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Abstract. This paper examines two hypotheses regarding how uncertainty affects investment–cash flow sensitivity. In this regard, one hypothesis pertains to the cautionary channel through which investment–cash flow sensitivity decreases as uncertainty increases, and the other relates to the financing constraint channel through which the sensitivity increases. This paper evaluates the impact of uncertainty on investment–cash flow sensitivity by using firm-level data on the Japanese manufacturing industry. We demonstrate that the cautionary effect that makes actual corporate investment decisions unresponsive to the firm's financing conditions becomes dominant under higher uncertainty irrespective of the type of corporate investment—capital investment and research and development (R&D)—and is more pronounced in firms with fewer cash holdings.

JEL classification: G01, G31, G32.

Keywords: uncertainty shock; capital investment; R&D; investment–cash flow sensitivity; system GMM; cautionary behavior.

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1. Introduction The prevailing COVID-19 crisis as well as the Global Financial Crisis provides an opportunity to highlight policy measures to support the economy. Each government maximizes its investment support to firms facing high uncertainty by maintaining highly accommodative financial conditions through, for example, utilizing lending by the central bank and credit guarantee programs. A major concern about such accommodative policies involves the suspicion that they distort corporate investment decisions.[1] In this paper, we seek to address this issue by empirically examining the relationship between uncertainty and investment sensitivity to a firm's financing sources. Thus, we reveal that high uncertainty causes the disappearance of investment–cash flow sensitivity and then explores some associated policy implications.

The downturn in economic variables, such as business profits, labor income, and corporate productivity, reflects the fluctuations in economic uncertainty.[2] The impact of increasing uncertainty on corporate decision-making has traditionally been analyzed within the framework of irreversible investment (Abel (1983), Bernanke (1983), Dixit and Pindyck (1994), Abel and Eberly (1994; 1996), Caballero (1999), Ogawa and Suzuki (2000), Bloom (2007; 2009), and Bachmann et al. (2013a)). This approach considers a firm's future investment opportunities to be the real option, i.e., when making investment decisions under high uncertainty, firms show cautionary behavior such that they wait until the uncertainty is resolved, and see whether the project is more clearly successful or not.

On the other hand, spurred by the drastic increase in asset price volatility and the credit crunch during the Global Financial Crisis, an emergent body of literature has emphasized the role of financial friction as an additional channel through which volatility fluctuations substantially and unfavorably affect the economy (Brunnermeier and Sannikov (2014), Christiano et al. (2014), and Gilchrist et al. (2014)). This approach predicts that increased uncertainty raises the user cost of capital through the interaction between heightened uncertainty and financial market frictions; thus, the heightened uncertainty causes firms with higher costs of capital to delever, inducing a decline in investment spend-

[1] See, e.g., Ioannidou et al. (2018) for unintended effects of credit guarantee programs after the Global Financial Crisis. As for concerns about loan guarantees during the COVID-19 crisis, see, e.g., Zoller-Rydzek and Keller (2020).

[2] See Bloom (2014) for a survey of the theoretical and empirical literature.

ing by firms with financing constraints (Bernanke et al. (1996) and Kiyotaki and Moore (1997)).

This study contributes to both these strands of the literature on firm investment under uncertainty. More concretely, it uses firm-level consolidated data on the Japanese manufacturing industry from 2001 to 2014, thereby empirically examining their theoretical predictions regarding how investment sensitivity to a firm's financing conditions depends on fluctuations in economic uncertainty. While the two strands of the literature on uncertainty and investment dynamics agree that uncertainty distorts the level of corporate investment through the cautionary and/or the financing constraint channel, Bloom (2014) highlights not only this level effect, but also a sensitivity effect regarding a firm's characteristics, which has received little attention in the extant literature. In this regard, we empirically examine this sensitivity effect by addressing the role of a firm's financing conditions through which fluctuations in uncertainty affect corporate investment dynamics. To our knowledge, this paper is the first to address the role of financing sources in corporate investment under uncertainty, particularly focusing on the sensitivity effect of uncertainty on corporate investment through internal financing from cash flows.

Our empirical analysis is motivated by economic environments where heightened economic uncertainty involves tightening financial conditions, resulting in widely observed stagnant corporate investment in any country (see, e.g., Popescu and Smets (2010) for the German economy, and Gilchrist et al. (2014) and Caldara et al. (2016) for the U.S. economy). Figure 1 shows uncertainty measures in Japan, while Figure 2 shows corporate investments by Japanese firms and their financing sources.[3] Uncertainty measures spiked during the Japanese banking crisis of the early 2000s and the Global Financial Crisis of 2008–2009, accompanied by the drastic decrease in cash flows and debt issues. Furthermore, such decreases in internal and external financing variables appear to be associated with the decrease in capital investment; however, not to be associated with research and development (R&D).[4] These casual observations suggest that higher uncertainty should

[3] See Section 2 for definitions of each variable.

[4] See Nakashima and Takahashi (2018; 2020) for details on the Japanese banking crisis of the early 2000s and its real effects. They show that the Japanese banking system malfunctioned in the early 2000s, such that the urgent write-off of nonperforming loans caused bank-driven terminations of bank-borrower

lead to more severe financial constraints, thus decreasing capital investment. However, once we consider the wait-and-see strategy, we cannot simply attribute the coexistence of higher uncertainty and decreases in corporate investment to severe financing constraints; that is, capital investment can decrease under high uncertainty independent of the severity of the financing conditions. Therefore, without distinguishing the financing constraint and cautionary effects, we cannot understand the role of a firm's financing conditions in their investment decisions under uncertainty.

This study seeks to disentangle these two effects in the empirics by providing two types of predictions about investment–financing sensitivity associated with the level of uncertainty. According to the literature emphasizing the interaction effect between uncertainty and financial friction, high uncertainty limits a firm's debt capacity because such heightened uncertainty favors its shareholders over its bondholders under limited liability. Thus, high uncertainty induces a decline in the value of debt claims (Merton (1974) and Nakashima and Saito (2009)), increases the cost of capital, and exacerbates a firm's financing constraints. This theoretical insight regarding the financing constraint effect under high uncertainty is followed by this study's first prediction that high uncertainty increases the sensitivity of corporate investment to cash flows since dependence on cash flows increases because of the increased cost of external financing and the resulting severity of financing constraints.

The second prediction is an extension of the traditional wait-and-see effect under high uncertainty. In this regard, high uncertainty makes managers less sensitive to changes in the fundamental economic conditions, including the cost of capital (Bloom (2007; 2014), Bloom et al. (2007), Drobetz et al. (2018), and Alfaro et al. (2019)). From this viewpoint, the strength of the relationship between corporate investment and the cost of capital (i.e., the dependence on cash flows or its premium over external financing) will be decreasing in uncertainty, although firms face a higher cost of capital. This financial aspect of the wait-and-see effect, or the cautionary effect, leads to the prediction that high uncertainty decreases investment sensitivity to cash flows; put differently, corporate investment decisions become indifferent to the firm's financing constraints under high uncertainty because

relationships under the Financial Revitalization Program: the so-called Takenaka Plan, implemented in October 2002.

of the dominance of the cautionary effect over the financing constraint effect.[5]

Given these two predictions, this study accordingly focuses on two types of corporate investments: capital investment and R&D. The comparative studies on the cash flow sensitivity of capital and R&D investments provide mixed results regarding which type of corporate spending is more affected by a firm's financing constraints (Himmelberg and Petersen (1994), Almeida and Campello (2007), and Brown and Petersen (2009)). Moreover, as shown in Figures 1 and 2, uncertainty impacts the dynamics of capital investment and R&D differently because of the presence of different adjustment costs (Bloom (2007) and Bontempi (2016)). We uncover the different characteristics of firms' sensitivity to financing conditions under uncertainty by focusing on Japanese manufacturing firms making both types of investments.

Our empirics also aim to contribute to the literature on investment–cash flow sensitivity, which constitutes one of the largest bodies of literature in corporate finance. Some studies have questioned the interpretation of investment–cash flow sensitivity as a measure of a firm's financing constraints based on the agency problem.[6] However, these empirical studies neither address nor control for the effect of the uncertainty faced by firms. Considering that many studies have still regarded investment–cash flow sensitivity as a useful measure of financing constraints (see Hoshi et al. (1991), the references in Hubbard (1998), and, more recently, Moyen (2004), Bhagat et al. (2005), Biddle and Hilary (2006), Almeida and Campello (2007), Carpenter and Guariglia (2008), Beatty et al. (2010), Larkin et al. (2018), and Sakai (2020)), the implication of investment–cash flow sensitivity should be reassessed regarding uncertainty. Accordingly, this study provides evidence that helps settle the debate, demonstrating that the sensitivity disappears under high uncertainty because

[5] Bloom (2007) and Bloom et al. (2007) emphasize this dominance of the cautionary effect on corporate investment decisions under uncertainty over the direct effects of changes in economic and financial conditions through which firms appear less responsive to any given fundamental shock.

[6] Kaplan and Zingales (1997) study firms classified as financially constrained by Fazzari et al. (1998) and find that U.S. firms that appear less constrained exhibit greater investment–cash flow sensitivities. More recently, Chen and Chen (2012) also find that investment–cash flow sensitivity is zero—even during the U.S. credit crunch—and suggest that investment–cash flow sensitivity is a poor measure of financing constraints. Brown and Petersen (2009) show that U.S. investment–cash flow sensitivity largely disappears for capital investment but remains comparatively strong for R&D investment, even though it is declining over time. Hori et al. (2006) point out that investment–cash flow sensitivity during the 1990s in Japan has a positive value, but it does not necessarily mean that Japanese firms were subject to financing constraints.

of firms' cautionary behavior.

The following section will discuss the study's empirical design by presenting the empirical model and method used, defining uncertainty measures, and describing the data sources. Section 3 reports the estimation results for capital investment and R&D spending. Section 4 addresses complementary issues, and Section 5 offers policy implications and conclusions.

2. Empirical Design

In this section, we define the sensitivity effect of uncertainty on corporate investment by introducing a dynamic investment equation. We then discuss our uncertainty measures, the estimation method, and our dataset. Appendix I includes an overview our identification strategy to estimate the sensitivity effect in more detail.

2.1. The Sensitivity Effect of Uncertainty on Corporate Investment

We start by discussing how to measure the effect of internal and external financing on corporate investment in association with the extent of uncertainty. To this end, we introduce a dynamic investment equation in the following general setting (Bond and Meghir (1994)):[7]

$$\begin{aligned} \mathrm{I}_{i,t} &= a_0 \mathrm{I}_{i,t-1} + a_{0u} \mathrm{I}_{i,t-1} \mathrm{U}^s_{i,t-1} + \sum_{k=0}^{m} \left(b_k f_{i,t-k} + b_{ku} f_{i,t-k} \mathrm{U}^s_{i,t-k} \right) + \sum_{k=0}^{m} c_{ku} \mathrm{U}^s_{i,t-k} \\ &\quad + d_0 y_{i,t} + v_t * \mathrm{IND}_i + a_i + \epsilon_{i,t}, \end{aligned} \tag{1}$$

where $y_{i,t}$ denotes a variable that controls for the demand conditions for corporate investment such as Tobin's Q (Hoshi and Kashyap (1990), Hayashi and Inoue (1991), and Hennessy et al. (2007)). $v_t * \mathrm{IND}_i$ is the interaction term of the year dummies and industry dummies, controlling for the time-varying industry effects. a_i is a firm fixed effect that controls for the time-invariant unobservable determinants of firm investment at the firm level. $\varepsilon_{i,t}$ is a stochastic error term.

As discussed in the introduction, Bloom (2014) argues that uncertainty affects not only the level of investment, but also the sensitivity of corporate investment to firm character-

[7] Bond and Meghir (1994) derive a similar reduced-form equation from the Euler equation for optimal investment, considering the availability of internal and external funds. Their reduced-form investment equation includes the one-period lagged investment and its squared term, both of which imply the presence of adjustment costs. Unlike their investment equation, equation (8) does not include the squared term; however, even if we include it, our results and conclusions do not essentially change.

istics that drive investment spending. Regarding the former prediction about the effect of uncertainty, the coefficient parameters c_{ku} capture it as the direct level effect. We focus more on the latter prediction for a particular important relation: the sensitivity of corporate investment to (i) the lagged investment and (ii) the internal and external financing variables. In our empirical analysis, the interaction effects, a_{0u} and b_{ku}, involve the respective sensitivity effects.

The corporate investment problem is subject to partial irreversibility and fixed adjustment costs (Abel (1983), Bernanke (1983), Abel and Eberly (1994; 1996), Caballero (1999), Bloom (2007; 2009), and Bachmann et al. (2013a)). These factors create the option value of "waiting," meaning that investment expenditure is more likely to be lumpy if it exists. Furthermore, the region of investment inaction expands in response to the increase in uncertainty. Consequently, high uncertainty prevents firms from launching a new investment project and/or maintaining the previous level of investment expenditure; thus, corporate investment and its persistence decrease. Such current and lagged cautionary effects arising from increasing uncertainty are characterized by the negative estimates of the level effect, c_{0u}, and sensitivity effect, a_{0u}, respectively.

The interaction effects, b_{ku}, capture how the increase in uncertainty changes the user cost of capital and investment sensitivity to internal and external financing. As discussed in the introduction, recent theoretical studies have noted the importance of financial friction and agency costs as an additional channel through which volatility fluctuations adversely affect macroeconomic outcomes (Brunnermeier and Sannikov (2014), Christiano et al. (2014), and Gilchrist et al. (2014)). According to this literature, to the extent that external financing is subject to agency problems, increasing uncertainty raises the user cost of capital in decreasing the market value of debt claims and then increases the dependence of internal financing from cash flows. Such an effect of high uncertainty through financial market friction and a firm's financing constraints is evaluated in terms of whether the interaction effects, b_{ku}, contribute to increasing investment sensitivity to cash flows.

Compared to the theoretical prediction of a positive relation between uncertainty and investment–cash flow sensitivity, Bloom (2007; 2014), Bloom et al. (2007), and Alfaro et al. (2019) note that high uncertainty makes managers less sensitive to changes in fundamental economic and financing conditions such as the cost of capital. According to this notion, the strength of the relationship between corporate investment and the cost of capital (i.e., the dependence on internal financing) will be decreasing in uncertainty (see also Drobetz et al. (2018)). The financial aspect of the wait-and-see effect arising from a firm's unresponsiveness to financing conditions and the dominance of this cautionary effect over the above financing constraint effect is assessed in terms of whether the interaction effect, b_{ku}, contributes to decreasing investment–cash flow sensitivity under high uncertainty.

In the dynamic investment equation (1), the response of corporate investment l period after a change in the financial variable in period t is expressed as in the following marginal effect in period $t+l$ ($l \geq m \geq 0$):

$$\begin{aligned} \mathrm{ME}_{l,f_t}(\mathrm{U}^s_{i,t}) = \frac{\partial \mathrm{I}_{i,t+l}}{\partial f_{i,t}} &= \left(a_0 + a_{0u}\mathrm{U}^s_{i,t}\right) \mathrm{ME}_{l-1,f_t}(\mathrm{U}^s_{i,t}) \\ &= \sum_{l \geq m} \left(a_0 + a_{0u}\mathrm{U}^s_{i,t}\right)^l \left(b_m + b_{mu}\mathrm{U}^s_{i,t}\right). \end{aligned} \quad (2)$$

The cumulative effect through period $t+l$ is defined as $\mathrm{QME}_{0,l,f_t}(\mathrm{U}^s_{i,t}) = \sum_{j=0}^{l} \mathrm{ME}_{j,f_t}(\mathrm{U}^s_{i,t})$, and then the long-run effect for $l \to \infty$ reduces to

$$\mathrm{QME}_{0,\infty,f_t}(\mathrm{U}^s_{i,t}) = \frac{\sum_{k=0}^{m} \left(b_k + b_{ku}\mathrm{U}^s_{i,t}\right)}{1 - a_0 - a_{0u}\mathrm{U}^s_{i,t}}. \quad (3)$$

Equations (2) and (3) show that the marginal and long-run effects depend on the lagged cautionary effect, a_{0u}, and financial interaction effect, b_{ku}, as well as the level of uncertainty in the initial period t. Importantly, where the lagged cautionary effect has a negative value implies that high uncertainty reduces the response of corporate investment to a change in the financing variables and promotes a firm's unresponsiveness to financing conditions. If the financial interaction term has a positive (negative) value, the high uncertainty increases (decreases) the causal link between corporate investment and financing conditions. We examine whether financing constraints amplify the dynamic effect on corporate investment under high uncertainty by using the marginal and long-run effects, focusing on both the lagged cautionary effect and the financial interaction effect in our analysis, which follows.

2.2. **Uncertainty Shocks** An exogenous measure of economic uncertainty is necessary to identify the causal effect of uncertainty on corporate investment through a firm's financing conditions. Accordingly, this subsection discusses such an exogenous measure.

2.2.1. **Firm- and Macro-Level Uncertainty** Previous studies have employed various types of measures to infer fluctuations in economic uncertainty, including uncertainty measures based on the frequency of the uncertainty-related words or phrases that occur across several news sources (Baker et al. (2016)), the cross-sectional dispersion of survey-based business forecasts (Bachmann et al. (2013b)), and the common factor of the unforecastable component of several economic indicators (Jurado et al. (2013)).

In this paper, we use uncertainty proxies based on stock market data, as in previous studies on uncertainty shocks (e.g., Gilchrist et al. (2014), Caldara et al. (2016), and Basu and Bundick (2017)). Stock prices, albeit readily available, encompass all aspects of the firm's environment that the investors view as important. Hence, many studies in this area rely on stock prices to infer fluctuations in economic uncertainty at the firm and macro levels. In this study, we focus on both firm- and macro-level uncertainty, thus also addressing which level of uncertainty matters more in firm-level investment decisions.

For firm-level uncertainty, we exploit information about the volatility of each firm's daily excess equity returns. Equity volatility is calculated in the annualized standard deviation of daily excess returns, according to

$$\sigma^E_{i,t} = \sqrt{\frac{1}{D(t)-1}\sum_{d(t)=1}^{D(t)}\left(ER_{i,d(t)} - \overline{ER}_{i,t}\right)^2} \times \sqrt{D(t)}, \tag{4}$$

where i indexes firms and $d(t)$ $(d(t) = 1, \cdots, D(t))$ indexes trading days in firm i's fiscal year t. In equation (4), $ER_{i,d(t)}$ denotes the daily excess return of firm i defined as $ER_{i,d(t)} = R_{i,d(t)} - r^f_{d(t)}$, where $r^f_{d(t)}$ is the risk-free rate. For the risk-free rate, we use the daily return of newly issued 10-year Japanese government bonds.

As for macro-level uncertainty, we focus on the Volatility Index Japan (VIXJ). The VIXJ is provided by the Center for the Study of Finance and Insurance of Osaka University and is in strict accordance with the Chicago Board Options Exchange approach underlying the

VIX. We convert monthly data from the VIXJ into quarterly data by taking the average to estimate the uncertainty shock, as we discuss in the next subsection. The uncertainty measure is calculated by taking the average for the firm's fiscal year, defined by the year of the closing date identified in this paper.

It should be noted that these uncertainty measures reflect the endogenously countercyclical effects of the economic and financing conditions faced by firms; hence, their direct use leads to an erroneous evaluation of the causal effect of uncertainty on corporate investment. Therefore, purely exogenous uncertainties moving independently of the economic and financing conditions need to be constructed. In this regard, these uncertainty shocks are constructed in the following subsection.

2.2.2. **Exogenous Uncertainty Measures** Our estimate of exogenous firm-level uncertainty is based on the following three-step procedure suggested by Gilchrist et al. (2014) and Caldara et al. (2016). First, the endogenous variation relating to the systematic risk in daily excess returns is removed using the factor model:

$$ER_{i,d(t)} = \alpha_i + \beta_{\mathbf{i}}'\mathbf{f}_{\mathbf{d(t)}} + u_{i,d(t)}, \tag{5}$$

where $ER_{i,d(t)}$ denotes the daily excess return of firm i, and $\mathbf{f}_{\mathbf{d(t)}}$ is a vector of the risk factors. We employ the Fama and French (1992) three-factor model for implementing this first step. For the three factors (i.e., the market, SMB, and HML factors), we use Kubota and Takehara's Fama–French data, compiled by Financial Data Solutions Inc.[8]

In the second step, we calculate the annualized firm-specific volatility of daily idiosyncratic excess returns as follows:

$$\sigma_{i,t} = \sqrt{\frac{1}{D(t)-1}\sum_{d(t)=1}^{D(t)}\left(\hat{u}_{i,d(t)} - \overline{u}_{i,t}\right)^2} \times \sqrt{D(t)}, \tag{6}$$

where $\hat{u}_{i,d(t)}$ denotes the ordinary least square (OLS) residual—the exogenous idiosyncratic return moving independently of the macro-level risk factors—from equation (5) and $\overline{u}_{i,t}$ is

[8] In this compiled data for the three factors, the daily return of newly issued 10-year Japanese government bonds is used to calculate the market factor.

the sample mean of the exogenous return in a firm's fiscal year t.

Lastly, we assume that firm-specific idiosyncratic volatility follows the following autoregressive process:

$$\ln \sigma_{i,t} = \gamma_i + \delta_i t + \rho \ln \sigma_{i,t-1} + \mathrm{U}^s_{i,t}, \tag{7}$$

where $\mathrm{U}^s_{i,t}$ denotes the idiosyncratic volatility shock.[9] γ_i denotes the firm's fixed effect used to control for the cross-sectional heterogeneity in $\sigma_{i,t}$, while the firm-specific term, $\delta_i t$, captures the trends in idiosyncratic risk. We obtain the idiosyncratic volatility shock by running the OLS estimation for the sample period from fiscal years 1978 to 2014.[10]

Our estimate of exogenous macro-level uncertainty is based on the structural vector autoregression (VAR) to identify an uncertainty shock as an exogenous movement in the VIXJ. Following Basu and Bundick (2017), we estimate a VAR with the following eight variables: the uncertainty measure, gross domestic product (GDP), consumption, investment, a GDP deflater, the stock price (Nikkei 225 Index), and two measures of the monetary policy stance: the monetary base and short-term policy rate (overnight call rate). Since VIXJ data starts from 1998, we estimate the VAR using quarterly data over the 1998 and 2015 sample periods. Except for the uncertainty measure and short-term policy rate, all the other variables are entered into the VAR in log levels.

We identify an uncertainty shock using a Cholesky decomposition with the macro-level uncertainty measure ordered last. This ordering allows us to extract an uncertainty shock by controlling for simultaneous endogeneity, assuming that the uncertainty shock does not have an immediate impact on the seven macroeconomic variables ordered above the uncertainty measure, whereas non-uncertainty shocks can simultaneously affect the uncertainty measure.[11] See Appendix II for the estimated impulse responses to an uncertainty shock

[9] The double-log specification of $\sigma_{i,t}$ reflects the fact that the firm-level idiosyncratic volatility of excess returns is highly positively skewed: a non-linear feature in which volatility has higher autocorrelation in a period of higher volatility.

[10] Following Gilchrist et al. (2014) and Caldara et al. (2016), we employ the OLS estimation because the average firm is in the long-term panel for more than 35 years, and hence the bias of the OLS estimator, because of a lagged dependent variable and firm fixed effects is likely to be negligible (Phillips and Sul, 2007). The estimation yields $\rho = 0.379$, indicating that idiosyncratic uncertainty does not tend to be long-lastingly persistent.

[11] Basu and Bundick (2017) order their uncertainty measures first in their VAR. Even if we order the VIXJ first and then use the identified uncertainty shocks in our analysis developed below, it produces

in the eight-variable VAR.

The left and right panels of Figure 1 show the firm- and macro-level uncertainty measures (FIRM and VIXJ) and their uncertainty shocks, respectively. For the firm-level uncertainty measure and uncertainty shock, their sample averages for each fiscal year are reported. As discussed in the study's introduction, the original measures of uncertainty and their associated shocks appear to rise during the Japanese banking crisis of the early 2000s and the Global Financial Crisis of 2008–2009.

Despite a similar pattern for the original uncertainty measures and uncertainty shocks at the aggregate level, their substantial feature differs, such that the pairwise correlation between FIRM and VIXJ is 0.381, while that between their uncertainty shocks is 0.250. Therefore, the correlation of the firm- and macro-level uncertainty shocks is lower than that of their original measures.

Such success in randomizing the uncertainty measures can also be confirmed by Table 1, which reports estimated correlations among the firm- and macro-level uncertainties and firm variables (see Section 2.4 for the definition of each of the firm variables). This table clearly shows that the uncertainty shocks have much lower correlations with the firm variables than reflected in the original uncertainty measures, indicating that the uncertainty shocks are well randomized. We will conduct a quasi-natural experiment in the following empirics by thoroughly utilizing these randomized shocks of uncertainty. Thus, we will identify the causal link between uncertainty and investment–financing sensitivity.

2.3. **Specification for Corporate Investment and Estimation Method** We run the empirical implementation of investment model (1) in the following specification:

$$\begin{aligned} \mathrm{I}_{i,t} \;=\; & a_0\mathrm{I}_{i,t-1} + a_{0u}\mathrm{I}_{i,t-1} * \mathrm{U}^s_{i,t-1} + \sum_{k=0}^{m}\left(b^k_c\mathrm{CF}_{i,t-k} + b^k_d\mathrm{DEBT}_{i,t-k} + b^k_s\mathrm{SI}_{i,t-k}\right) \\ & + \sum_{k=0}^{m}\left(b^k_{cu}\mathrm{CF}_{i,t-k} + b^k_{du}\mathrm{DEBT}_{i,t-k} + b^k_{su}\mathrm{SI}_{i,t-k}\right) * \mathrm{U}^s_{i,t-k} + \sum_{k=0}^{m} c_{ku}\mathrm{U}^s_{i,t-k} \\ & + d_q\mathrm{Q}_{i,t} + d_l\mathrm{SALES}_{i,t-1} + v_t * \mathrm{IND}_i + a_i + \epsilon_{i,t}, \end{aligned} \tag{8}$$

qualitatively the same results as those reported in Section 3.

where $\text{CF}_{i,t}$ represents the firm's cash flows as a measure of the use of internal financing (Fazzari et al. (1988) and Moyen (2004)). $\text{DEBT}_{i,t}$ and $\text{SI}_{i,t}$ denote the ratio of the firm's debt issues and stock issues to total assets, respectively, which are included as measures of the use of external financing (Chen and Chen (2012), Brown and Peterson (2009), and Brown et al. (2009; 2012)). $\text{Q}_{i,t}$ and $\text{SALES}_{i,t-1}$ denote Tobin's Q and the one-lagged value of the sales to total assets ratio that controls for the firm's investment demand.[12]

Firm investment equation (8) includes the interaction terms of the uncertainty indicator with the firm's alternative finance sources—cash flows, debt issues, and stock issues—and the interaction term of the uncertainty indicator with the one-period lagged dependent variable. We identify a dynamic relationship between high uncertainty and investment sensitivity to internal and external financing using the financial interaction effects, b^k, and compare their economic significance with that of the direct cautionary effect, a_{0u}, thereby examining how high uncertainty affects investment spending.

Furthermore, we estimate the above dynamic panel model with a lagged dependent variable, $\text{I}_{i,t-1}$, by employing the pooled OLS estimation and the Blundell–Bond (1998) system generalized method of moments (GMM) estimation, which allows for addressing the potential endogeneity among all the financial variables and interaction terms by estimating investment equation (8) in differences and in levels, using lagged levels of the instruments for the regression in differences and lagged differences of the instruments for the regression in levels. In addition to these lagged instruments, we also use the uncertainty shock as an instrument for all the endogenous variables.

This paper selectively screens sets of these candidates for instruments by using their various lagged values, particularly in terms of robustness of estimation results and test results for the validity of instruments and moment conditions (i.e., Hansen and Arellano-Bond tests). However, regarding the tests for instrument validity, Roodman (2009) point out the problem of instrument proliferation, which could weaken the power of these validity tests.

[12] The canonical dynamic investment model reduces to an empirical specification for investment that includes the simultaneous value of Tobin's Q as an explanatory variable if its role is investigated (e.g., Hayashi and Inoue (1991)). By contrast, it reduces to a model that includes the one-lagged value of the sales to total assets ratio if its role is focused on (e.g., Bond and Meghir (1994)). Considering this point, we include the simultaneous value of Tobin's Q and the one-lagged value of the sales to total assets ratio in our investment equation, as in Brown et al. (2012).

To deal with this potential problem in selective screening, this paper employs Roodman's (2009) method to collapse instruments. Thus, in Section 3, we will report the results based on a particular set of instruments determined through selective screening. Furthermore, in Section 4, we will conduct the weak and invalid instrument robust inference based on the Kleibergen (2005) testing procedure to complement our instrumental variable estimation.

Notably, we employ the Blundell–Bond system GMM estimation as more persistent R&D spending, or a certain near random walk in it (see Section 3.2), could lead to substantial bias in the estimated coefficients when employing the Arellano–Bond (1991) GMM estimation. The Blundell–Bond system GMM estimation can ease this problem.

Before performing a full-fledged analysis of the dynamic effect of uncertainty on corporate investment, lag length m in investment equation (8) is selected. To this end, we employ the modified BIC, AIC, and HQIC model selection criteria developed based on Andrews and Lu's (2001) consistent model and moment selection criteria (MMSC) for the GMM estimation: the MMSC-BIC, MMSC-AIC, and MMSC-HQIC. Given the selection criteria, we adopt the zero-lag specification for the firm's capital investment and R&D spending. See Appendix III for details of the results.

2.4. **Dataset** All data from the published annual accounts (consolidated base) of manufacturing firms, compiled by Nikkei Digital Media Inc, is obtained for the study's sample period, from 2001 to 2014, based on the timing of the consolidated closing date. The data include Japanese manufacturing firms making both capital and R&D investments to compare their dynamics under high uncertainty.[13] Almost all manufacturing firms in the consolidated data—about 95% of them in our dataset—make both capital and R&D investments simultaneously. Furthermore, the simultaneous correlation between capital and R&D investments is calculated as 0.119, considered considerably low. Therefore, hardly suffering from the sample selection and the simultaneity problem, we can separately estimate capital and R&D investment equations to disentangle the difference in their dynamics

[13] The reason for using the sample from 2001 is that "Accounting Standards for Research and Development" has been enforced in Japan since 2001. Hence, before this enforcement, Japanese-listed firms scarcely disclose financial information on R&D investments because of the lack of its accounting standards.

from the investment decision of each firm under uncertainty.[14]

For the investment spending ($I_{i,t}$) included in equation (8), we use the firm's fixed investment or R&D, each defined by dividing the original variables by its total assets, where the fixed investment is defined as the net change in fixed assets plus depreciation.

Regarding the uncertainty variable ($U_{i,t}$), we alternately use the exogenous components of the firm-level volatility index, $\sigma_{i,t}$, and the macro-level uncertainty measure of the VIXJ (see Section 2.2).

As shown in equation (8), we consider three alternative financing sources: cash flows, debt financing, and stock issues. We define cash flows ($CF_{i,t}$) as the ratio of current net income plus depreciation and amortization to its total assets. Furthermore, we include the ratio of annual changes in total debt outstanding to its total asset holding for the debt financing of firm i ($DEBT_{i,t}$). The firm's stock issues ($ST_{i,t}$) are defined as an increase in capital stock when a firm raises both outstanding shares and capital stock, normalized by its total assets.

Tobin's Q ($Q_{i,t}$) is the ratio of the market value of firm i to its book value, where the market value of the firm is the market value of its equity plus the book value of its total liabilities.[15] Sales ($SALES_{i,t}$) is defined as the ratio of the firm's gross sales to its total assets. We include the two firm covariates to control for the firm's investment demand. The industry dummy variables for each year are set according to the 17 industry sectors defined by the Securities Identification Code Committee in Japan. Observations that are three standard deviations away from the sample mean are excluded. Table A-2 provides the descriptive statistics for each variable.

Figure 2 shows the sample averages of the two types of corporate investments and the three financing sources, calculated in each fiscal year. As discussed in the introduction, capital investment, cash flows, and debt issues appear to decline during the Japanese banking crisis and the Global Financial Crisis, whereas R&D investment remains unchanged. This appearance suggests that the financing constraint channel should explain the stagnancy of

[14] See Almeida and Campello (2007) for the simultaneity problem due to a strong association between capital and R&D investments.

[15] We calculate the market value of equity by multiplying the end-of-year stock price by the number of shares.

capital investment in the two financial crises, but the cautionary channel should not. The following sections will answer this point.

3. Estimation Results This section reports the estimation results for corporate investment equation (8), particularly focusing on the effect of uncertainty on the sensitivity of corporate investment spending to internal and external financing. By doing so, we examine how firms finance capital investment and R&D under high uncertainty and then analyze the differences that exist between these two types of investment spending.

3.1. **Uncertainty and Capital Investment** Table 2 reports the estimation results for capital investment spending with the firm-level uncertainty shock (FIRM) in the left and middle panels, and those with the macro-level uncertainty shock based on the VIXJ in the right panel. The left panel shows the results obtained by running the pooled OLS (OLS) regression, while the middle and right panels show those obtained by employing the Blundell-Bond system GMM (SGMM) estimation. For the system GMM estimation, after conducting thorough screening of various sets of instruments (see Section 2.3), we determine the set of instruments comprising the uncertainty shock, Year×Ind, three- and four-lagged values of the capital investment, and two- and three-lagged values of all the other explanatory variables.[16]

It should be recalled that we emphasize the zero-lag model since the information criteria select a zero lag for capital investment spending, as discussed in Section 2.3. We also show the estimation results of the one-lag model to ensure that the results do not rely on the lag length.[17]

When using the firm-level uncertainty shock (FIRM), the pooled OLS and the system GMM estimation provide qualitatively the same results, though the pooled OLS would cause the overestimation of the coefficient on the lagged capital investment, a_0, and the

[16] More precisely, we determine this set of instruments in terms of ensuring the moment conditions and using more valid instruments because the use of other sets of instruments, including the same set of instruments to estimate R&D investment equation (see the next subsection), does not much change estimated coefficients quantitatively and qualitatively, but does not pass Hansen, difference-in-Hansen, and Arellano-Bond tests in some cases. Furthermore, we also find that the uncollapsed instruments provide quantitatively and qualitatively the same result reported below.

[17] We found that estimated coefficients reported here do not depend on the lag length. Estimation results based on other lag models are available upon request to the authors.

underestimation of the interaction effect between the firm-level uncertainty shock and cash flows ($\text{CASHFLOW}_{i,t} * \text{U}_{i,t}$).

The lagged dependent variable of capital investment, a_0, has significantly negative estimates between 0.1 and 0.3, indicating that capital investment is lumpy in nature. More importantly, the lagged cautionary effect, a_{0u}, has significantly negative values, implying that high uncertainty reduces the persistence of capital investment and that capital investment becomes lumpier because firms are reluctant to maintain the previous level of capital investment under high uncertainty.

Internal financing sources, b_k, appear to have significantly positive estimates for cash flows in a statistically robust manner. As for external financing sources, debt issuances have positive estimates. This finding implies that as long as firms are under low uncertainty, they are more likely to increase capital investment by raising cash flows, issuing debt, or both.

However, the financial interaction effects with the three financing variables, b_{ku}, in the model including the firm-level uncertainty shock (FIRM) appear to have significantly negative estimates for cash flows regardless of the estimation method or the length of the lag. The interaction effects with debt issue also have a negative value, although they are not statistically significant for all the system GMM estimations. This finding indicates that high idiosyncratic uncertainty reduces the sensitivity of capital investment to cash flows because of the cautionary channel, through which high firm-specific uncertainty leads to a firm's unresponsiveness to financing conditions.

Such a cautionary channel can be observed in terms of the dynamic response of capital investment. Figure 3 reports the estimated dynamic responses of capital investment to a one percentage point change in the three financing variables at low and high levels of firm-level uncertainty, obtained using the zero-lag model. Apparently, high uncertainty reduces the response of capital investment to the change in cash flows. Under low uncertainty, the dynamic response to cash flows has a significantly positive value for a longer period than under high uncertainty. This finding implies that at low idiosyncratic uncertainty, cash flows determine capital investment and, hence, capital investment–cash flow sensitivity is active; however, under high idiosyncratic uncertainty, the cautionary effect weakens the causal link between cash flows and capital investment. Previous literature highlights that high uncertainty raises the cost of capital and worsens financing conditions (Merton (1974), Bernanke et al. (1996), Kiyotaki and Moore (1997), Brunnermeier and Sannikov (2014), Christiano et al. (2014), and Gilchrist et al. (2014)); however, when making capital investment decisions under high firm-specific uncertainty, firms respond less to such deteriorated financing conditions under the cautionary strategy.

The dynamic response to the change in debt issues has a significantly positive value under both low uncertainty and high uncertainty, though the response under high uncertainty slightly decreases. Although high uncertainty lessens the sensitivity of capital investment to cash flows, there is no significant decrease in the sensitivity to debt issues. These results suggest that the cautionary channel of uncertainty would be ascribed to its decreasing effect on capital investment–cash flow sensitivity.

Once again, in Table 2, the investment equations that do not control for the interaction effects with the firm-level uncertainty shock have significantly negative estimates for their level effect, c_{0u} (see the first column of each panel), indicating that increasing uncertainty directly decreases capital investment. However, once the investment equations also control for the sensitivity effects with uncertainty a_{0u} and b_{ku}, the direct level effect disappears (see the second and third columns of each panel). Given these results, the sensitivity effect through the firm's lagged cautionary behavior and financing conditions would have a more substantive role in capital investment than the direct level effect.

As for the macro-level uncertainty shock (VIXJ), its financial interaction effects with the three financing variables, b_{ku}, have insignificant estimates, while its lagged interaction effect with the lagged capital investment, a_{0u}, has significantly negative estimates. This result implies that the macro-level uncertainty shock does not involve a firm's unresponsiveness to financing conditions; however, as in the firm-level uncertainty shock, the macro-level uncertainty inhibits firms from maintaining the level of capital investment in the lagged cautionary effect.

3.2. **Uncertainty and R&D** Next, we report the estimation results for R&D in Table 3. In this regard, we again focus on the zero-lag model because the information criteria selected a zero lag for most of the specifications of R&D investment (see Section 2.3);

however, we also examine the one-lag model for robustness check. When employing the system GMM estimation, it determines the set of instruments comprising the uncertainty shock, Year×Ind, three- and four-lagged values of the interaction term of the lagged dependent variable with the uncertainty shocks, and two- to four-lagged values of all the other explanatory variables.[18]

The most noticeable difference between R&D and capital investment is that the estimated coefficients on the lagged dependent variable of R&D, a_0, are much higher than those on the lagged dependent variable of capital investment, being close to one. This result implies that, compared with capital investment, R&D has a more persistent feature and fairly near random work behavior; put differently, a one-time shock to R&D has a long-lasting effect without it disappearing quickly. With all else unchanged, firms are more likely to maintain the level of R&D and engage in R&D smoothing (Brown et al. (2009), Brown et al. (2012), and Hall et al. (2016)). Regarding the degree of R&D smoothing, the result for Japanese manufacturing firms corresponds to the findings provided by Brown et al. (2009) for mature U.S. high-tech firms over the 1990–2004 period and Brown et al. (2012) for European listed firms making R&D investment over the 1995–2007 period. Notwithstanding, R&D smoothing by Japanese manufacturing firms is much more substantial. It should be noted that the lagged cautionary effect, a_{0u}, in R&D is not statistically significant, indicating that even if firms face fluctuations in uncertainty, it does not weaken R&D smoothing.

Considering that the estimated coefficients on the lagged dependent variable are close to one, the study tests whether they are statistically indistinguishable from one, $a_0 = 1$. If the coefficient on the lagged dependent variable is close to one, the weak instrument problem can emerge even when employing the Blundell–Bond system GMM estimation (see Section 2.3 and Blundell and Bond, 1998). As shown in the bottom row of Table 3, the null hypothesis $a_0 = 1$ is rejected in a statistically significant manner.[19] Nonetheless,

[18] As in the estimation of capital investment equation, we determine this set of instruments after screening various sets of instruments in terms of the validity of moment conditions and instruments. We also found that the reported estimated coefficients do not qualitatively and quantitatively change even if we use the uncollapsed instruments and the same set of instruments used to estimate the capital investment equation.

[19] Panel-data unit-root tests are conducted for R&D. The tests strongly reject the null hypothesis that all the panels contain unit roots.

to ensure the validity of the study's results, the R&D equation with the restriction $a_0 = 1$ is also estimated using the same instruments. The seventh and eighth columns of Table 3 report the estimation results for the model using the difference in R&D (ΔR&D) as the dependent variable. Both models with R&D and ΔR&D share the same estimation results for the financing variables, b_k, and their interaction effects with uncertainty, b_{ku}, in that cash flows have significantly positive estimates, and its interaction effect with the firm-level uncertainty shock (FIRM) have significantly negative estimates, albeit much smaller than those estimates in capital investment.

It is also noted that the evidence of R&D cash flow sensitivity for Japanese manufacturing firms being much smaller than that of capital investment (i.e., compared to capital investment, R&D spending is less affected by a firm's financing constraints) corresponds to the findings of previous comparative studies on the sensitivity of capital and R&D investments by U.S. firms in the pre-2000 period. However, it does not apply to those in the post-2000 period (Himmelberg and Petersen (1994), Almeida and Campello (2007), and Brown and Petersen (2009)).[20]

Figure 4 shows the estimated dynamic responses of R&D to a one percentage point change in the three financing variables at low and high levels of firm-level uncertainty obtained using the zero-lag model of Table 3. Except for R&D–cash flow sensitivity, sensitivity to debt and stock issuances is not significant. From the dynamics in R&D–cash flow sensitivity, we observe that under low uncertainty, R&D is much more persistently affected following the change in cash flows than capital investment is, although the estimated impact on R&D is much smaller than that on capital investment. However, more importantly, as in capital investment, high uncertainty weakens the causal link between cash flows and R&D. Therefore, although R&D is more persistently and less affected by the shortage in cash flows (i.e., financing constraints) under low idiosyncratic uncertainty, the two types of corporate investments share evidence that high idiosyncratic uncertainty

[20] More precisely, this evidence for Japanese manufacturing firms over the 2001–2014 period corresponds with Himmelberg and Petersen's (1994) findings for U.S. small firms in high-tech industries over the 1983–1985 period, Almeida and Campello (2007) for U.S. manufacturing over the 1985–2000 period, and Brown and Petersen (2009) for U.S. manufacturing firms over the 1970–1993 period, but not to Brown and Petersen's (2009) findings over the 1994–2006 period, during which the cash flow sensitivity of R&D becomes larger than that of capital investment.

reduces investment–cash flow sensitivity because of firms' cautionary behavior.

In contrast to the firm-level uncertainty shock (FIRM), the macro-level uncertainty shock (VIXJ) has a significantly positive estimate for its interaction effect with stock issuances (see the last two columns of Table 3), implying that the macro-level uncertainty shock may contribute to R&D spending through stock issuances. Furthermore, as in capital investment, the macro-level uncertainty shock does not affect investment–cash flow sensitivity in R&D investment.

3.3. **Uncertainty and the Long-run Effect** Table 4 shows the long-run effect of a one percentage point change in the three financing variables on corporate investment and R&D using the firm-level uncertainty shock (see equation (3) in Section 2.1 for the long-run effect). As shown in the left panel of Table 4 for capital investment, the long-run effect of the change in cash flows is much smaller under high uncertainty than under low uncertainty. This result indicates that as firm-specific uncertainty increases, the importance of cash flows (i.e., a firm's financing constraints) becomes smaller in making capital investment decisions. Furthermore, a debt issuance shock has less effect on capital investment under high uncertainty, although the difference between low and high uncertainty is slightly smaller than that for cash flows. In addition, a stock issuance shock does not yield significant long-run effects under low or high uncertainty.

Compared with capital investment, the long-run effect of each financing source shown in the right panel for R&D investment is very weak in terms of its statistical significance; however, the magnitude of the long-run effect of cash flows for R&D spending is larger than that for capital investment spending under low uncertainty. In the previous subsection, we found that under low idiosyncratic uncertainty, compared to capital investment, R&D is more persistently affected following the marginal change in cash flows, although the temporal impact on R&D is smaller than on capital investment. Given this finding, the larger long-run effect of cash flows on R&D would be attributed to its inherent long-lasting persistency. However, the point estimates of the long-run effect of cash flows on R&D appear to be much smaller under high uncertainty than under low uncertainty. This result indicates that for both capital investment and R&D, there is evidence that as firm-specific uncertainty increases, the importance of financing constraints becomes smaller because of the cautionary strategy.

4. Extension and Robustness of the Cautionary Effect This section addresses as some extension and robustness checks of the empirical analysis, two complementary issues: the role of firm attributes in the cautionary effect and the weak and invalid instrument robust inference for this effect. We then provide our insight into corporate investment–cash flow insensitivity in high uncertainty.

4.1. **Firm Attributes and Cautionary Effect** This subsection examines how the cautionary channel depends on firm attributes. To this end, we take up two firm characteristics: the degree of cash holdings and firm size.

4.1.1. **Cash Holding** Some literature has focused on the role of firms' cash holdings as a precautionary motive for financing future corporate investment (e.g., Bates et al. (2009) and Almeida et al. (2014)). Here, we address the issue of whether or how investment–cash flow sensitivity depends on firms' cash holdings under firm-specific uncertainty. To this end, we define cash-rich firms as an indicator variable of firms with higher cash holdings. We then include the interaction term of cash flows and the indicator of cash-rich firms (CASHRICH_i) and the triple interaction term of cash flows, the firm-level uncertainty shock, and the indicator of cash-rich firms into capital investment equation (8).

The left panel of Table 5 shows the estimation result for capital (CAPITAL) and R&D investment equations (8), including the two interaction terms. It defines the indicator of cash-rich firms in the top 75th percentiles of averages on cash holdings to total assets in the sample period. The interaction term of cash flows and the indicator of cash-rich firms ($\text{CASHFLOW}_t{*}\text{CASHRICH}$) appears to have a significantly negative coefficient in the capital investment equation, but not in the R&D equation, indicating that as long as uncertainly does not exist at a firm level, capital investment–cash flow sensitivity for cash-rich firms is smaller than that for cash-strapped firms. This result implies that when making capital investment, cash-rich firms are less financially constrained in the non-uncertainty situation.

On the other hand, in capital investment, the triple interaction term ($\text{CASHFLOW}_t * \text{U}_t * \text{CASHRICH}$) appears to have a significantly positive coefficient and cancels the interaction effect of cash flows and the firm-level uncertainty shock. In other words, even in high idiosyncratic uncertainty, cash-rich firms do not suffer from the cautionary effect and the financing constraint effect in capital investment because their capital investment–cash flow sensitivity remains near zero irrespective of the level of uncertainty; hence, uncertainty does not change the sensitivity. By contrast, such a substantial effect of cash holdings is not observed in R&D investment.

The estimation results for capital investment can be observed more clearly in Figure 5, which reports the dynamic response of capital investment to a one percentage point change in cash flows for cash-rich (upper panels) and cash-poor firms (lower panels), under low (left panels), and high firm-specific uncertainty (right panels). This figure shows that capital investment–cash flow sensitivity for cash-rich firms diminishes in the cases of both low and high uncertainty. By contrast, the sensitivity for cash-poor firms decreases in uncertainty, as also observed in Figure 3. Thus far, our results indicate that, in conducting capital investment, the cautionary effect in high idiosyncratic uncertainty would emerge for firms with fewer cash holdings, but not for firms with more cash holdings.

4.1.2. **Firm Size** Some recent studies on corporate investment in Japan have highlighted that larger firms were more likely to be financially constrained in the 2010s (e.g., Sakai, 2020). On this matter, we examine the role of firm size in the cautionary channel.

The right panel of Table 5 shows the estimation result for corporate investment equation (8), including the interaction term of cash flows and an indicator of large firms (LARGE_i), and the triple interaction term of cash flows, the firm-level uncertainty shock, and the large firm indicator. We define the indicator of large firms in the top 75th percentiles of averages on total assets in the sample period.

The interaction effect between cash flows and the large firm indicator ($\text{CASHFLOW}_t * \text{LARGE}$) has a significantly positive estimate in the capital investment equation (CAPITAL), indicating that large Japanese firms face more severe financial constraints in conducting capital investment for our overall sample period (i.e., fiscal years 2001 to 2014). Moreover, the triple interaction term ($\text{CASHFLOW}_t * \text{U}_t * \text{LARGE}$) in the capital investment equation does not have a statistically significant coefficient, indicating that when making capital investment decisions, large firms are more likely to be financially constrained irrespective of the degree of uncertainty.

It is also noted that this type of firm size effect does not exist in the R&D investment equation. The evidence in this subsection shows that firm size as well as the degree of cash holdings bears no effect on R&D–cash flow sensitivity, revealing a noticeable feature of R&D spending by Japanese manufacturing firms. Previous studies show that R&D spending by larger European firms are less likely to be financially constrained (e.g., Brown et al. (2012)), and highly R&D-intensive U.S. firms are more likely to hold a cash buffer against a future shortage of free cash flows (e.g., Bates (2009) and Almeida et al. (2014)). Unlike these findings, our findings in this subsection indicate that firm size and the degree of cash holdings do not systematically explain the dependency of R&D spending by Japanese manufacturing firms on free cash flows.

Figure 6 shows the dynamic response of capital investment to a one percentage point change in cash flows for large (upper panels) and small firms (lower panels) under low (left panels) and high firm-specific uncertainty (right panels). This figure confirms the result for large firms; that is, their capital investment–cash flow sensitivity has a positive value under both low and high uncertainty. On the other hand, the sensitivity for small firms disappears under high uncertainty, whereas it has a positive value under low uncertainty. These results suggest that capital investment by large Japanese firms would be subject to financing constraints irrespective of the degree of firm-specific uncertainty, at least for the overall sample period from 2001 to 2014. However, capital investment by small Japanese firms would be subject to financing constraints under low uncertainty, but subject to the cautionary behavior under high uncertainty.

4.2. **Weak and Invalid Instrument Robust Inference for Cautionary Effect** The plausibility of our empirical results presented thus far relies on the assumption that our instruments in the system GMM estimation are relevant to the three financing variables and their interaction terms with the uncertainty shocks, though the instruments were carefully adopted through preliminary screening in terms of validity (see Section 2.3). Unacknowledged weak instruments could provide a spurious finding because no standard test for weak instruments in dynamic panel GMM regressions exist (see, e.g., Bazzi and Clemens (2013)). Moreover, many instruments could weaken the power of the tests for instrument validity (see, e.g., Roodman (2009)). We address these potential problems by employing the Kleibergen (2005) testing procedure to conduct the weak and invalid instrument robust inference.

The Kleibergen procedure allows us to generate a confidence set for the case of multiple endogenous regressors and many instruments, based on the null hypothesis that coefficient parameters on endogenous variables take the true values, without assuming that the parameters are identified with relevant and valid instruments in the GMM estimation (Kleibergen (2005) refers this test as the J-K test); therefore, the confidence set derived using the J-K test is robust not only to weak, but also to invalid instruments. It is noted that, as pointed out by Kleibergen (2005), the J-K confidence set from some set of instruments can become empty or have several confidence sets because the invalid instrument robust test (the J test) and the weak instrument robust test (the K test) may not produce an overlapped region or could produce several overlapped regions of the confidence sets that result from the respective tests.[21]

The weak and invalid instrument robust inference is conducted for two estimated coefficients on cash flows and its interaction term with the firm-level uncertainty shock. This approach is taken because the two coefficients mainly involve the study's finding that high uncertainty reduces the sensitivity of capital investment and R&D to this internal financing source because of the cautionary channel. Figure 7 and Table 6 report the confidence sets obtained by using the same instruments to estimate the capital and R&D investment equations (see Sections 3.1 and 3.2), assuming that they could be weak and invalid instruments. Figure 7 shows the joint confidence region of the two estimated coefficients as Case I, in which the two coefficients could not be identified with relevant and valid instruments. Table 6 reports the confidence interval of the interaction effect as Case II, in which only the interaction effect could not be identified with relevant and valid instruments. In these figure and table, WALD and J-K denote the 90% confidence sets derived using the conventional Wald test and J-K test, respectively. The left and right panels of Figure 7 show

[21] It is also noted that even if the J-K confidence set becomes empty or has several confidence sets, it does not mean that the estimation and test results reported in Sections 3 and 4.1 do not hold. As long as the confidence sets for the coefficient parameter on cash flows and its interaction effects with the firm-level uncertainty shock take (do not take) significantly positive and negative regions, respectively, the cautionary effect is (not) positively supported by the robust inference. This study uses the Stata package weakiv to compute the J-K confidence set reported below.

the joint Wald and J-K confidence regions, and in each panel, the coefficient parameter on cash flows (CASHFLOW_t) is plotted on the horizontal axis, and the interaction effect ($\text{CASHFLOW}_t * \text{U}_t$) is on the vertical axis. The models of capital investment and R&D are based on the zero-lag models, additionally including the indicator of cash-rich firms and its interaction terms into equation (8) (see Section 4.1.1).

Regarding capital investment, Case I produces three 90% confidence sets for the coefficient parameter on cash flows and its interaction effect with the uncertainty shock in the J-K test (see the upper right panel of Figure 7). However, Case II produces one confidence set for the interaction effect, as reported in Table 6. More concretely, the J-K confidence set of the estimated interaction effect can take positive or negative regions for Case I, but takes only a significantly negative interval (-2.379, -1.966) for Case II. It is also noted that, as shown in Case I, the J-K confidence set of the estimated coefficient on cash flows falls into positive regions for all three 90% confidence sets. These results indicate that the finding that high uncertainty decreases capital investment–cash flow sensitivity is robust to weak and invalid instruments.

As for R&D investment, Case I produces four J-K confidence sets for the two coefficient parameters (see the lower right panel of Figure 7); however, Case II generates an empty set for the interaction effect. Therefore, all J-K confidence sets of the interaction effect take significantly negative regions for Case I, while its J-K confidence interval becomes empty for Case II. Unlike capital investment, the coefficient parameter on cash flows in R&D investment does not have a significant region in the J-K test for Case I. Overall, although significantly negative interaction effects are estimated in Case I, the robustness of the cautionary effect in R&D is slightly weak in terms of the statistical significance of the coefficient on cash flows.

Nonetheless, irrespective of those differences in robustness, our inference based on the Kleibergen (2005) procedure suggests that, even if our instruments could be weak and invalid, our key result—high idiosyncratic uncertainty reduces the cash flow sensitivity of capital investment and R&D—typically still holds.

4.3. **Insight into Investment–Cash Flow Insensitivity** The above analysis provides an insight into the causal link between the shortage of free cash flows and corporate investment under uncertainty. If firms lack sufficient access to cash flows under low idiosyncratic uncertainty, such a liquidity shortage negatively impacts both capital investment and R&D. Furthermore, this negative impact is longer-lasting for R&D than for capital investment.

Although the persistence of this liquidity shortage effect differs between capital investment and R&D under low idiosyncratic uncertainty, the two types of corporate investment share the effect of uncertainty through which investment–cash flow sensitivity decreases in uncertainty because of firms' cautionary behavior. This financial aspect of the wait-and-see effect under high idiosyncratic uncertainty is particularly remarkable in capital investment in terms of its magnitude. It makes the firm's investment decisions indifferent to their financing conditions, while capital investment being lumpier, with its levels decreasing over time because of the lagged cautionary effect of uncertainty. These cautionary behavior would be responsible for the stagnancy of capital investment under high uncertainty in the Japanese banking crisis and the Global Financial Crisis, as observed in Figures 1 and 2. Furthermore, regarding firm attributes, the cautionary behavior in capital investment is more pronounced for firms that are smaller or hold less cash in high idiosyncratic uncertainty.

Given that R&D investment inherently has a high degree of intertemporal inertia because of higher adjustment costs for the intangibles accumulated through R&D investment (Hall and Lerner (2010), Brown and Petersen (2011), Brown et al. (2012), and Hall et al. (2016)), it is reasonable that, once firms face a shortage of free cash flows under low uncertainty, such a liquidity shortage has a larger long-run impact on R&D through the financing constraint channel. However, as firm-specific uncertainly increases, R&D—as with capital investment—does not respond to a firm's severe financing conditions since the cautionary channel becomes dominant. The remarkable unchangeability of R&D in high uncertainty compared to capital investment (see Figure 2) would be ascribed not only to its inherent long-lasting persistency based on the higher adjustment costs, but also the unresponsiveness to financing conditions based on the cautionary strategy. Furthermore, such a cautionary strategy in R&D investment decisions—in contrast to that in capital investment decisions—does not depend on firms' cash holdings and sizes.

It should also be noted that the cautionary channel, or the investment–cash flow insensitivity in high uncertainty, is involved with the firm-level idiosyncratic uncertainty, but not with the macro-level uncertainty because the macro-level uncertainty cannot fully capture firm-level heterogeneity in uncertainty and its firm-level interactions with financing conditions. As observed in Figure 1, the macro- and the firm-level uncertainty apparently have a similar pattern. Therefore, failure to distinguish these two types of uncertainty measures and then ascribe stagnant investment under high uncertainty to more severe financing conditions from the simple observation at an aggregate level will lead to a wrong assessment about the stagnancy of corporate investment, such that the financing constraint channel could matter. Firm-level idiosyncratic uncertainty as well as firms' cautionary behavior must be addressed to evaluate the role of financing sources in corporate investment decisions for a period of high uncertainty.

5. Conclusion High uncertainty has two channels through which the relation between corporate investment and financing conditions is affected. The first channel involves financing constraints: firms with a higher cost of capital depend more on cash flows and their investment sensitivity to cash flows increases. The second channel is based on a financial aspect of the traditional wait-and-see effect through which the strength of investment–cash flow sensitivity is decreasing in uncertainty because of the firm's unresponsiveness to financing conditions.

We use firm-level data on the Japanese manufacturing industry from fiscal years 2001 to 2014, thereby identifying the causal impact of uncertainty on the relation between those corporate investments and financing conditions. Thus, we demonstrate that the cautionary effect is increasingly dominant under high uncertainty irrespective of the type of corporate investment: capital investment and R&D. The dominance of the cautionary effect over the financing constraint effect reduces investment–cash flow sensitivity, thereby making actual corporate investment decisions indifferent to the firm's financing conditions under high uncertainty. Furthermore, such a cautionary effect is intertwined with the firm-level idiosyncratic uncertainty and is more pronounced in capital investment by smaller firms with fewer cash holdings.

The above evidence has rich policy implications regarding proffering a waring on policy easing to support corporate investment for a period of heightened economic uncertainty.

Effective policy options for stagnant corporate investment depend heavily on whether this stagnancy arose out of an increase in financial constraints or firms' cautionary strategy. Our evidence suggests that policies aimed at easing firms' financing constraints to encourage corporate investment—particularly, capital investment—cannot work without lowering firm-level idiosyncratic uncertainty, especially if they are small firms or hold less cash. Therefore, even if a government maintains highly accommodative financial conditions, small or cash-strapped firms do not respond to such easing of financial conditions. Furthermore, if accommodative policies are designed to enforce corporate investment rather than to cover short-term liquidity needs, such policies would result in distorting corporate investment decisions and *promoting inefficient investment* by small or cash-strapped firms facing high idiosyncratic uncertainty.

In this paper, we have addressed the role of firm characteristics including firm size, but not the role of macrofinancial conditions in the emergence of investment-cash flow insensitivity under high idiosyncratic uncertainty. Our analysis of the cautionary channel should be extended along this line.

Appendix I: Identification of the Sensitivity Effect of Uncertainty To identify the causal effect of uncertainty on corporate investment–financing sensitivity, we introduce the following dynamic system based on linear functions g:

$$\mathrm{I}_{i,t} = g_1\left(\mathrm{I}_{i,t-1},\ f_{i,t},\ \mathrm{U}_{i,t},\ f_{i,t} * \mathrm{U}_{i,t},\ \mathrm{Others}^{\mathrm{I}}_{i,t}\right), \quad \text{(A-1)}$$

$$f_{i,t} = g_2\left(f_{i,t-1},\ \mathrm{I}_{i,t},\ \mathrm{U}_{i,t},\ \mathrm{Others}^{f}_{i,t}\right), \quad \text{(A-2)}$$

$$\mathrm{U}_{i,t} = g_3\left(\mathrm{U}_{i,t-1},\ \mathrm{I}_{i,t},\ f_{i,t},\ \mathrm{Others}^{\mathrm{U}}_{i,t}\right), \quad \text{(A-3)}$$

where $\mathrm{I}_{i,t}$ is investment spending, including capital investment and R&D, for firm i in period t. $\mathrm{U}_{i,t}$ denotes a firm-level measure for the uncertainty faced by each firm in period t. $f_{i,t}$ represents a financial variable for the internal and external financing of corporate investment such as cash flows and debt issuance. $\mathrm{Others}_{i,t}$ in equations (A-1)–(A-3) represents other factors that can determine a firm's investment and financing decisions. It should be noted that investment equation (A-1) includes an interaction term $f_{i,t} * \mathrm{U}_{i,t}$ to capture the sensitivity effect of uncertainty through a firm's financing conditions. Equations (A-1) to (A-3) have a linear dynamic structure with one-lagged dependent variables.

In this paper, we examine the dynamic causal link between the financing variable and corporate investment $f_{i,t} \rightarrow \mathrm{I}_{i,t+k}$ ($k = 0, \ldots, \infty$) in an uncertain environment $\mathrm{U}_{i,t}$, using the interaction effect in investment equation (A-1) (see Section 2.1). To this end, investment equation (A-1) must be estimated by controlling for the dynamics in $f_{i,t}$ and $\mathrm{U}_{i,t}$, each represented in equations (A-2) and (A-3).

We control for the dynamics in uncertainty, $\mathrm{U}_{i,t}$, expressed in equation (A-3) by constructing an uncertainty shock, $\mathrm{U}^{s}_{i,t}$, moving independently of the economic conditions—$\mathrm{I}_{i,t}$, $f_{i,t}$ and $\mathrm{Others}^{\mathrm{U}}_{i,t}$. This uncertainty shock is included in equations (A-1) and (A-2) as an uncertainty measure (see Section 2.2). In preparing for such an uncertainty shock, a quasi-natural experiment with a randomized shock of uncertainty can be established; that is, the study can examine whether and how investment–financing sensitivity $f_{i,t} \rightarrow \mathrm{I}_{i,t+k}$ ($k = 0, \ldots, \infty$) depends on the level of uncertainty in initial period t, particularly through the interaction effect of the financing variable and uncertainty shock, $f_{it} * \mathrm{U}^{s}_{i,t}$.

Lastly, we conduct the Blundell–Bond (1998) system GMM estimation for the dynamic panel investment model (A-1), preparing for appropriate instruments for the one-period lagged investment, $\mathrm{I}_{i,t-1}$, and the financing variable, $f_{i,t}$, to control for the dynamics of the financial variable in equation (A-2) (see Section 2.3). In particular, to control for the effects of the uncertainty shock, $\mathrm{U}^{s}_{i,t}$, on the financial variable in equation (A-2), we use this exogenous shock as an instrument to estimate investment equation (A-1).

Appendix II: Impulse Responses to an Uncertainty Shock at the Macro Level

We estimate a structural VAR to identify an uncertainty shock as a purely exogenous movement in the uncertainty indicator: the VIXJ. Following Basu and Bundick (2017), the study estimates a VAR with the following eight variables: one of the uncertainty indicators, GDP, consumption, investment, a GDP deflater, the stock price (Nikkei 225 Index), and two indicators of the monetary policy stance—the monetary base and short-term policy rate (overnight call rate). Since the VIXJ data starts from 1998, the VAR is estimated using quarterly data over the 1998 and 2015 sample periods. With the exception of the uncertainty indicator and short-term policy rate, all the other variables enter the VAR in log levels. An uncertainty shock is identified using a Cholesky decomposition with the VIXJ ordered last.

In this instance, the estimated impulse responses to an identified uncertainty shock of the VIXJ are reported. Figure A plots the estimated impulse responses to a one-standard-deviation uncertainty shock along with the 90% confidence intervals. The one-standard-deviation shock increases the VIXJ by 3%. Following the shock, output, consumption, investment, and stock prices all decline together, with their peak responses occurring after about one year. The peak decline in investment is roughly five times as large as the decline in output and consumption. Prices begin to decrease about two year after the uncertainty shock hits and then continue to fall. The declines in economic activity and inflation lead the monetary authority to reduce its nominal interest rate and increase the monetary base, although such a response is not immediate and statistically indistinguishable from zero, particularly for the monetary base. The above results are essentially similar to the findings of previous studies on the economy's response to an uncertainty shock, including those by Christiano et al. (2014), Gilchrist et al. (2014), Jurado et al. (2015), and Basu and Bundick (2017).

Appendix III: Lag Selection in the Dynamic Investment Model The lag length in dynamic investment model (8) is selected by employing Andrews and Lu's (2001) consistent model and moment selection criteria (MMSC) for the GMM estimation. They define the conventional BIC, AIC, and HQIC model selection criteria in the framework of the MMSC as follows:

$$\text{MMSC-BIC}_n(b,c) = J_n(b,c) - (|c| - |b|)\ln n, \tag{A-4}$$

$$\text{MMSC-AIC}_n(b,c) = J_n(b,c) - 2(|\mathrm{c}| - |\mathrm{b}|), \tag{A-5}$$

$$\text{MMSC-HQIC}_n(b,c) = J_n(b,c) - Q(|c| - |b|)\ln\ln n, \tag{A-6}$$

where n is the number of observations and $|b|$ and $|c|$ denote the number of parameters b and moments c in the GMM estimation, respectively. $J_n(b,c)$ indicates the J test statistics for testing overidentifying restrictions, constructed based on the parameters b and moments c. Q is a parameter that meets $Q > 2$.

When selecting lag length m in corporate investment equation (8), we calculate the three types of MMSC criteria for the zero- to three-lag models and then select a model that minimizes each of these criteria. When calculating the MMSC-HQIC, we set the parameter Q to $Q = 2.1$. Table A-1 reports the calculated information criteria for each lag model. In the models of capital investment using both the firm-level uncertainty shock (FIRM) and the macro-level uncertainty shock (VIXJ), two MMSC criteria select a zero lag, although the MMSC-AIC selects a two lag. Regarding the model of R&D investment, the MMSC-BIC for both uncertainty shocks and MMSC-HQIC for the firm-level uncertainty shock (FIRM) select a zero lag, while the MMSC-AIC select a three lag. As is well known, the BIC is inherently more likely to select a shorter lag, whereas the AIC selects a longer lag. Given this, we adopt the zero-lag specification for the firm's capital investment and R&D spending.

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Table 1: **Correlations among Uncertainty and Firm Variables**

	Firm-level Uncertainty		Macro-level Uncertainty	
	Original Measure	Extracted Shock	Original Measure	Extracted Shock
Capital Investment	-0.132	-0.056	-0.066	-0.045
R&D	-0.051	-0.021	-0.015	-0.012
Cash Flows	-0.254	-0.109	-0.191	-0.099
Debt Issues	-0.133	-0.083	-0.192	-0.035
Stock Issues	0.066	0.012	-0.061	-0.008

Note: This table reports estimated correlations among uncertainty measures, corporate investment, and financing sources. For uncertainty measures, we use the firm-level uncertainty calculated from the volatility in the daily excess equity returns of each firm and its associated shock and the macro-level uncertainty of the volatility index Japan (VIXJ) and its associated shock. See Section 2.2.2 for details of the extraction of the uncertainty shocks. See Section 2.4 regarding the definition of the firm variables.

Table 2: **Estimation Results for the Capital Investment Equation**

Estimator:		OLS			SGMM			SGMM	
Uncertainty Shock:		FIRM			FIRM			VIXJ	
Parameters: a_0 and a_{0u}									
INV_{t-1}	0.307***	0.302***	0.289***	0.144***	0.176***	0.262***	0.151***	0.173***	0.253***
	(0.011)	(0.011)	(0.013)	(0.036)	(0.045)	(0.060)	(0.037)	(0.033)	(0.048)
INV_{t-1}*U_{t-1}		-0.065**	-0.105**		-0.084**	-0.107*		-7.136***	-9.422***
		(0.032)	(0.047)		(0.034)	(0.063)		(1.150)	(1.762)
Parameters: b_k $(k = 0, 1)$									
$CASHFLOW_t$	0.216***	0.222***	0.193***	0.212***	0.212***	0.243***	0.204***	0.207***	0.241***
	(0.010)	(0.009)	(0.011)	(0.043)	(0.042)	(0.051)	(0.042)	(0.036)	(0.041)
$DEBT_t$	0.174***	0.174***	0.174***	0.184***	0.177***	0.155***	0.171***	0.152***	0.130***
	(0.007)	(0.007)	(0.006)	(0.051)	(0.041)	(0.033)	(0.050)	(0.038)	(0.044)
$STOCKISSUE_t$	0.309***	0.311***	0.317***	0.165	0.330	0.141	0.140	0.164	0.015
	(0.047)	(0.047)	(0.047)	(0.328)	(0.328)	(0.322)	(0.308)	(0.249)	(0.291)
$CASHFLOW_{t-1}$			0.062***			-0.040*			-0.047*
			(0.011)			(0.024)			(0.027)
$DEBT_{t-1}$			-0.011**			-0.022**			-0.024**
			(0.005)			(0.011)			(0.010)
$STOCKISSUE_{t-1}$			-0.129**			-0.009			-0.028
			(0.051)			(0.054)			(0.067)
Parameters: b_{ku} $(k = 0, 1)$									
$CASHFLOW_t$*U_t		-0.125***	-0.114***		-0.339**	-0.419***		-2.022	-1.365
		(0.031)	(0.031)		(0.162)	(0.147)		(2.413)	(2.508)
$DEBT_t$*U_t		-0.056**	-0.058**		-0.046	-0.099		2.921	2.496
		(0.024)	(0.023)		(0.134)	(0.142)		(3.719)	(3.766)
$STOCKISSUE_t$*U_t		0.061	0.076		1.499	0.906		59.422*	36.74
		(0.187)	(0.184)		(1.186)	(1.075)		(34.828)	(36.25)
$CASHFLOW_{t-1}$*U_{t-1}			-0.058*			0.054			0.406
			(0.031)			(0.046)			(1.299)
$DEBT_{t-1}$*U_{t-1}			0.021			-0.022			1.064*
			(0.019)			(0.026)			(0.632)
$STOCKISSUE_{t-1}$*U_{t-1}			-0.151			0.012			4.730
			(0.218)			(0.231)			(7.674)
Parameters: c_{ku} $(k = 0, 1)$									
U_t	-0.004***	0.003	0.003	-0.005***	0.010	0.017**	-0.015	0.040	0.031
	(0.001)	(0.002)	(0.002)	(0.002)	(0.008)	(0.008)	(0.064)	(0.156)	(0.158)
U_{t-1}			0.008***			-0.001			0.215
			(0.002)			(0.005)			(0.260)
$TOBINQ_t$	-0.002**	-0.003**	-0.004***	-0.005	-0.006	-0.006	-0.004	-0.005	-0.001
	(0.001)	(0.001)	(0.001)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
$SALES_{t-1}$	0.006***	0.005***	0.005***	0.019***	0.017***	0.020***	0.019***	0.021***	0.024***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)
Constant	0.008**	0.008**	0.009**	0.002	0.004	-0.002	0.001	0.000	-0.009
	(0.003)	(0.003)	(0.003)	(0.006)	(0.005)	(0.007)	(0.006)	(0.006)	(0.008)
Dummy variable	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.
No. of Obs.	11861	11861	11861	11861	11861	11861	11861	11861	11861
Adj. R seq.	0.450	0.454	0.458						
No. of IVs				323	335	335	323	335	335
Hansen test (p-value)				0.271	0.225	0.269	0.282	0.201	0.288
Diff. in Hansen test (p-value)				0.597	0.358	0.371	0.609	0.284	0.468
Arellano-Bond test for AR(1). p-value				0.000	0.000	0.000	0.000	0.000	0.000
Arellano-Bond test for AR(2). p-value				0.098	0.151	0.149	0.021	0.893	0.330

Note: The dynamic capital investment models from equation (8) are estimated using pooled OLS (OLS) and the Blundell–Bond system GMM (SGMM). The dependent variable is capital investment divided by total assets (INV). We use two types of uncertainty shocks (U): the firm-level uncertainty shock (FIRM) and the macro-level uncertainty shock extracted from the VIXJ. Year×Ind. indicates the cross-terms of the time dummy and industrial dummy variables. The uncertainty shock, Year×Ind., three- and four-lagged values of the capital investment, and two- and three-lagged values of all the other explanatory variables are used as instrumental variables. Standard errors are in parentheses. *, **, and *** represent the 10%, 5%, and 1% levels of significance, respectively.

Table 3: **Estimation Results for the R&D Equation**

Estimator:		OLS			SGMM		SGMM			SGMM	
Dependent Variable:		R&D			R&D		ΔR&D			R&D	
Uncertainty Shock:		FIRM			FIRM		FIRM			VIXJ	
Parameters: a_0 **and** a_{0u}											
R&D$_{t-1}$	0.963***	0.963***	0.966***	0.952***	0.948***	0.977***			0.951***	0.946***	0.969***
	(0.004)	(0.004)	(0.004)	(0.020)	(0.019)	(0.015)			(0.020)	(0.017)	(0.014)
R&D$_{t-1}$*U$_t$		-0.009	-0.007		0.003	0.115	0.006	0.078		1.118	0.845
		(0.011)	(0.014)		(0.021)	(0.083)	(0.022)	(0.057)		(0.881)	(1.267)
Parameters: b_k $(k=0,1)$											
CASHFLOW$_t$	0.003	0.003	0.006***	0.024***	0.018**	0.019**	0.014	0.008	0.024***	0.018***	0.016
	(0.002)	(0.002)	(0.002)	(0.008)	(0.008)	(0.008)	(0.011)	(0.007)	(0.008)	(0.007)	(0.010)
DEBT$_t$	0.007***	0.007***	0.007***	-0.003	0.006	0.002	0.004	0.009*	-0.003	-0.006	-0.002
	(0.001)	(0.001)	(0.001)	(0.007)	(0.006)	(0.005)	(0.009)	(0.005)	(0.007)	(0.006)	(0.006)
STOCKISSUE$_t$	0.019**	0.020**	0.023***	0.174	0.106	0.057	0.062	0.023	0.168	0.221**	0.135
	(0.009)	(0.009)	(0.009)	(0.106)	(0.085)	(0.051)	(0.074)	(0.049)	(0.105)	(0.092)	(0.091)
CASHFLOW$_{t-1}$			-0.005**			-0.004		-0.002			-0.003
			(0.002)			(0.004)		(0.003)			(0.005)
DEBT$_{t-1}$			-0.017***			-0.017***		-0.018***			-0.016***
			(0.001)			(0.001)		(0.001)			(0.002)
STOCKISSUE$_{t-1}$			-0.026***			-0.031**		-0.027**			-0.027**
			(0.008)			(0.013)		(0.013)			(0.013)
Parameters: b_{ku} $(k=0,1)$											
CASHFLOW$_t$*U$_t$		-0.004	-0.003		-0.079**	0.023	-0.100*	-0.070		0.622	1.527***
		(0.005)	(0.005)		(0.033)	(0.037)	(0.053)	(0.039)		(0.641)	(0.694)
DEBT$_t$*U$_t$		0.004	0.004		0.025	-0.043**	0.047	-0.008		0.800	0.009
		(0.003)	(0.003)		(0.023)	(0.020)	(0.046)	(0.032)		(0.614)	(0.611)
STOCKISSUE$_t$*U$_t$		0.016	0.014		0.470	0.356	0.379	0.232		29.92***	19.067*
		(0.023)	(0.023)		(0.426)	(0.265)	(0.352)	(0.214)		(10.988)	(10.064)
CASHFLOW$_{t-1}$*U$_{t-1}$			-0.000			0.004		0.002			-0.008
			(0.005)			(0.012)		(0.009)			(0.364)
DEBT$_{t-1}$*U$_{t-1}$			-0.000			0.001		0.001			-0.032
			(0.003)			(0.005)		(0.004)			(0.110)
STOCKISSUE$_{t-1}$*U$_{t-1}$			-0.066**			-0.048		-0.035			0.759
			(0.034)			(0.042)		(0.036)			(1.341)
Parameters: c_{ku} $(k=0,1)$											
U$_t$	-0.000	0.000	0.000	-0.000	0.003*	-0.002	0.005	-0.000	0.011	-0.056	-0.102**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.003)	(0.002)	(0.011)	(0.045)	(0.043)
U$_{t-1}$			0.000			-0.003*		-0.002			0.020
			(0.000)			(0.001)		(0.002)			(0.063)
TOBINQ$_t$	0.001**	0.001**	0.001***	-0.000	0.001	0.002*	0.001	0.003**	-0.000	0.001	0.003**
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SALES$_{t-1}$	-0.001***	-0.001***	-0.000	-0.005***	-0.004***	-0.000	-0.004***	0.001	-0.005***	-0.004***	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.000	0.000	-0.001	0.005***	0.003**	-0.002	0.002	-0.003***	0.004***	0.003**	-0.003*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Dummy variable	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.
No. of Obs.	11861	11864	11861	11861	11861	11861	11861	11861	11861	11861	11861
Adj. R seq.	0.953	0.953	0.955								
No. of IVs				345	360	360	356	356	345	360	360
Hansen test (p-value)				0.353	0.711	0.795	0.914	0.939	0.399	0.725	0.761
Diff. in Hansen test (p-value)				0.097	0.104	0.050	0.453	0.117	0.116	0.138	0.153
Arellano-Bond test for AR(1). p-value				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Arellano-Bond test for AR(2). p-value				0.104	0.365	0.375	0.169	0.317	0.092	0.148	0.266
Test for $a_0 = 1$ (p-value)	0.000	0.000	0.000	0.019	0.005	0.119			0.016	0.001	0.031

Note: The dynamic R&D investment models from equation (8) are estimated using pooled OLS (OLS) and the Blundell–Bond system GMM (SGMM). The dependent variable is R&D divided by total assets or the difference in it (ΔR&D). The uncertainty shock, Year×Ind., three- and four-lagged values of the interaction term of the lagged dependent variable with the uncertainty shocks, and two- to four-lagged values of all the other explanatory variables are used as instrumental variables. See also the note for Table 2.

Table 4: **Long-run Effects of Financing Variables**

Financing Variables	Capital Investment Low Uncertainty	Capital Investment High Uncertainty	R&D Investment Low Uncertainty	R&D Investment High Uncertainty
CASH FLOW	0.402***	0.124*	0.810**	-0.140
	(0.090)	(0.070)	(0.349)	(0.250)
DEBT ISSUE	0.241***	0.191***	-0.035	0.275
	(0.068)	(0.069)	(0.144)	(0.256)
STOCK ISSUE	-0.189	0.942	-0.855	4.957
	(0.342)	(0.773)	(2.271)	(4.272)

Note: We measure the long-run effects of marginal changes in the financing variables on capital investment and R&D investment, as expressed in equation (3), using the system GMM estimates of the zero-lag models with the firm-level uncertainty shock in Tables 2 and 3. The tenth percentile value of the firm-level uncertainty shock is defined as the low uncertainty shock, while the 90th percentile value is defined as the high uncertainty shock. Standard errors are in parentheses. *, **, and *** represent the 10%, 5%, and 1% levels of significance, respectively.

Table 5: **Estimated Effects of Cash Holdings and Firm Size**

Firm Attributes:	CASHRICH		LARGE	
Uncertainty Shock:	FIRM		FIRM	
Dependent Variable:	CAPITAL	R&D	CAPITAL	R&D
Parameters: b_0				
CASHFLOW$_t$	0.272***	0.015**	0.195***	0.017*
	(0.040)	(0.006)	(0.042)	(0.009)
CASHFLOW$_t$*CASHRICH	-0.120*	0.010		
	(0.072)	(0.021)		
CASHFLOW$_t$*LARGE			0.156**	0.013
			(0.071)	(0.019)
Parameters: b_{0u}				
CASHFLOW$_t$*U$_t$	-0.682***	-0.085*	-0.457***	-0.081**
	(0.175)	(0.050)	(0.158)	(0.036)
CASHFLOW$_t$*U$_t$*CASHRICH	0.855***	0.064		
	(0.277)	(0.093)		
CASHFLOW$_t$*U$_t$*LARGE			0.368	-0.018
			(0.286)	(0.065)
Dummy variable	Year×Ind.	Year×Ind.	Year×Ind.	Year×Ind.
No. of Obs.	11861	11861	11861	11861
No. of IVs	335	360	335	360
Hansen test (p-value)	0.373	0.543	0.262	0.552
Diff. in Hansen test (p-value)	0.474	0.150	0.573	0.086
Arellano-Bond test for AR(1). p-value	0.000	0.000	0.000	0.000
Arellano-Bond test for AR(2). p-value	0.852	0.164	0.668	0.200

Note: The dynamic capital investment models from equation (8) are estimated using the Blundell–Bond system GMM, in which capital (CAPITAL) and R&D investments and the firm-level uncertainty shock (FIRM) are included as the dependent variable and the uncertainty shock, respectively. For instruments used for the system GMM estimation of the capital and R&D investment equations, see the notes of Tables 2 and 3. The indicator of cash-rich firms (CASHRICH) is the dummy variable taking one if the averages on ratios of cash holdings to total assets in the sample period are in the top 75th percentiles. The indicator of large firms (LARGE) is the dummy variable if the averages on total assets in the sample period are in the 75th percentiles. Only estimated coefficients on cash flows and their interaction terms are reported in this table. Standard errors are in parentheses. *, **, and *** represent the 10%, 5%, and 1% levels of significance, respectively.

Table 6: **Weak and Invalid Instrument Robust Inference**

Case II: Only Interaction Effect Could Be Weakly Identified

Coefficient	Test	Capital Investment	R&D Investment
CASHFLOW$_t$*U$_t$	WALD	(-0.971, -0.394)	(-0.166, -0.003)
	J-K	(-2.379, -1.966)	Empty

Note: This table reports the 90% confidence intervals for the interaction effect of cash flows and the firm-level uncertainty shock (CASHFLOW$_t$*U$_t$). The confidence intervals for "WALD" and "J-K" show a hypothesized value for the interaction effect that is not rejected by the Wald and J-K (Kleibergen, 2005) tests at the 10% level of significance. Regarding the confidence intervals based on the J-K test, each hypothesized value is searched in the range from -3 to 3 with 30 grid points. The confidence intervals for the J-K test are robust to weak and invalid instruments under the assumption that coefficients on other endogenous regressors, except for the interaction term are strongly identified. See also the note for Figure 7.

Table **A-1: Information Criteria for Lag Selection:**

Corporate Investment:	Capital Investment		R&D	
Uncertainty Shock:	FIRM	VIXJ	FIRM	VIXJ
Zero-lag Model				
BIC	-1361.12	-1359.57	-1595.28	-1596.05
AIC	-150.64	-149.08	-200.27	-201.04
HQIC	-593.64	-592.09	-710.81	-711.57
One-lag Model				
BIC	-1321.85	-1324.93	-1560.77	-1556.61
AIC	-148.27	-151.35	-202.66	-198.51
HQIC	-577.76	-580.85	-699.69	-695.53
Two-lag Model				
BIC	-1282.60	-1283.86	-1485.24	-1498.24
AIC	-159.46	-160.72	-171.25	-184.25
HQIC	-571.37	-572.63	-653.15	-666.15
Three-lag Model				
BIC	-1205.17	-1206.25	-1475.83	-1518.18
AIC	-132.00	-133.08	-205.55	-247.90
HQIC	-526.42	-527.50	-672.42	-714.77

Note: We calculate three types of information criteria for the zero- to three-lag models, BIC, AIC, and HQIC, as shown in Appendix III.

Table **A-2: Summary Statistics (2001–2014):**

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Uncertainty Measures					
Firm-level Uncertainty ($\sigma^E_{i,t}$)	16569	0.405	0.159	0.067	1.764
Macro-level Uncertainty (VIXJ$_t$)	16569	0.261	0.067	0.152	0.459
Uncertainty Shocks (U$_{i,t}$)					
Firm-level Uncertainty Shock (U$^s_{i,t}$)	16569	-0.011	0.246	-0.779	0.765
Macro-level Uncertainty Shock	16569	0.002	0.010	-0.019	0.025
Corporate Investment Spending (I$_{i,t}$)					
Capital Investment	16569	0.038	0.039	-0.161	0.241
R&D	16569	0.024	0.022	0.000	0.121
Firm Financing Variables					
Cash Flows (CF$_{i,t}$)	16569	0.056	0.050	-0.413	0.553
Debt Issues (DEBT$_{i,t}$)	16569	-0.001	0.074	-0.493	0.624
Stock Issues (STOCK$_{i,t}$)	16569	0.001	0.008	0.000	0.173
Control Variables					
Tobin's Q (Q$_{i,t}$)	16569	0.995	0.326	0.080	2.849
Sales (SALES$_{i,t}$)	16569	0.943	0.324	0.090	2.168
Firm Attributes					
Cash-rich Firm Dummy (CASHRICH$_i$)	16569	0.216	0.411	0.000	1.000
Large Firm Dummy (LARGE$_i$)	16569	0.294	0.456	0.000	1.000

Note: The mean and standard deviation of all variables are calculated on the firm basis. All the variables except for Tobin's Q are scaled by total assets at the beginning of the period. Observations that are three standard deviations away from the sample mean as the outliers are preliminarily removed.

(a) Uncertainty Measures **(b) Uncertainty Shocks**

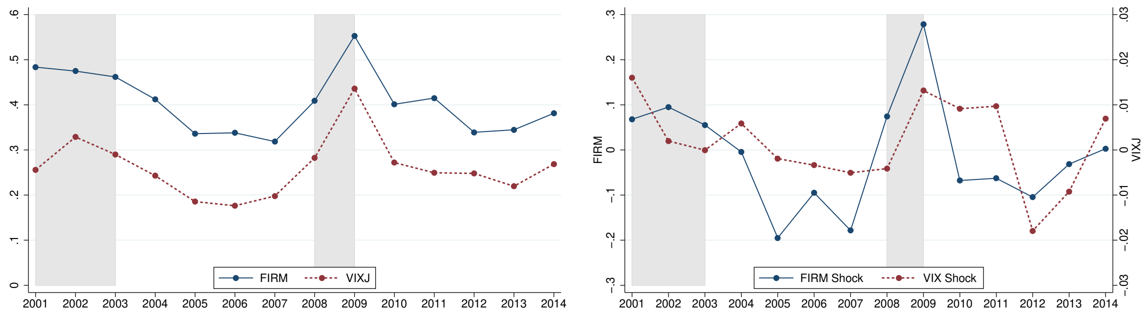

Figure 1: **Firm- and Macro-level Uncertainty**

Note: Panels (a) and (b) report two uncertainty measures and their associated shocks, respectively, from fiscal years 2001 to 2014. The periods of the Japanese banking crisis, 2001–2003, and the Global Financial Crisis, 2008–2009, are shaded distinctly. The solid lines in panels (a) and (b) show the firm-level idiosyncratic uncertainty (FIRM) calculated from the volatility in the daily excess equity returns of each firm and its associated shock, while the dotted lines represent the VIXJ and its shock. The FIRM and its shock are reported as their year-by-year sample average. See Section 2.2 and Appendix II for the details on the calculation for each of the uncertainty measures and their shocks.

(a) Capital Investment and R&D **(b) Financing Sources**

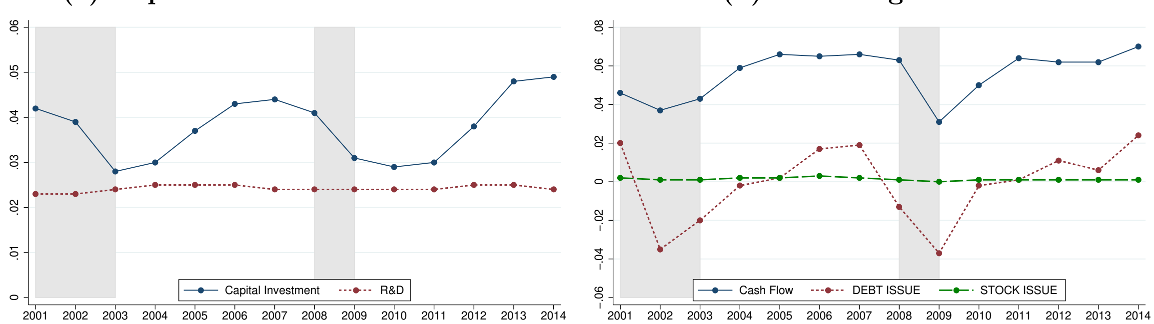

Figure 2: **Corporate Investment and Firms' Financing Sources**

Note: Panel (a) shows capital investment and R&D from fiscal years 2001 to 2014, while Panel (b) shows firms' three financing sources: cash flows, debt issues, and stock issues. All the variables are reported as their year-by-year sample average. See Section 2.4 for the details on the definition of each of the variables. The periods of the Japanese banking crisis, 2001–2003, and the Global Financial Crisis, 2008–2009, are shaded in the two panels.

Figure 3: **Estimated Dynamic Response of Capital Investment**

Note: The solid line shows the dynamic response of capital investment to marginal changes in the financing variables, estimated using equation (2). This dynamic response is calculated based on the system GMM estimation results for the zero-lag model for capital investment. The horizontal axis corresponds to the four-period-ahead response in equation (2). "Low" indicates the estimated response to the low uncertainty shock, which is the tenth percentile value of the firm-level uncertainty shock, while "High" indicates the high uncertainty shock, which is the 90th percentile. The shaded area denotes the 90% confidence interval of the estimated response.

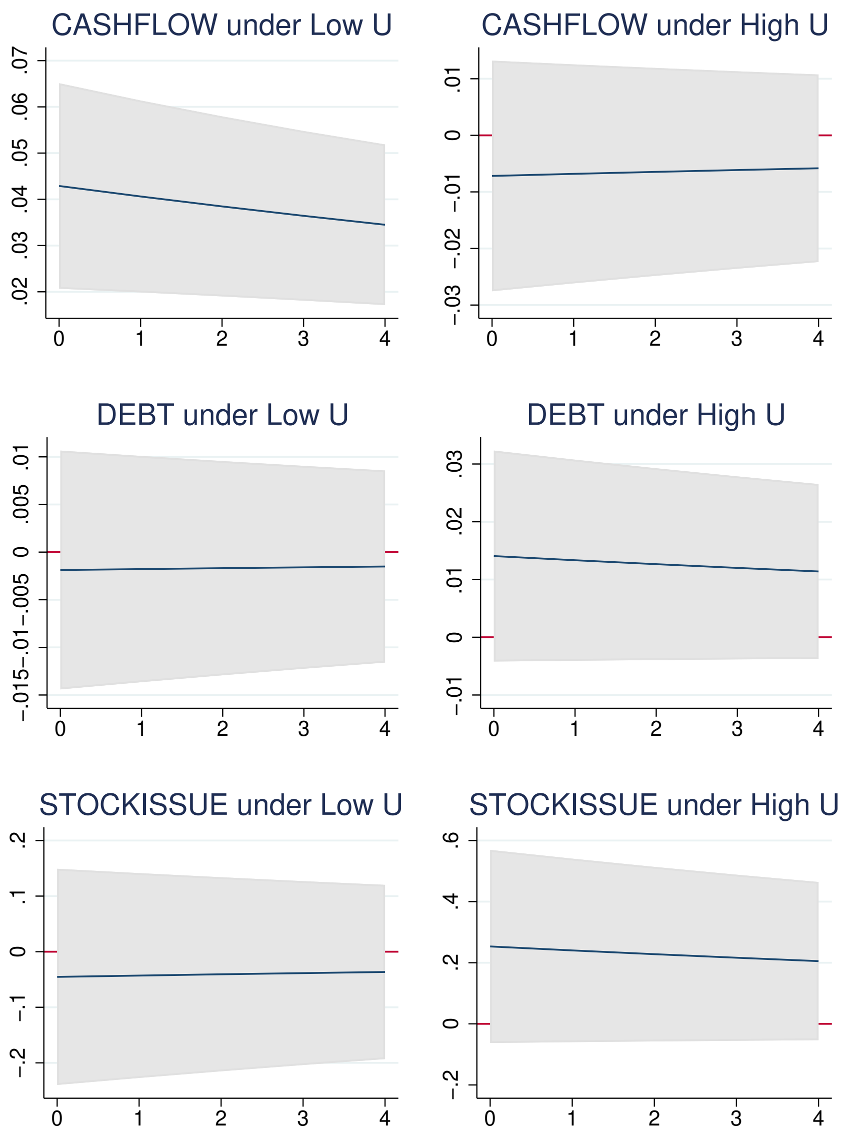

Figure 4: **Estimated Dynamic Response of R&D Investment**

Note: The solid line shows the dynamic response of R&D investment to marginal changes in the financing variables, estimated using equation (2). This dynamic response is calculated based on the system GMM estimation results for the zero-lag model for R&D. See also the note for Figure 3.

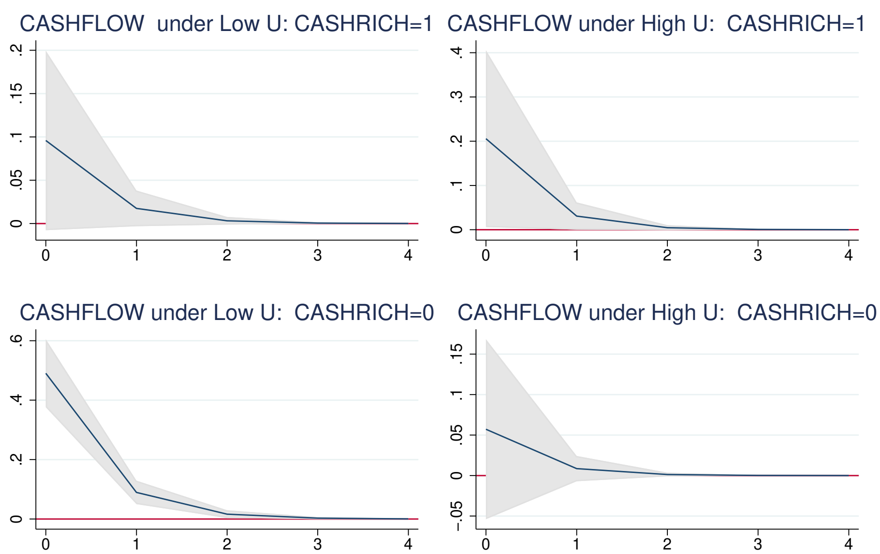

Figure 5: **Response of Investment in Cash-rich and Cash-poor Firms**

Note: The solid line shows the dynamic response of capital investment to marginal changes in the variable of cash flows, estimated using equation (2) with the interaction term of cash flows ($\mathrm{CF}_{i,t}$) and the indicator of cash-rich firms ($\mathrm{CASHRICH}_i$), and the triple interaction term of cash flows, the uncertainty variable ($\mathrm{U}_{i,t}$), and the indicator of cash-rich firms. Cash-rich firms (i.e., $\mathrm{CASHRICH}_i$=1) are defined when the average on cash holdings to total assets in the sample period is above the 75th percentile, while cash-poor firms (i.e., $\mathrm{CASHRICH}_i$=0) have the ratio below the 75th percentile. This dynamic response is calculated based on the system GMM estimation results for the zero-lag model for capital investment. See also the note for Figure 3.

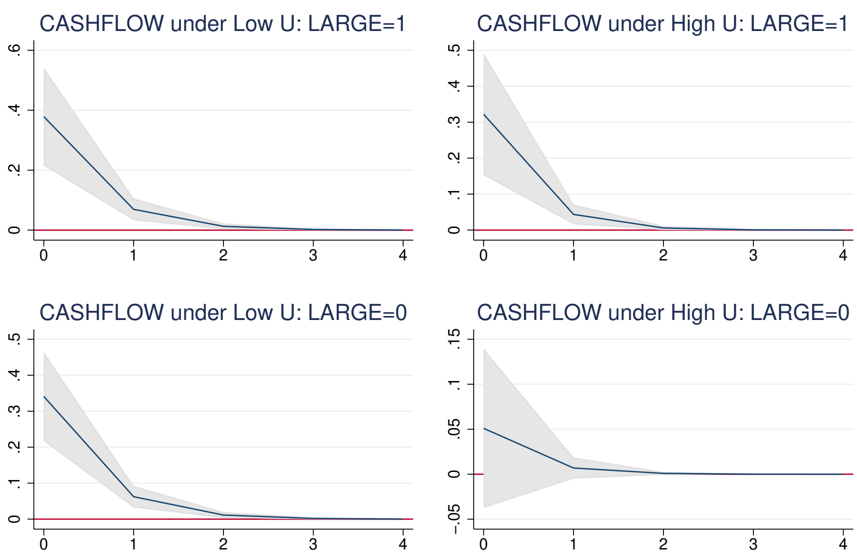

Figure 6: **Response of Capital Investment in Large and Small Firms**

Note: The solid line shows the dynamic response of capital investment to marginal changes in the variable of cash flows, estimated using equation (8) with the interaction term of cash flows ($CF_{i,t}$) and the indicator of large firms ($LARGE_i$), and the triple interaction term of cash flows, the uncertainty variable ($U_{i,t}$), and the indicator of large firms. Large firms (i.e., $LARGE_i$=1) are defined when the average on total assets in the sample period is above the 75th percentile, while small firms (i.e., $LARGE_i$=0) have the value below the 75th percentile. This dynamic response is calculated based on the system GMM estimation results for the zero-lag model for capital investment. See also the note for Figure 3.

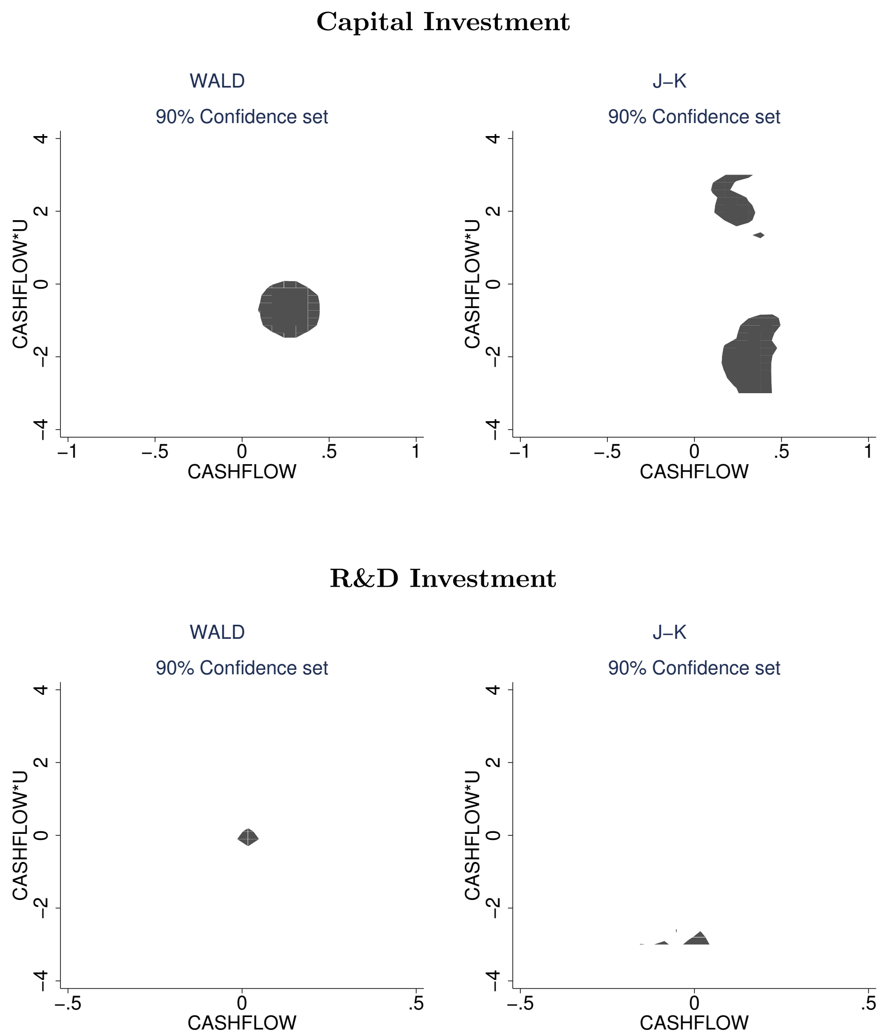

Figure 7: **Weak and Invalid Instrument Robust Inference**
Case I: Two Coefficients Could Be Weakly Identified

Note: The shaded areas show the 90% joint confidence regions for the estimated coefficients on cash flows (CASHFLOW; horizontal axis) and its interaction term with the firm-level uncertainty shock (CASHFLOW*U; vertical axis). The confidence regions for "WALD" and "J-K" show that the pairs of hypothesized values for the two coefficients are not jointly rejected by the Wald and J-K (Kleibergen, 2005) tests at the 10% level of significance. Regarding the confidence regions based on the J-K test, each pair of hypothesized values is searched in the range from -1 to 1 (-0.5 to 0.5) for CASHFLOW of capital investment (R&D investment) and in the range from -3 to 3 for CASHFLOW*U with $30^2 = 900$ grid points. The confidence regions for the J-K test are robust to weak and invalid instruments under the assumption that the coefficients on the other endogenous regressors are strongly identified. The confidence intervals based on the Wald test are calculated using the estimation results for the zero-lag model of capital investment (upper panel) and R&D investment (lower panel), additionally including the indicator of cash-rich firms and its interaction terms into equation (8) (See Table 5 for these estimation results). The sets of instruments are the same ones used for estimating the two investment equations (see the notes for Tables 2 and 3).

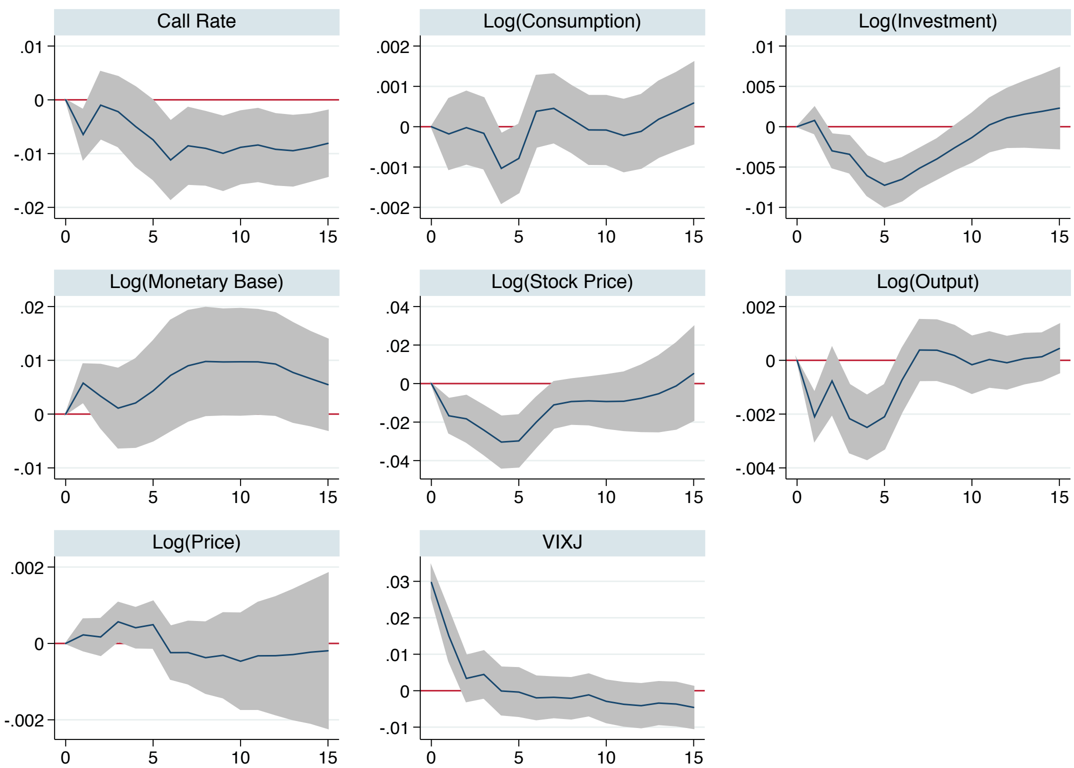

Figure A: **Impulse Responses to the Macro-level Uncertainty Shock**:

Note: The solid lines show the impulse responses to a one-standard-deviation uncertainty shock and the shaded areas are the 90% confidence intervals. See Section 2.2.2 and Appendix II for details of the calculation of the estimated impulse responses.