratio as:

$$\mathrm{MB/L} = \frac{\text{Short - Term Loans Outstanding which a bank with the largest loan share provides}}{\text{Short - Term Loans Outstanding}}.$$

We then compute the average MB/L for 1983–1993 for each individual firm. We think that having the largest share of short-term loans, rather than that of both short-term and long-term loans, is the hallmark of the main bank. The reason is that a main bank has the pivotal oversight role in the ongoing financing of the firms and, at times, the ability to obtain and exercise leverage over the firm's operations and management by monitoring the flow of short-term loans. We also tried using the main-bank-loan ratio defined by both short-term and long-term loans, in place of short-term loans, with little change in the qualitative results. See Aoki and Patrick (1994) for a further analysis of the Japanese Main Bank System.

24 We identify low-MB/L firms as those in the lower 40 percentile and high-MB/L firms

firm and the lenders. These firms can mitigate information asymmetry problems by establishing a relationship with a particular bank—that is, the main-bank relationship. However, large firms are not likely to face information asymmetry problems. To establish a relationship with a main bank, if anything, brings firms to face hold-up problems and amplifies the negative relationship between investment and uncertainty.

In order to test this implication, we split the sample into large-firm and medium-to-small firm subsamples to estimate the following Equation (7) that includes the interaction term between the main-bank-loan ratio and uncertainty as a regressor:

$$(7)\ I_{i,t} / K_{i,t-1} = \alpha_1 MRQ_{i,t} + \alpha_2 FIN_{i,t-1} + \alpha_3 LK_{i,t-1} + \alpha_4 UC(m,q)_{i,t} + \alpha_5 R_{i,t-1} \cdot UC(m,q)_{i,t} + z_i + d_t + u_{i,t},$$

where $R_{i,t-1}$ denotes the main-bank-loan-to-total-loan ratio. If α_5 is a positive value, the negative relationship between investment and uncertainty is alleviated by adopting the main-bank system. Otherwise, the relationship is amplified.[25]

Table 8 presents our empirical results. Although the uncertainty coefficients for medium-to-small firms are negative and significant at the 5% level, the coefficients of the interaction between main-bank ratio and uncertainty are positive but statistically insignificant. However, although the uncertainty coefficients for large firms are insignificant, the interaction terms are statistically significant at the 5% level in the two

as those in the higher 60 percentile of the sample.

25 We use instrument-variable methods to estimate Equation (7). As instruments, we use the first and second lags of the rate of investment, $I_{i,t} / K_{i,t-1}$, marginal q, $MRQ_{i,t}$, two beginning-of-period financial variables, $FIN_{i,t-1}, LK_{i,t-1}$, current measured uncertainty, $UC(m,q)_{i,t}$, the interaction term between the beginning-of-period main bank loan ratio and current measured uncertainty, $R_{i,t-1} \cdot UC(m,q)_{i,t}$, firm dummies, z_i, and time

firm-specific uncertainty measures, $UC(2,3)$ and $UC(2,5)$, and are marginally significant at the 10% level in the remaining two cases of the uncertainty measures.

These results do not necessarily support the argument that to establish the main-bank relationship makes it useful for firms to mitigate information asymmetry problems. We find that the negative relationship between investment and uncertainty is, if anything, amplified for large firms that have established a tie relationship with a main bank. Our findings are consistent with the argument of Weinstein and Yafeh (1995, 1998), indicating that large firms with a higher main-bank-loan ratio have faced more serious hold-up problems.

7. Conclusions

In our paper, we examine the relationship between investment and uncertainty by investigating not only the configuration of marginal q but also the imperfections of the capital market. We divide the sample of Japanese manufacturing firms into two groups depending on various criteria, to explore the differences in the relationship across groups.

The finding of our paper is consistent with the notion that the negative relationship is accounted for by the imperfections of the capital market. Other things being equal, we find that the relationship is negative and large in absolute value for medium-to-small firms and high-leverage firms that are likely to be subject to a liquidity constraint.

Another finding is that establishing a close relationship with a main bank creates

---

dummies, d_t.

hold-up problems and prevents the firm from investing more. Firms without access to multiple banking relationships and public debt markets exploit no privileged position in loan contracts and bear extra additional rents from a bank. This implies an increase in a firm's cost of capital. Therefore, an increase in uncertainty increases rents that a main bank demands of these firms, resulting in it being easier for them to invest. Our results indicate that large firms tend to face these hold-up problems after the financial deregulation of the 1980s.

Acknowledgments

I would like to thank Yuzo Honda, Kazuo Ogawa, Naomichi Hosaka, and Yoshiro Tsutsui for reading the whole manuscript and giving extremely helpful comments and suggestions. All remaining errors are, of course, my own.

Appendix

We give some brief explanations about the data set employed. See Hayashi and Inoue (1991), Ogawa and Suzuki (2000), and Suzuki (2001) for detailed procedures on the construction of data on the capital stock and the land stock.

Construction of the Capital Stock

We first classify the values of depreciable assets excluding land into five categories: (1) nonresidential buildings; (2) structures; (3) machinery; (4) transportation equipment;

and (5) instruments and tools. We follow the perpetual inventory method in calculating the series of the physical depreciable capital stock, as suggested by Hayashi and Inoue (1991) and Suzuki (2001). We choose the fiscal year of 1970 as our benchmark period. We utilize the physical depreciation rates (δ) that are based on those reported in Suzuki (2001). Given the benchmark value of the depreciable stock, real investment series, and depreciation rate, we calculate the series of capital stock from the following formula:

$$K_t = (1-\delta)K_{t-1} + I_t .$$

Construction of the Land Stock

We also apply the perpetual inventory method to the calculation on the series of the land stock. We choose the fiscal year of 1970 as our benchmark period. The benchmark of land at the market price is computed by multiplying the book value of land stock in the balance sheet by the market-book ratio, 5.27, which is taken from Ogawa and Suzuki (2000). The net investment in land at the market price $(NILAND_t)$ is calculated as the increment of land, which is evaluated at current price, minus the decrement of land at current price. The decrement of land in the balance sheet is originally book-valued, so that it is converted into market value under the last-in-first-out assumption that the land sold in period t was purchased in the most recent period, period t-1. Finally, the land stock at the market price is constructed by the following formula:

$$LAND_t = LAND_{t-1}\frac{p_t^L}{p_{t-1}^L} + NILAND_t ,$$

where $LAND_t$ is the stock of land at market price; and p_t^L is the land price.

Construction of Marginal q

Marginal q is defined as the ratio of profit per unit of capital to the cost of capital under the combination of a constant-returns-to-scale technology and statistic expectation. We construct our proxy for marginal q MRQ as follows:

$$\text{Marginal q} = \frac{\text{Marginal profit of Capital}}{\text{Cost of Capital}} .$$

The marginal profit of capital $\pi_{i,t}$ is computed as follows:

$$\pi_{i,t} = \frac{OR_{i,t}}{K_{i,t-1}},$$

where $OR_{i,t} = \frac{\text{Ordinary Income} + \text{Interest Payments} + \text{Depreciation - Corporate Taxes}}{\text{Investment Good Price}}$.

The cost of capital is computed as follows:

$$r_{i,t} = (1-\tau_t) \times R_{i,t} + \delta,$$

where τ_t is the effective corporate tax rate, $R_{i,t}$ is the borrowing rate of the firm, and δ is an appropriate depreciation rate for the physical capital stock, respectively. The values of $R_{i,t}$ are computed as flows:

$$R_{i,t} = \frac{\text{Interest and Discount Paid} + \text{Bond Interest Expenses}}{\text{Short Term and Long Term Loans Payable} + \text{Bonds Payable} + \text{Discount Notes}}.$$

δ is assumed to be constant (0.075 per annum).

Construction of Uncertainty

Following Pindyck and Solimano (1993), Honda and Suzuki (2000), and Suzuki (2001), we adopt the volatility of marginal q as an uncertainty proxy. See Section 4.

Construction of the Liquidity Asset Ratio

The liquidity asset ratio, $FIN_{i,t}$ is computed as follows:

$$FN_{i,t} = \frac{\text{Current Asset}}{\text{Total Asset}}$$

References

[1] Abel, A.B. (1983), "Optimal Investment Under Uncertainty," *American Economic Review* 73, 228–233.

[2] Abel, A.B. (1986), "Stochastic Model of Investment, Marginal q and the Market Value of

the Firm," *International Economic Review* 26, 305–322.

[3] Abel, A.B. and J.C. Eberly (1994), "A Unified Model of Investment Under Uncertainty," *American Economic Review* 84, 1369–1384.

[4] Abel, A.B. and J.C. Eberly (1999), "The Effects of Irreversibility and Uncertainty on Capital Accumulation," *Journal of Monetary Economics* 44, 339–377.

[5] Aizenman, J. and N.P. Marion (1993), "Macroeconomic Uncertainty and Private Investment," *Economic Letters* 41, 207–210.

[6] Aizenman, J. and N.P. Marion (1996), "Volatility and the Investment Response," NBER Working Paper 5841.

[7] Aizenman, J. and N.P. Marion (1999), "Volatility and Investment: Interpreting Evidence from Developing Countries," *Economica* 66, 157–179.

[8] Anderson, C.W. and A.K. Makhija (1999), "Deregulation, Disintermediation, and Agency Costs of Debt: Evidence from Japan," *Journal of Financial Economics* 51, 309–339.

[9] Aoki, M. and H. Patrick (1994), *The Japanese Main Bank System: Its Relevance for Developing and Transforming Economies*, Oxford University Press, Oxford.

[10] Appelbaum, E. and E. Katz (1986), "Measures of Risk Aversion and Comparative Statics of Industry Equilibrium," *American Economic Review* 76, 524–529.

[11] Baltagi, B.H. (1995), *Econometric Analysis of Panel Data,* Wiley.

[12] Bar-Ilan A. and W.C. Strange (1999), "The Timing and Intensity of Investment," *Journal of Macroeconomics* 21, 57–77.

[13] Bell, G.K. and J.M. Campa (1997), "Irreversible Investments and Volatile Markets: A Study of the Chemical Processing Industry," *Review of Economics and Statistics* 79, 79–87.

[14] Berlin, M. and J. Loeys (1988), "Bond Covenants and Delegated Monitoring," *Journal of Finance* 53, 397–412.

[15] Bo, Hong and R. Lensink (2000), "Is the Investment–Uncertainty Relationship Non-linear?: An Empirical Analysis for the Netherlands," Working paper.

[16] Caballero, R.J. (1991), "On the Sign of the Investment–Uncertainty Relationship," *American Economic Review* 81, 279–288.

[17] Calcagnini, G. and E. Saltari (2000), "Real and Financial Uncertainty and Investment Decisions," *Journal of Macroeconomics* 22, 491–514.

[18] Carruth, A, A. Dickerson, and A. Henley (1998), "Econometric Modeling of UK Aggregate Investment: The Role of Profits and Uncertainty," Working paper.

[19] Detragiache, E., P. Garella, and L. Guiso (2000) "Multiple Versus Single Banking Relationships: Theory and Evidence," *Journal of Finance* 55, 1133–1161.

[20] Diamond, D.W. (1984), "Financial Intermediation and Delegated Monitoring," *Review of*

Economic Studies 51, 393–414.

[21] Diamond, D.W. (1991), “Monitoring and Reputation: The Choice between Bank Loans and Directly Placed Debt,” *Journal of Political Economy* 99, 689–721.

[22] Diamond, D.W. (1993), “Seniority and the Maturity of Debt Contracts,” *Journal of Financial Economics* 33, 341–368.

[23] Dixit, A.K. and R.S. Pindyck (1994), *Investment Under Uncertainty*, Princeton, N.J.: Princeton University Press.

[24] Domowitz, I., R.G. Hubbard, and B.C. Petersen (1986), “Business Cycles and the Relationship between Concentration and Price-cost Margins,” *Rand Journal of Economics* 17, 1–17.

[25] Driver, C. and D. Moreton (1991), “The Influence of Uncertainty on UK Manufacturing Investment,” *Economic Journal* 101, 1452–1459.

[26] Fama, E. (1985), “What’s Different about Banks?” *Journal of Monetary Economics* 15, 29–39.

[27] Fazzari, S.M., R.G. Hubbard and B.C. Petersen (1988), “Financing Constraints and Corporate Investment,” *Brookings Papers on Economic Activity* 1, 141–195.

[28] Ferderer, J.P. (1993a), “Does Uncertainty Affect Investment?” *Journal of Post Keynesian Economics* 16, 19–35.

[29] Ferderer, J.P. (1993b), “The Impact of Uncertainty on Aggregate Investment Spending: An Empirical Analysis,” *Journal of Money, Credit and Banking* 25, 30–48.

[30] Ghosal, V. and P. Loungani (1996), “Product Market Competition and the Impact of Price Uncertainty on Investment: Some Evidence from us Manufacturing Industries,” *Journal of Industrial Economics* 45, 217–228.

[31] Ghosal, V. and P. Loungani (2000), “The Differential Impact of Uncertainty on Investment in Small and Large Businesses,” *Review of Economics and Statistics* 82, 338–349.

[32] Gilchrist, S. and C.P. Himmelberg (1999), “Investment, Fundamentals and Finance,” in: B.S. Bernanke and J.J. Rotemberg (eds), *NBER Macroeconomics Annual* 1999, Cambridge: MIT Press, 223–262.

[33] Greenwald, B., J.E. Stiglitz, and A. Weiss (1984), “Information Imperfections in the Capital Market and Macroeconomic Fluctuations,” *American Economic Review* 74, 194–199.

[34] Greenwald, B. and J.E. Stiglitz (1990), “Macroeconomic Models with Equity and Credit Rationing,” in R.G. Hubbard (ed.), *Asymmetric Information, Corporate Finance, and Investment*, University of Chicago Press, 15–42.

[35] Guiso, L. and G. Parigi (1999), “Investment and Demand Uncertainty,” *Quarterly*

Journal of Economics 114, 185–227.

[36] Hartman, R. (1972), "The Effects of Price and Cost Uncertainty on Investment," *Journal of Economic Theory* 5, 258–266.

[37] Hayashi, F. (1982), "Tobin's Marginal Q and Average Q: A Neoclassical Interpretation," *Econometrica* 50, 213–224.

[38] Hayashi, F. and T. Inoue (1991), "The Relation between Firm Growth and Q with Multiple Capital Goods: Theory and Evidence from Panel Data on Japanese Firms," *Econometrica* 59, 731–753.

[39] Honda, Y. and K. Suzuki (2000), "Estimation of the Investment Thresholds of Large Japanese Manufacturers," *Japanese Economic Review* 51, 473–491.

[40] Hoshi, T., A.K. Kashyap and D. Scharfstein (1990), "The Role of Banks in Reducing Financial Distress in Japan," *Journal of Financial Economics* 27, 67–88.

[41] Hoshi, T., A.K. Kashyap and D. Scharfstein (1991), "Corporate Structure, Liquidity and Investment: Evidence from Japanese panel data," *Quarterly Journal of Economics* 106, 33–60.

[42] Houston, J. and C. James (1996), "Bank Information Monopolies and the Mix of Public and Private Debt Claims," *Journal of Finance* 51, 1863–1889.

[43] Hubbard, R.G. (1998), "Capital-Market Imperfections and Investment" *Journal of Economic Literature* 36, 193–225.

[44] Huizinga, J. (1993), "Inflation Uncertainty, Real Price Uncertainty, and Investment in U.S. Manufacturing," *Journal of Money, Credit, and Banking* 25, 521–549.

[45] Kalckreuth, U. (2000), "Exploring the Role of Uncertainty for Corporate Investment Decisions in Germany," Discussion Paper, Economic Research Group of Deutsche Bundesbank.

[46] Kaplan, N.K. and L. Zingales (1997), "Do Investment–Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?" *Quarterly Journal of Economics* 112, 169–215.

[47] Kaplan, S. and B. Minton (1994), "Appointments of Outsiders to Japanese Boards: Determinants and Implications for Managers," *Journal of Political Economy* 36, 225–258.

[48] Leahy, J.V. and T.M. Whited (1996), "The Effect of Uncertainty on Investment: Some Stylized Facts," *Journal of Money, Credit, and Banking* 28, 65–83.

[49] Lee, J. and K. Shin (2000), "The Role of a Variable Input in the Relationship Between Investment and Uncertainty," *American Economic Review* 90, 667–680.

[50] Lensink, R. (1998), "Uncertainty, Financial Development and Economic Growth: An Empirical Analysis," Working paper.

[51] Lensink, R. (2000), “Is There an Uncertainty–Laffer Curve? “ Working paper.

[52] Lensink, R., H. Bo, and E. Sterken (1999), “Does Uncertainty affect Economic Growth?” *Weltwitschaftiches Archive* 135, 379–396.

[53] Lensink, R., P.V. Steen, and E. Sterken (1999), “Is Size Important for the Investment–Uncertainty Relationship? Empirical Analysis for Dutch Firms,” Working paper.

[54] Lensink, R., P.V. Steen, and E. Sterken (2000), “Uncertainty and Growth of Firm,” Working Paper.

[55] Matsubayashi, Y (1995), “Kitairijyunritsu, Fukakujitsusei to Setsubi Toshi” *Nihon Keizau Kenkyu* 28, 31-52 (in Japanese).

[56] McDonald, R. and D. Siegel (1986), “The Value of Waiting to Invest” *Quarterly Journal of Economics* 101, 707–728.

[57] Metcalf, G.E. and K.A. Hassett (1995), “Investment Under Alternative Return Assumptions: Comparing Random Walks and Mean Reversion,” *Journal of Economic Dynamics and Control* 19, 1471–1488.

[58] Minton, B.A. and C. Schrand (1999), “The Impact of Cash Flow Volatility on Discretionary Investment and Costs of Debt and Equity Financing,” *Journal of Financial Economics* 54, 423–460.

[59] Nakamura, T. (1999), “Risk-Aversion and the Uncertainty-Investment Relationship: A Note” *Journal of Economic Behavior & Organization* 38, 357–363.

[60] Ogawa, K. and K. Suzuki (2000), “Uncertainty and Investment: Some Evidence from the Panel Data of Japanese Manufacturing Firms,” *Japanese Economic Review* 51, 170–192.

[61] Ogawa, K. and S. Kitasaka (1998), *Shisan Shijyo to Keiki Hendo – Gendai Nippon Keizai no Jissho Bunseki*, Nippon Keizai Shinbunsha (in Japanese).

[62] Ogawa, K., S. Kitasaka, T. Watanabe, T. Maruyama, H. Yamaoka and Y. Iwata (1994), “Asset Markets and Capital Investment in Japan,” in: Asset Markets and Business Fluctuations in Japan, The Keizai Bunseki (The Economic Analysis), Economic Research Institute, Economic Planning Agency.

[63] Pattillo, C. (1998), “Investment, Uncertainty, and Irreversibility in Ghana,” *IMF Staff Papers* 45, 522–553.

[64] Petersen, M. and R.G. Rajan (1994), “The Benefits of Lender Relationships: Evidence form Small Business Data,” *Journal of Finance* 49, 3–37.

[65] Pindyck, R.S. and A. Solimano (1993), “Economic Instability and Aggregate Investment,” *NBER Macroeconomics Annual* 8, 259–303.

[66] Price, S. (1995), “Aggregate Uncertainty, Capacity Utilization and Manufacturing

Investment," *Applied Economics* 27, 147–154.

[67] Price, S. (1996), "Aggregate Uncertainty, Investment and Asymmetric Adjustment in the UK Manufacturing Sector," *Applied Economics* 28, 1369–1379.

[68] Prowse, S. (1990), "Institutional Investment Patterns and Corporate Financial Behavior in the United States and Japan," *Journal of Financial Economics* 27, 43–66.

[69] Rajan, R. (1992), "Insiders and Outsiders: The Choice between Informed and Arm's-length Debt," *Journal of Finance* 47, 1367–1400.

[70] Ramey, G. and V. Ramey (1995), "Cross-Country Evidence on the Link Between Volatility and Growth," *American Economic Review* 85, 1138–1151.

[71] Sarkar, S. (2000), "On the Investment–Uncertainty Relationship in a Real Option Model," *Journal of Economic Dynamics and Control* 24, 219–225.

[72] Sakellaris, P. (1994), "A Note on Competitive Investment Under Uncertainty: Comment," *American Economic Review* 84, 1107–1112.

[73] Sharpe, S. (1990), "Asymmetric Information, Bank Lending, and Implicit Contracts: A Stylized Model of Customer Relations," *Journal of Finance* 45, 1069–1087.

[74] Stulz, R.M. (1990), "Managerial Discretion and Optimal Financing Policies," *Journal of Financial Economics* 26, 3–27.

[75] Suzuki, K (2001), *Setsubi Toshi to Kinyu Shijyo – Jyoho no Hitaisyousei to Fukakujitsusei*, Tokyo Daigaku Syuppankai (in Japanese).

[76] Weinstein, D.E. and Y. Yafeh (1995), "Japan's Corporate Groups: Collusive or Competitive? An Empirical Investigation of Keiretsu Behavior," *Journal of Industrial Economics*, 43, 359–376.

[77] Weinstein, D.E. and Y. Yafeh (1998), "On the Costs of a Bank-centered Financial System: Evidence from the Changing Main Bank Relations in Japan," *Journal of Finance* 53, 635–672.

[78] Yoshikawa, H. (1980), "On the "q" Theory of Investment," *American Economic Review* 70, 739–743.

[79] Zeira, J. (1990), "Cost Uncertainty and the Rate of Investment," *Journal of Economic Dynamics and Control* 14, 53–63.

Table 1.
Summary Statistics; Sample Period: 1983-1993 (Fiscal Year)

		Full Sample	Firm Size (1)		PCM (2)	
			Medium-to-Small	Large	Low	High
	Number of Observations	2631	1019	1075	1057	1037
I/K	Mean	0.150	0.132	0.167	0.137	0.159
	Median	0.130	0.103	0.153	0.118	0.141
	Standard Deviation	0.106	0.116	0.093	0.107	0.106
MRQ	Mean	2.216	2.377	2.116	1.968	2.420
	Median	2.045	2.235	1.961	1.905	2.194
	Standard Deviation	1.491	1.871	1.075	1.364	1.576
FIN	Mean	0.975	1.342	0.736	0.907	1.082
	Median	0.663	0.841	0.565	0.601	0.711
	Standard Deviation	1.203	1.657	0.698	1.001	1.512
LK	Mean	1.347	2.026	0.788	1.669	1.215
	Median	0.808	1.251	0.591	0.920	0.763
	Standard Deviation	1.692	2.280	0.667	2.171	1.323
UC(1,3)	Mean	0.491	0.709	0.300	0.503	0.494
	Median	0.290	0.439	0.200	0.270	0.312
	Standard Deviation	0.582	0.722	0.357	0.599	0.604
UC(1,5)	Mean	0.644	0.926	0.393	0.667	0.641
	Median	0.424	0.620	0.273	0.410	0.435
	Standard Deviation	0.666	0.819	0.388	0.677	0.696
UC(2,3)	Mean	0.498	0.720	0.306	0.483	0.521
	Median	0.304	0.465	0.199	0.277	0.324
	Standard Deviation	0.561	0.701	0.344	0.532	0.616
UC(2,5)	Mean	0.608	0.868	0.380	0.605	0.620
	Median	0.408	0.637	0.277	0.384	0.422
	Standard Deviation	0.592	0.711	0.382	0.587	0.619

Notes:

(1) According to the magnitude of capital stock at end-of-fiscal-year 1993, we divide the sample of firms into two: medium-to-small firms, of which the observations are below the 40th percentile of the full sample, and large firms, of which the observations are above the 60th percentile.

(2) According to the magnitude of the average price cost margin for 1983–1993, we divide the sample of firms into the low-PCM firms, of which the observations are below the 40th percentile of the full sample, and the high-PCM firms, of which the observations are above the 60th percentile.

Table 1 (Continued).
Summary Statistics; Sample Period: 1983-1993 (Fiscal Year)

D/A (3)		B/D (4)		MB/L (5)	
Low	**High**	**Low**	**High**	**Low**	**High**
1071	1026	1042	1057	1049	1046
0.168	0.127	0.131	0.168	0.152	0.148
0.149	0.105	0.107	0.152	0.138	0.119
0.107	0.107	0.107	0.105	0.094	0.114
2.410	1.977	2.058	2.347	2.395	2.035
2.154	1.905	1.957	2.088	2.114	1.944
1.386	1.679	1.688	1.454	1.561	1.506
0.926	1.046	0.923	1.109	1.088	0.910
0.707	0.656	0.613	0.746	0.737	0.624
0.879	1.238	1.062	1.426	1.184	1.339
0.941	1.905	1.819	0.900	1.291	1.385
0.639	1.201	0.994	0.626	0.792	0.846
1.199	2.180	2.279	0.907	1.549	1.552
0.414	0.638	0.627	0.420	0.476	0.533
0.256	0.369	0.357	0.267	0.256	0.326
0.485	0.715	0.708	0.485	0.613	0.602
0.541	0.843	0.814	0.543	0.610	0.709
0.369	0.531	0.520	0.357	0.371	0.486
0.535	0.821	0.763	0.578	0.688	0.704
0.421	0.640	0.632	0.431	0.464	0.554
0.272	0.383	0.381	0.272	0.266	0.361
0.460	0.685	0.681	0.475	0.564	0.598
0.515	0.779	0.757	0.531	0.571	0.673
0.363	0.520	0.527	0.348	0.357	0.497
0.486	0.717	0.678	0.542	0.626	0.604

Notes:

(3) According to the magnitude of the average debt ratio for 1983–1993, we divide the sample of firms into the low-D/A firms, of which the observations are below the 40th percentile of the full sample, and the high-D/A firms, of which the observations are above the 60th percentile.

(4) According to the magnitude of the average bond-to-total-debt ratio for 1983–1993, we divide the sample of firms into the low-B/D firms, of which the observations are below the 40th percentile of the full sample, and the high-B/D firms, of which the observations are above the 60th percentile.

(5) According to the magnitude of the average main-bank-loan-to-total-loan ratio for 1983–1993, we divide the sample of firms into the low-MB/L firms, of which the observations are below the 40th percentile of the full sample, and the high-MB/L firms, of which the observations are above the 60th percentile. Here, MB/L is short-term loans outstanding, which a bank with the largest loan share provides, divided by short-term loans outstanding.

Table 2

Empirical Results of the Investment Function

Full Sample

Part 1 (individual-specific and industry-wide uncertainty)								
	Uncertainty Proxy: UC(1,3)				Uncertainty Proxy: UC(1,5)			
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0273**	7.26***	**0.0279**	7.36***	**0.0282**	7.41***	**0.0290**	7.45***
FIN	**0.0115**	3.51***	**0.0112**	3.39***	**0.0123**	3.74***	**0.0125**	3.79***
LK	**0.0168**	6.11***	**0.0170**	6.17***	**0.0170**	6.19***	**0.0169**	6.12***
UC(m,q)	**-0.0102**	-2.05**	**0.0062**	0.62	**-0.0137**	-2.52**	**-0.0030**	-0.28
UC(m,q)^2			**-0.0058**	-1.89*			**-0.0032**	-1.19
Adjusted R^2	**0.232**		**0.232**		**0.233**		**0.232**	

Part 2 (individual-specific uncertainty)								
	Uncertainty Proxy: UC(2,3)				Uncertainty Proxy: UC(2,5)			
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0279**	7.35***	**0.0279**	7.34***	**0.0280**	7.32***	**0.0280**	7.31***
FIN	**0.0118**	3.59***	**0.0117**	3.56***	**0.0117**	3.56***	**0.0118**	3.58***
LK	**0.0165**	6.02***	**0.0165**	6.02***	**0.0167**	6.09***	**0.0167**	6.07***
UC(m,q)	**-0.0108**	-1.98**	**-0.0145**	-1.25	**-0.0114**	-1.70*	**-0.0041**	-0.28
UC(m,q)^2			**0.0014**	0.36			**-0.0026**	-0.56
Adjusted R^2	**0.232**		**0.231**		**0.231**		**0.2300**	

Note: The estimation procedure uses the instrument-variable method. The dependent variable is the rate of investment. Instruments that we utilize in the first and third columns of part 1 and part 2 are the first and second lags of the rate of investment, marginal q, two beginning-of-period financial variables, current measured uncertainty, firm dummies, and time dummies. Also, in the second and fourth columns of part 1 and part 2, we add the square of current measured uncertainty to the set of instruments. Adjusted R^2 is the coefficient of the determination adjusted for the degrees of freedom. t-values are based on White-corrected standard errors. All equations include firm dummy and time dummy variables. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Table 3

Empirical Results of the Investment Function

Classification by Firm Size

Medium-to-Small Firms

	UCE(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0300**	4.80***	**0.0317**	4.89***	**0.0314**	4.88***	**0.0317**	4.78***
FIN	**0.0097**	2.30**	**0.0108**	2.59***	**0.0103**	2.48**	**0.0102**	2.44**
LK	**0.0135**	3.74***	**0.0133**	3.70***	**0.0131**	3.64***	**0.0133**	3.72***
UC(m,q)	**-0.0158**	-2.17**	**-0.0164**	-2.05**	**-0.0206**	-2.56***	**-0.0223**	-2.06**
Adjusted R^2	**0.183**		**0.183**		**0.183**		**0.182**	

Large Firms

	UCE(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0251**	3.77***	**0.0222**	3.50***	**0.0269**	4.25***	**0.0249**	3.96***
FIN	**0.0031**	0.33	**0.0058**	0.64	**0.0009**	0.10	**0.0034**	0.38
LK	**0.0687**	7.69***	**0.0706**	7.78***	**0.0675**	7.56***	**0.0678**	7.44***
UC(m,q)	**0.0055**	0.52	**-0.0118**	-1.08	**0.0195**	1.77*	**0.0057**	0.49
Adjusted R^2	**0.248**		**0.248**		**0.251**		**0.248**	

Notes: See the notes for Table 2.

Table 4

Empirical Results of the Investment Function

Classification by Price–Cost Margin

	Low PCM							
	UCE(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0220**	3.37***	**0.0227**	3.50***	**0.0237**	3.64***	**0.0232**	3.57***
FIN	**0.0236**	3.19***	**0.0233**	3.16***	**0.0233**	3.16***	**0.0238**	3.23***
LK	**0.0065**	1.85*	**0.0072**	2.04**	**0.0066**	1.88*	**0.0070**	1.98**
UC(m,q)	**-0.0123**	-1.60	**-0.0204**	-2.31**	**-0.0260**	-2.88***	**-0.0313**	-2.97***
Adjusted R^2	**0.219**		**0.221**		**0.224**		**0.222**	
	High PCM							
	UCE(1,3)		**UC(1,5)**		**UC(2,3)**		**UC(2,5)**	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0275**	4.50***	**0.0288**	4.62***	**0.0276**	4.49***	**0.0272**	4.35***
FIN	**0.0093**	2.28**	**0.0103**	2.50**	**0.0094**	2.31**	**0.0094**	2.31**
LK	**0.0441**	7.02***	**0.0443**	7.06***	**0.0436**	6.96***	**0.0434**	6.91***
UC(m,q)	**-0.0111**	-1.35	**-0.0119**	-1.43	**0.0013**	0.16	**0.0061**	0.58
Adjusted R^2	**0.27**		**0.271**		**0.271**		**0.272**	

Notes: See the notes for Table 2.

Table 5

Empirical Results of the Investment Function

Classification by Debt Ratio

	Low D/A							
	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0357**	7.72***	**0.0354**	7.72***	**0.0351**	7.67***	**0.0351**	7.67***
FIN	**0.0140**	1.86*	**0.0144**	1.91*	**0.0131**	1.73*	**0.0134**	1.78*
LK	**0.0061**	1.16	**0.0065**	1.23	**0.0062**	1.19	**0.0061**	1.17
UC(m,q)	**0.0084**	0.91	**0.0022**	0.24	**0.0181**	1.80*	**0.0206**	1.75*
Adjusted R^2	**0.264**		**0.265**		**0.267**		**0.266**	

	High D/A							
	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0183**	2.47**	**0.0207**	2.65***	**0.0203**	2.65***	**0.0206**	2.67***
FIN	**0.0151**	2.77***	**0.0173**	3.23***	**0.0147**	2.70***	**0.0151**	2.80***
LK	**0.0194**	4.97***	**0.0195**	5.02***	**0.0192**	4.88***	**0.0195**	5.05***
UC(m,q)	**-0.0132**	-1.83*	**-0.0191**	-2.21**	**-0.0198**	-2.49**	**-0.0236**	-2.29**
Adjusted R^2	**0.201**		**0.202**		**0.203**		**0.202**	

Notes: See the notes for Table 2.

Table 6

Empirical Results of the Investment Function

Classification by Bond Ratio

Low B/D

	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0222**	3.42***	**0.0251**	3.65***	**0.0237**	3.55***	**0.0249**	3.65***
FIN	**0.0192**	2.87***	**0.0188**	2.80***	**0.0184**	2.75***	**0.0180**	2.68***
LK	**0.0090**	2.59***	**0.0093**	2.67***	**0.0089**	2.54***	**0.0092**	2.63***
UC(m,q)	**-0.0105**	-1.53	**-0.0218**	-2.66***	**-0.0163**	-2.14**	**-0.0284**	-2.87***
Adjusted R^2	**0.175**		**0.178**		**0.176**		**0.178**	

High B/D

	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0247**	5.12***	**0.0253**	5.31***	**0.0253**	5.31***	**0.0252**	5.32***
FIN	**0.0091**	2.10***	**0.0086**	1.94*	**0.0086**	1.96**	**0.0082**	1.89*
LK	**0.0385**	4.43***	**0.0376**	4.30***	**0.0379**	4.38***	**0.0372**	4.27***
UC(m,q)	**-0.0065**	-0.64	**0.0029**	0.29	**0.0021**	0.21	**0.0089**	0.77
Adjusted R^2	**0.272**		**0.272**		**0.272**		**0.273**	

Notes: See the notes for Table 2.

Table 7

Empirical Results of the Investment Function

Classification by Main-Bank-Loan Ratio

	Low-MB/L							
	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0215**	4.70***	**0.0218**	4.74***	**0.0216**	4.72***	**0.0214**	4.68***
FIN	**-0.0058**	-0.29	**-0.0045**	-0.23	**-0.0064**	-0.32	**-0.0055**	-0.28
LK	**0.0165**	4.33***	**0.0168**	4.43***	**0.0164**	4.32***	**0.0166**	4.36***
UC(m,q)	**-0.0003**	-0.05	**-0.0073**	-0.97	**0.0027**	0.35	**-0.0014**	-0.15
Adjusted R^2	**0.231**		**0.232**		**0.232**		**0.231**	

	High-MB/L							
	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0364**	5.53***	**0.0392**	5.74***	**0.0387**	5.71***	**0.0388**	5.66***
FIN	**0.0622**	2.60***	**0.0609**	2.54**	**0.0556**	2.31**	**0.0573**	2.38**
LK	**0.0352**	5.90***	**0.0346**	5.80***	**0.0339**	5.66***	**0.0339**	5.65***
UC(m,q)	**-0.0219**	-2.63***	**-0.0197**	-2.25**	**-0.0198**	-2.11**	**-0.0233**	-2.02**
Adjusted R^2	**0.234**		**0.233**		**0.232**		**0.232**	

Notes: See the notes for Table 2.

Table 8

Empirical Results of the Investment Function

Main Bank Effect between Medium-to-Small Firms and Large Firms

Medium-to-Small Firms

	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**	**Estimate**	**t-value**
MRQ	**0.0300**	4.77***	**0.0320**	4.84***	**0.0314**	4.87***	**0.0319**	4.77***
FIN	**0.0100**	2.39**	**0.0109**	2.59***	**0.0103**	2.47**	**0.0102**	2.43**
LK	**0.0138**	3.82***	**0.0142**	3.92***	**0.0132**	3.63***	**0.0139**	3.85***
UC(m,q)	**-0.0218**	-2.19**	**-0.0255**	-2.40**	**-0.0220**	-2.22**	**-0.0287**	-2.28**
R*UC(m,q)	**0.0167**	0.94	**0.0235**	1.44	**0.0047**	0.26	**0.0218**	1.12
Adjusted R^2	**0.1810**		**0.1820**		**0.1820**		**0.1810**	

Large Firms

	UC(1,3)		UC(1,5)		UC(2,3)		UC(2,5)	
Variable	**Estimate**	**t-value**	**Estimate**	**t-value**	***Estimate***	**t-value**	**Estimate**	**t-value**
MRQ	**0.0246**	3.75***	**0.0219**	3.49***	**0.0273**	4.34***	**0.0251**	4.03***
FIN	**0.0030**	0.33	**0.0047**	0.52	**-0.0006**	-0.07	**0.0017**	0.19
LK	**0.0682**	7.63***	**0.0700**	7.72***	**0.0673**	7.53***	**0.0677**	7.44***
UC(m,q)	**0.0154**	1.25	**-0.0002**	-0.02	**0.0313**	2.35**	**0.0162**	1.28
R*UC(m,q)	**-0.0586**	-1.87*	**-0.0644**	-2.29**	**-0.0528**	-1.65*	**-0.0722**	-2.24**
Adjusted R^2	**0.2480**		**0.2490**		**0.2510**		**0.2490**	

Note: The estimation procedure uses the instrument variable method. The dependent variable is the rate of investment. Instruments that we utilize are the first and second lags of the rate of investment, marginal q, two beginning-of-period financial variables, current measured uncertainty, the interaction term between the main bank loan ratio and uncertainty, firm dummies, and time dummies. Adjusted R^2 is the coefficient of the determination adjusted for the degrees of freedom. t-values are based on White-corrected standard errors. All equations include firm dummy and time dummy variables. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.