HETEROGENEOUS EFFECT OF UNCERTAINTY ON CORPORATE INVESTMENT

EVIDENCE FROM LISTED FIRMS IN THE REPUBLIC OF KOREA

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ABSTRACT

In this paper, we analyze the effect of financial uncertainty on corporate investment using firm-level panel data from the Republic of Korea. We find that financial uncertainty has a significant negative effect on corporate investment, and that the effect is heterogeneous across firms of different sizes. Small firms and large firms are more exposed to the negative effect of uncertainty than are medium-sized firms. The negative effect of uncertainty on large firms slightly declined after the global financial crisis, but it increased for small and medium-sized enterprises (SMEs). Financial constraints and investment irreversibility amplify the negative effect of uncertainty. The inverted U-shaped curve of the uncertainty effect along the firm-size spectrum can be understood as follows: Small firms are more financially constrained and large firms' investments are more irreversible in nature. Lastly, contrary to widespread belief, uncertainty has waned since 1990, dampening the trend of declining investment ratios. To counter the negative effect of uncertainty on SMEs, policies need to be directed toward the development of capital markets and bond markets for SMEs. Furthermore, SME policies should be redirected to target competitiveness, not protection.

Keywords: uncertainty, corporate investment, financial constraints, investment irreversibility

JEL codes: E22, G31

I. INTRODUCTION

The economic growth of Asian economies has declined substantially since 2000. One major reason for the slowdown has been the decline in investment growth. The share of gross fixed capital formation in gross domestic product (GDP) dropped 4.9 percentage points in Hong Kong, China; 1.4 percentage points in the Republic of Korea (ROK); and 9.2 percentage points in Singapore between 2000 and 2018. While a multitude of factors influence corporate investments, uncertainty has been attracting attention in recent studies (Baker, Bloom, and Davis 2016). The simple assumption is that firm investments are negatively influenced by greater uncertainty, since corporate investment decisions depend on the future prospects of market conditions. Bernanke (1983), Pindyck (1991), Dixit and Pindyck (1994), and Bloom (2009) documented the hypothesized negative link between investment and uncertainty based on empirics and theoretical models.

The extent to which uncertainty has influenced corporate investment is a matter of empirics, and must be evaluated based on relevant data. For the purposes of this paper, we need to define the nature of uncertainty and how it is measured. Uncertainty can arise from many different sources, including government regulations, market demand and supply, and the effects of technological innovations. In this paper, we pay attention to financial uncertainty, which is measured by stock price volatility and reflects market perceptions of various market-relevant factors.

The goal of this paper is to analyze how the financial uncertainty facing Korean firms has evolved over time, and the extent to which corporate investments have responded to changes in the level of financial uncertainty. Our analysis is based on firm-level panel data from ROK. We examine how the effect is heterogeneous across firms with different characteristics, such as size, irreversibility of investments, and financial constraints. Since the effect of uncertainty is felt through the channel of financial constraints, we will note the implications of uncertainty in financial markets, including bond markets, for corporate investments.

There are different measures of uncertainty, depending on the focus of interest. Recent studies, such as that by Baker, Bloom, and Davis (2016), focus on policy uncertainty. They choose specific words associated with uncertainty and extract the frequency of the selected words from newspaper articles to derive an index of policy uncertainty at the country level. A more conventional measure of uncertainty is an index of financial uncertainty measured by stock price volatility; this measure is used in studies by Leahy and Whited (1996); Bloom, Bond, and Van Reenen (2007); and Bloom (2009), among others. The index is defined as the standard deviation of daily stock returns of firms. Therefore, this measure of uncertainty is firm-specific and we use this index in our paper.

Uncertainty may have differential impacts on firms with different characteristics. The impact of uncertainty on the aggregate economy depends on the composition of these heterogeneous firms. Studies have identified two major factors that amplify the effect of uncertainty on corporate investments—investment irreversibility and financial constraints.

First, uncertainty may have a negative influence on corporate investment decisions because investments are intrinsically irreversible in nature. Once a decision on investment is made and implemented, it is difficult to reverse it, as a reversal will usually inflict significant losses on the firm due to the reduction in the value of the investments. This fact makes firms hesitant to cancel existing projects. The degree of irreversibility may differ depending on the type of investment. Due to

irreversibility, however, firms may become more cautious in making investments when they face greater uncertainty. Kim and Kung (2017) argue that the impact of uncertainty on corporate investments is influenced by a firm's asset redeployability. Firms using general capital goods that can be readily resold are less influenced by uncertainty in their investment decisions. Gulen and Ion (2016) use capital intensity, sunk costs, and sensitivity to business cycles as proxies for industry-specific investment irreversibility. Both of these studies conclude that the policy-uncertainty, or VIX, index shows a differential impact on corporate investment, depending on the extent of the investment irreversibility of firms. However, these studies only look at policy uncertainty, which is not firm-specific, so they may fail to capture the heterogeneity of uncertainty across firms.

A second factor that influences corporate investment decisions in the face of uncertainty is the existence of financial constraints. Studies have found that the negative impact of uncertainty on investment is greater for the firms facing financial constraints. Fazzari, Hubbard, and Petersen (1988) point out that a firm's level of investment depends on its financial capacity, and that a firm's cost of capital for internal and external financing is influenced by the firm's financial constraints. Baum, Caglayan, and Talavera (2010) find that, when firm-specific uncertainty rises, manufacturing firms in the United States with high leverage ratios reduce their investments more than those with low leverage ratios. Gilchrist, Sim, and Zakrajsek (2014) find that a widening of credit spreads will lead to an increase in the cost of capital, and thus to a reduction in investments. Choi et al. (2018) investigate 25 industries in 18 advanced economies, and find that uncertainty shocks have a relatively stronger negative effect on the investments of industries that rely heavily on external financing.

In addition, the effect of uncertainty on investment is found to be dissimilar for firms of different sizes and for firms facing different market conditions. Ghosal and Loungani (2000) find that when uncertainty about the operating surplus rises, most small firms reduce their investments. Byun and Jo (2018) show that the negative effect of uncertainty follows an inverted U-shaped curve across the spectrum of firm size, with a higher negative effect for small and large firms than for medium-sized firms. Bulan (2005) suggests that firms in markets with limited competition are more influenced by uncertainty than others, but Ghosal and Loungani (1996) find that more competitive markets with large distributions of small firms are actually affected more.

In this paper, we address the differential effect of uncertainty on corporate investment and gauge the extent to which uncertainty affects it, using Korean firm-level data.[1] The questions and issues dealt in this paper are as follows: First, we analyze the extent to which the uncertainty effect is heterogeneous across firms with different characteristics and across different times, in particular before the global financial crisis (GFC) and afterward. Second, we identify the different channels through which uncertainty influences investments by firms. In this context, we include both the degree of investment irreversibility and liquidity constraints, which have been proposed in the literature as potential channels. This paper is the first to incorporate both channels and analyze the extent to which they can explain the heterogeneous effect of uncertainty on different firms in different periods. Third, we explore how the growth of bond markets can influence the uncertainty effect on corporate investment through the financial-constraint channel. Fourth, we calculate the relative significance of uncertainty in explaining trends in corporate investments, based on the resulting regression estimates. Lastly, we estimate the overall impact of uncertainty on the corporate sector and identify policy implications.

[1] This paper develops extensive analyses based on the work of Kim (2019).

After this introductory section, the paper is organized as follows: Section II discusses alternative measures of uncertainty, investment irreversibility, and financial constraints. Section III presents the empirical model and the data used in the empirical analysis. Section IV reports and discusses our main empirical results on the heterogeneous effect of uncertainty on investments. Section V discusses the magnitude of the uncertainty effect on corporate investment. Section VI presents our conclusions.

II. ALTERNATIVE MEASURES OF UNCERTAINTY, INVESTMENT IRREVERSIBILITY, AND FINANCIAL CONSTRAINTS

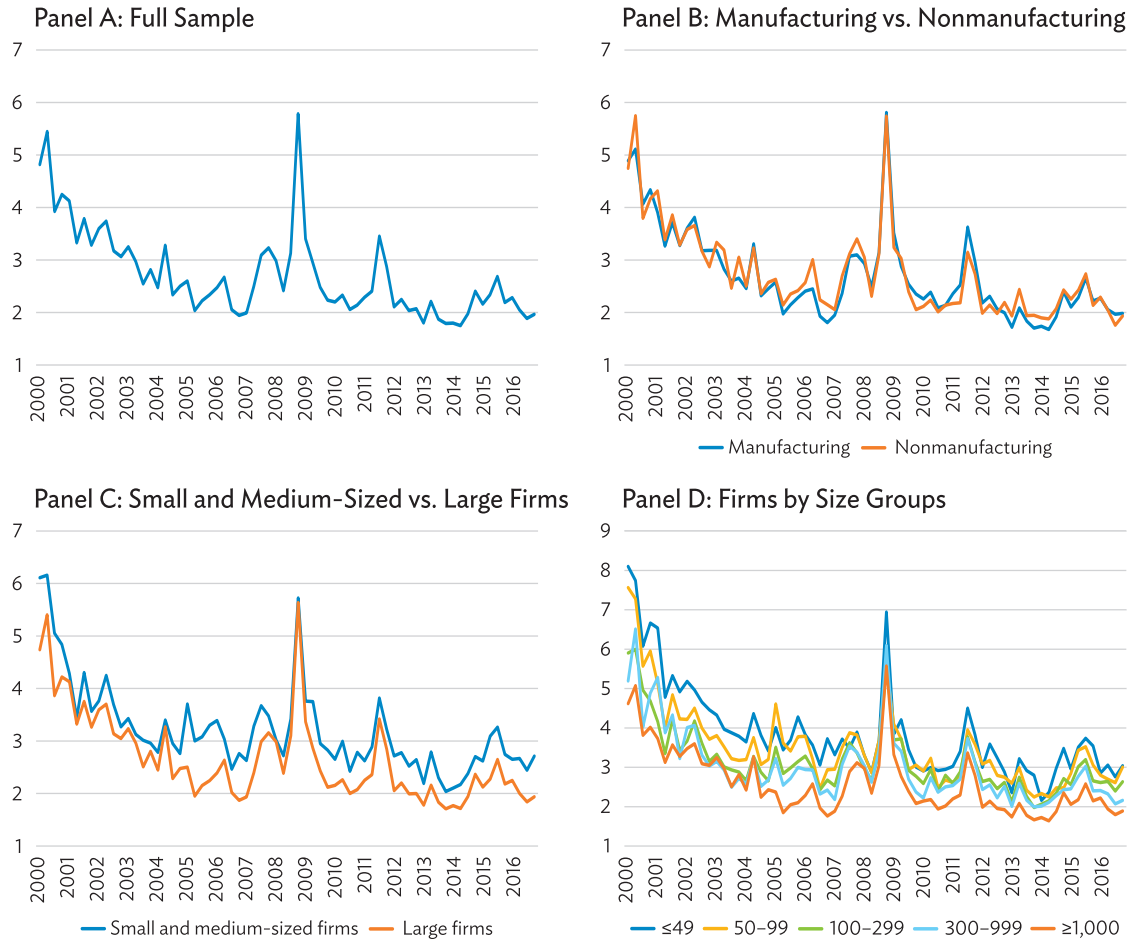
In this section, we define the uncertainty index and show the trends for publicly listed Korean firms during 2000–2016, presenting the results for the full sample and for the subsamples based on firm size and sector (manufacturing versus nonmanufacturing). Then we introduce and define the two indices of financial constraint and the three indices of investment irreversibility, which we apply later in this paper.

A. Uncertainty Index

The uncertainty index is calculated for each individual firm. It is measured by the volatility of the firm's daily stock price returns, as suggested by existing studies such as Leahy and Whited (1996); Bloom, Bond, and Van Reenen (2007); and Bloom (2009). The index is assumed to reflect the relevant information concerning the future prospects of a firm. As new information is revealed, the firm's stock prices will fluctuate accordingly. Price volatility will be greater when the market receives mixed signals about the firm's prospects. Like Leahy and Whited (1996), we define uncertainty measures as the standard deviations of the daily stock returns of individual firms on a quarterly basis.

The uncertainty indices for publicly listed Korean firms are presented in Figure 1. Panel A shows the sales-weighted average of the financial uncertainty of each listed Korean firm during 2000–2016. The indices decline sharply from 2000 until the global financial crisis (GFC), but the degree of overall uncertainty is stable in the post-GFC period up to 2016. The pattern of uncertainty indices for the manufacturing and nonmanufacturing sectors do not differ qualitatively from that of the aggregate index, as can be seen in Panel B. Panel C shows that the uncertainty indices are significantly higher for the SMEs than those for the large firms. However, long-term declining trends are evident in both groups. Panel D shows that the uncertainty indices are monotonically higher for smaller firms and that all firm size groups share a common declining trend.

Figure 1: Financial Uncertainty Index for Korean Firms

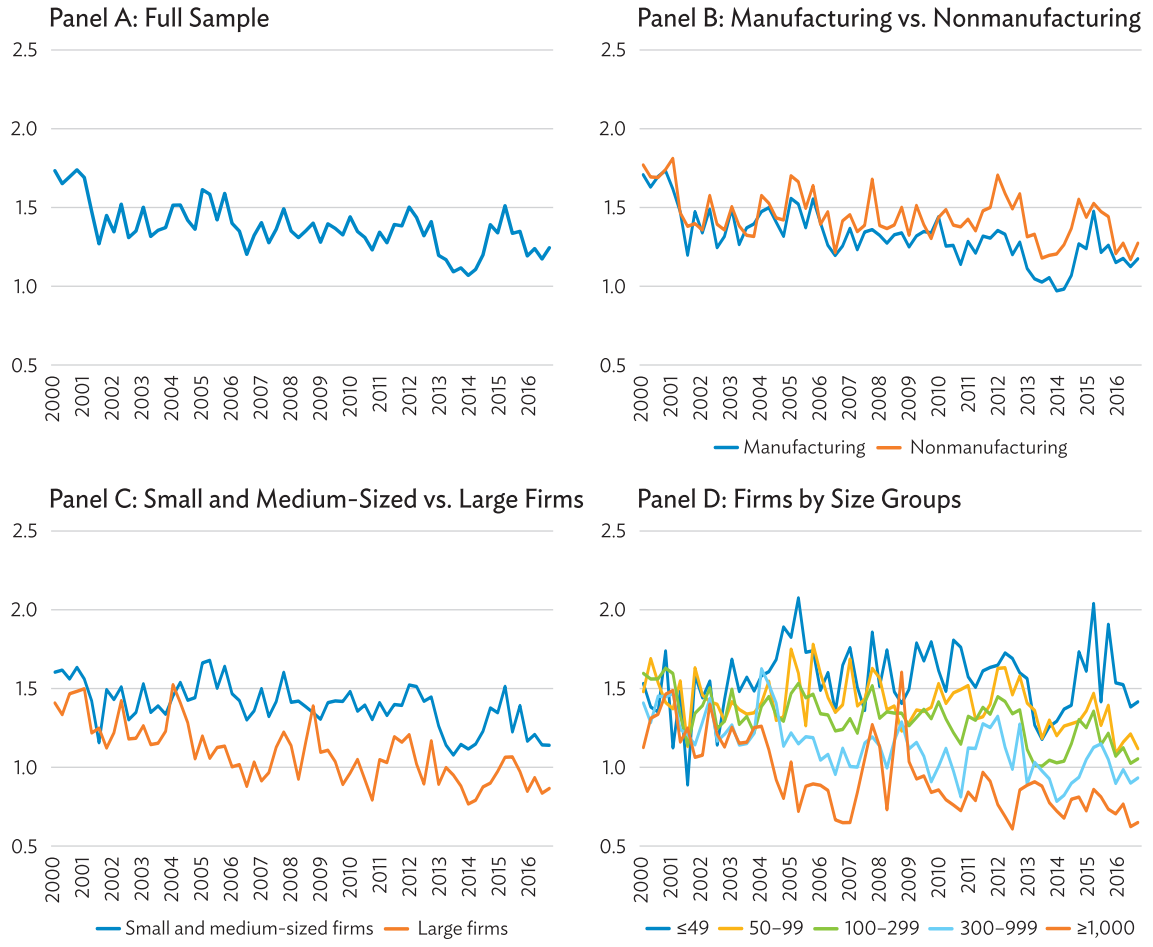


Note: The unit of an individual firm's financial uncertainty is the standard deviation of daily stock returns of firm price volatility. The financial uncertainty index is calculated by taking sales-weighted averages of the financial uncertainty of individual listed Korean companies.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

To examine the heterogeneity of the uncertainty index across firms in a given year, the cross-section variation of the uncertainty indices of listed Korean firms is presented in Figure 2. The full-sample heterogeneity of uncertainty does not seem to be subjected to any long-term trends, as shown in Panel A of Figure 2. However, a mild decline is visible after 2012. The degree of heterogeneity in the manufacturing sector shows a visible decline, while that of the nonmanufacturing sector is relatively stable, as shown in Panel B. Panels C and D show that the heterogeneity in uncertainty indices significantly declined for large firms, but remained relatively stable for smaller firms.

Figure 2: Cross-Section Variation of the Financial Uncertainty Index: Korean Firms



Note: The unit of an individual firm's financial uncertainty is the standard deviation of daily stock returns of firm price volatility. The financial uncertainty index is calculated by taking the sales-weighted averages of the financial uncertainty of individual listed Korean companies.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

B. Measures of Financial Constraints

"Financial constraint" can be defined as the cost gap between internal and external financing. Investment and growth strategy may be influenced by this cost gap. When uncertainty rises, banks may avoid lending to firms with high leverage ratios and weak financial conditions. We follow two measures of financial constraints from Whited (1992) and Alfaro, Bloom, and Lin (2018). Financial constraints may hinder the efforts of firms to implement investment projects. Firms with a lower interest coverage ratio (ICR) are more likely to be financially constrained (Whited 1992). The ICR is calculated by dividing the operating profits by the interest cost. A higher ICR implies that the firm is in a strong position to repay its existing debts, so the firm will be favorably treated in the financial market. The financial constraint caused by the ICR, *fc1*, is assigned the value of 1 for the firms with an ICR lower than 1, and the value of zero for firms with an ICR that is greater than 1. The financial constraint designated as *fc2* is measured based on the credit ratings of firms (Alfaro, Bloom, and Lin 2018). Firms

with low credit ratings are more likely to face financing difficulties when uncertainty increases. Using Korean credit rating agency scores, we assigned the *fc2* value of zero for the highest credit ratings (1–3), 1 for the medium ratings (4–6), and 2 for the lowest ratings (7–10).

Table 1: Alternative Indices for Measuring Financial Constraints

Index	Explanations
fc1 (interest coverage ratio)	Interest coverage ratio (ICR) = operating income/interest cost fc1 = 1 if ICR(i) < total sample average ICR. Otherwise, fc1 = 0. A higher value means a firm is financially constrained.
fc2 (credit rating)	For the KIS credit rating, scores run from 1 to 10, depending on the financial situation of the firm i. fc2 = 0 if KIS(i) = 1–3, fc2 = 1 if KIS(i) = 4–6, and fc2 = 2 if KIS(i) = 7–10. A higher value means a firm is financially constrained.

fc = financial constraint, ICR = interest coverage ratio.

Source: Authors.

C. Measures of Investment Irreversibility

Gulen and Ion (2016) provide three measures of irreversibility. These indices are defined for three-digit industries under the Standard Industrial Classification codes, and we assumed that firms in an industry share common industry-specific features, as follows:

The *ir1* index is measured based on the capital intensity ratio. The higher this ratio, the greater the chance that firms will find it difficult to reverse their investment decisions. A firm's capital intensity ratio is the ratio of its tangible assets to its total assets. Industry-specific irreversibility is defined as the median capital intensity ratio for the industry concerned.

The *ir2* index is measured based on the sunk costs. Industries with higher sunk costs are likely to have higher levels of irreversibility. If a firm belongs to an industry that requires heavy capital investment with slow depreciation, or that relies on low-use equipment and building rentals, then reversing investments will be especially costly. We compare the ratio of rental costs to tangible assets and the ratio of depreciation to the tangible assets of each firm with the ratios' respective industry medians. If both ratios are above their industry medians, the *ir2* value of 2 is assigned. If one ratio is above the industry median, then the value of 1 is assigned. If both ratios are below their industry medians, then the value of 0 is assigned.

The *ir3* index is measured based on the responsiveness of industry demand to the business cycle. Uncertainty will influence consumption as well as investments. If industry demand is responsive to the business cycle, an increase in uncertainty will lead to a negative demand shock, which will harm sales. If the demand shock is common to all firms in the same industry, the firms will find it difficult to sell off their capital assets in the resale market. This path is valid not only when industry-level uncertainty is used, but also when stock return volatility is used as a measure of firm-level uncertainty. Firm-specific uncertainty includes industry-level uncertainty. Therefore, companies in the same industry have a high correlation of uncertainty with each other. Bloom (2009) argues that other measures of uncertainty, such as firm-level volatility and industry-level earnings, are also strongly correlated with each other. Thus, *ir3* is also defined as the correlation between industry sales growth and nominal GDP growth. Industry sales growth is calculated as the median growth of firms' sales within a three-digit industry.

Table 2: Alternative Measures of Investment Irreversibility

Index	Explanations
ir1 (capital intensity ratio)	(i) Capital intensity ratio = tangible assets/total assets (ii) Investment irreversibility in a three-digit industry is defined as the median capital intensity ratio for the firms in that industry.
ir2 (sunk costs)	(i) Sunk costs = rental expenses + losses due to depreciation (ii) Investment irreversibility is calculated in two ways for a firm in a three-digit-level industry: the ratio of rental costs to the tangible assets of the firm and the ratio of depreciation to the tangible assets. (iii) If both ratios are above medians for the industry to which the firm belongs, the value assigned is 2; if one of the ratios is above the industry's median, the value assigned is 1; and if both ratios are below the industry's medians, the assigned value is 0.
ir3 (firms' sales cyclicality)	The cyclicality of a firm = the correlation coefficient between that firm's quarterly sales and GDP. (ii) The cyclicality of a three-digit-level industry is measured by the median coefficient of the firms in that industry.

GDP = gross domestic product, ir = investment irreversibility.

Note: Three-digit industries belong to categories identified by three-digit codes under the Standard Industrial Classification system.

Source: Authors.

III. MODEL AND DATA DESCRIPTION

In this section, we present our empirical model and the data we used in our analysis. We studied the effect of uncertainty on corporate investment based on the empirical model developed by Gulen and Ion (2016) to describe investment irreversibility. To accommodate both potential channels of the uncertainty effect, the model is modified to additionally include a financial constraint variable. The econometric analyses are performed based on a quarterly panel data set of listed Korean firms for the period from the first quarter (Q1) of 2000 to Q4 2016. Our basic model is the following fixed effects model, with the individual corporate investment ratio as the dependent variable:

$$\frac{\mathrm{Capx}_{i,t}}{\mathrm{ta}_{i,t-1}} = \beta_1 \mathrm{unc}_{i,t-1} + \beta_2 \mathrm{tq}_{i,t-1} + \beta_3 \frac{\mathrm{cf}_{i,t-1}}{\mathrm{ta}_{i,t-2}} + \beta_4 \mathrm{sg}_{i,t-1} + \beta_5 \mathrm{fc}_{i,t-1} + \beta_6 \mathrm{ir}_{i,t-1} + \lambda_t + \eta_i + \epsilon_{i,t}$$

The dependent variable is the firm-level investment ratio ($\frac{\mathrm{capx}_{i,t}}{\mathrm{ta}_{i,t-1}}$), which is defined as the ratio of the current period's capital expenditure to the previous period's total assets. Independent variables include the lagged values of uncertainty (unc), Tobin's q (tq), cash flow (cf), sales growth (sg), the index of financial constraint (fc), and the index of investment irreversibility (ir). The regressions are based on unbalanced firm panel data for the periods of Q1 2000 to Q4 2016, the first half (H1) of 2000 to H2 2016, and 2000 to 2016. All the regressions include both firm-specific fixed effect dummies and time fixed effect dummies. To gauge the amplifying effects of the two channels, we introduced terms referring to the interaction of the two factors with the uncertainty index (unc × fc and unc × ir) in an alternative model.

The data used in this paper are firm-level unbalanced panel data from KISVALUE Database of NICE Information Service, which includes the financial statements of all listed and externally audited

firms in the ROK. We limited our samples to nonfinancial listed firms because the uncertainty index is calculated based on stock prices. Financial firms are excluded from the sample because the investments and financial structure of financial firms are noticeably different from those of nonfinancial firms. The sample starts from 2000 to exclude the observations affected by the Asian financial crisis of 1997–1998. We winsorized the top 1% and lowest 1% of the sample to avoid biases due to extreme values. The uncertainty index is calculated for each firm based on daily stock prices on a quarterly basis. The base model includes the financial constraint index based on the interest coverage ratio (*fc1*) and the investment irreversibility index based on the capital intensity variable (*ir1*) calculated for each firm.

A summary of the statistics from the quarterly sample is provided in Table 3. Panel A shows that the ratios of capital expenditure to assets are similar for the periods before and after the global financial crisis (GFC). On the other hand, the uncertainty index is lower for the post-GFC period (0.029) than for the pre-GFC period (0.035). The investment ratio rose from 0.287% to 0.317% between the two periods. Financial constraints slightly worsened, but investment irreversibility slightly declined. A t-test of the differences in the means indicated that the differences are statistically significant, except for the differences in the investment ratios. We examine the pre-GFC versus post-GFC differences more closely in the regressions below.

Panel B presents a summary of the statistics from the firm-size subsamples. The total sample was divided into 5 subsamples by firm size: firms with fewer than 50 employees, 50–99 employees, 100–299 employees, 300–999 employees, and 1,000 or more employees. The capital expenditure ratio, which is a firm's capital expenditure divided by total sales, is the greatest for firms with 100–299 employees (0.391) and is slightly lower for firms with 300 or more employees. The uncertainty index monotonically falls with firm size. Financial constraints fall with firm size, while investment irreversibility rises with firm size.

In panel C, the subsamples are also divided by the degree of market competition that the firms faced in their respective industries. The degree of market competition is determined based on the Herfindahl-Hirschman Index (HHI). The firms were divided into subsamples of low-competition markets and high-competition markets. The ratios of capital expenditure to assets and the uncertainty indices do not differ significantly between the two subsamples. Panel D summarizes the statistics for the subsamples of firms categorized into different age groups. The capital expenditure ratios and uncertainty indices were found to be lower for older firms.

Table 3: Descriptive Statistics

Panel A: By Period

	Full Sample		Before GFC (Q1 2000–Q2 2008)		After GFC (Q1 2010–Q4 2016)		Differences between Pre- and Post-GFC
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**t-statistic**
capx_ta	0.359	2.729	0.287	2.645	0.317	2.557	–1.368
unc	3.202	1.430	3.456	1.449	2.867	1.276	50.968***
tq	118.326	73.805	106.627	60.137	129.945	83.755	–38.948***
cf_ta	0.494	3.406	0.617	3.540	0.437	3.167	6.328***
sg	9.664	49.397	10.806	48.826	8.712	48.641	5.119***
fc	0.338	0.473	0.329	0.470	0.341	0.474	–3.070***
ir	0.293	0.112	0.316	0.112	0.276	0.111	42.343***
No. of firm IDs		1,654		1,172		1,633	
No. of observations		64,248		24,948		32,858	

continued on next page

Table 3 *continued*

Panel B: By Size

	Firm Size									
	1–49		50–99		100–299		300–999		1,000+	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
capx_ta (%)	0.055	2.797	0.208	2.606	0.391	2.815	0.312	2.584	0.320	2.373
unc	3.976	1.695	3.568	1.529	3.321	1.416	2.893	1.252	2.709	1.110
tq	150.400	108.520	129.067	89.101	115.731	68.297	105.672	58.339	127.126	75.609
cf_ta (%)	–1.642	5.479	0.107	4.025	0.575	3.197	0.877	2.548	1.197	2.450
sg (%)	18.689	94.545	11.485	61.401	10.496	48.387	7.049	34.061	5.724	26.437
fc	0.604	0.489	0.399	0.490	0.342	0.474	0.290	0.454	0.221	0.415
ir	0.228	0.107	0.272	0.108	0.289	0.103	0.312	0.111	0.320	0.132
No. of firm IDs		290		576		1,070		726		265
No. of observations		3,751		8,530		23,603		16,983		7,279

Panel C: By Level of Market Competition

	Market Competition			
	Low		High	
Variable	**Mean**	**SD**	**Mean**	**SD**
capx_ta (%)	0.331	2.830	0.410	2.724
unc	3.189	1.388	3.136	1.398
tq	114.977	70.495	111.965	67.574
cf_ta (%)	0.515	3.348	0.668	2.948
sg (%)	8.899	45.863	9.311	44.751
fc	0.343	0.475	0.316	0.465
ir	0.319	0.069	0.331	0.081
No. of firm IDs		487		609
No. of observations		18,776		24,708

Panel D: By Age

	Age ≤ 9		Age 10–19		Age 20–29		Age 30–39		Age ≥ 40	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
capx_ta (%)	0.612	2.959	0.541	2.864	0.422	2.776	0.250	2.722	0.175	2.498
unc	3.355	1.464	3.480	1.407	3.320	1.437	3.180	1.460	2.849	1.340
tq	131.178	77.034	139.691	87.079	123.761	75.530	105.822	61.860	101.559	59.727
cf_ta (%)	0.545	3.977	0.233	4.120	0.523	3.488	0.635	3.060	0.592	2.652
sg (%)	14.164	58.335	15.285	63.715	10.296	49.553	7.299	40.128	4.950	36.441
fc	0.348	0.476	0.372	0.483	0.340	0.474	0.324	0.468	0.313	0.464
ir	0.273	0.107	0.254	0.097	0.290	0.112	0.316	0.115	0.316	0.115
No. of firms		351		837		725		592		526
No. of observations		3,755		15,963		13,589		13,045		17,896

capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraint, GFC = global financial crisis, ir = investment irreversibility, No. = number, SD = standard deviation, sg = sales growth, tq = Tobin's q, unc = uncertainty, *** = $p < 0.01$.

Notes: 1. These tables show the basic statistics of dependent and independent variables employed in this paper. The dependent variable is capx_ta, while independent variables include the lagged values unc, tq, sg, and cash flow (cf).
2. The data are quarterly and the period is from the first quarter (Q1) of 2000 to Q4 2016.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

The correlation statistics of the quarterly sample are provided in Table 4. Panel A shows the correlation between the dependent and explanatory variables. As hypothesized, the capital expenditure ratio and the uncertainty index have a strong negative correlation. Tobin's q, cash flow, and sales growth are all positively correlated with the capital expenditure ratio. Financial constraints are negatively correlated with the capital expenditure ratio. The investment irreversibility index is also negatively correlated with capital expenditure ratio, but the correlation is not statistically significant.

Panel B provides some indication of the full-sample correlation between *fc1* and *fc2*, the two alternative measures of financial constraints. They have a positive correlation with each other. Panel B also provides an indication of the full-sample correlation among *ir1*, *ir2*, and *ir3*, the three alternative indices of investment irreversibility. They also have a strong positive correlation with each other.

Table 4: Correlation Matrices of Key Variables

Panel A: Correlation Coefficients of Variables—Basic Variables

Variable	capx_ta	unc	tq	cf_ta	sg	fc	ir
capx_ta	1						
unc	−0.017***	1					
tq	0.073***	0.188***	1				
cf_ta	0.091***	−0.206***	−0.039***	1			
sg	0.054***	0.047***	0.093***	0.141***	1		
fc	−0.076***	0.186***	0.019***	0.475***	−0.147***	1	
ir	−0.002	−0.081***	−0.189***	0.063***	−0.051***	−0.037***	1

Panel B: Correlation Coefficients of Variables—Investment Irreversibility and Financial Constraints

Index	ir1	ir2	ir3	fc1	fc2
ir1	1				
ir2	0.534***	1			
ir3	0.300***	0.411***	1		
fc1	−0.037***	−0.039***	−0.038***	1	
fc2	0.024***	0.026***	−0.014***	0.408***	1

capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraint, GFC = global financial crisis, ir = investment irreversibility, No. = number, SD = standard deviation, sg = sales growth, tq = Tobin's q, unc = uncertainty, *** = $p < 0.01$.

Notes:
1. The dependent variable is capx_ta, while independent variables include the lagged values unc, tq, sg, and cash flow (cf).
2. The indices of financial constraint are measured according to a firm's interest coverage ratio (fc1) or the firm's credit rating (fc2). The indices of irreversibility of investment are measured according to the capital intensity ratio (ir1), sunk costs (ir2), or the cyclicality of the firm's sales (ir3).
3. The data are quarterly and the period is from the first quarter (Q1) of 2000 to Q4 2016.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

Tables 5 and 6 present the average values of the alternative indices of financial constraints and investment irreversibility for the different firm size subsamples. In Table 5, we can clearly observe that SMEs are financially more constrained than larger firms in terms of both indices of financial constraints (*fc1, fc2*). On the other hand, the investments of SMEs are less irreversible—that is, they are more reversible—than the investments of larger firms in terms of all the indices of investment irreversibility (*ir1, ir2, ir3*).

Table 5: Average Values of Financial Constraint Indices, by Firm Size

Index	Description	Size (number of employees)					
		Full Sample	≤49	50–99	100–299	300–999	≥1,000
fc1	interest coverage ratio	0.338	0.604	0.399	0.342	0.290	0.221
fc2	credit rating	1.059	1.263	1.037	1.063	1.046	1.017

fc = financial constraint.

Source: NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

Table 6: Average Values of Investment Irreversibility Indices, by Firm Size

Index	Description	Size (number of employees)					
		Full Sample	≤49	50–99	100–299	300–999	≥1,000
ir1	Capital intensity ratio	0.293	0.228	0.272	0.289	0.312	0.320
ir2	Sunk cost	0.545	0.228	0.485	0.549	0.631	0.581
ir3	Firms' sales cyclicality	0.140	0.099	0.130	0.144	0.150	0.141

pir = investment irreversibility.

Source: NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

IV. EMPIRICAL RESULTS

In this section, we report and discuss our main empirical results, starting with the baseline model results, and then focusing in turn on the results of the subsamples based on the sizes of the firms, the ages of the firms, and the periods (i.e., before and after the GFC). Then we look at models based on the two channels of the uncertainty effect: financial constraints (*fc*) and investment irreversibility (*ir*).

A. Baseline Model Results

The baseline models for evaluating the effect of uncertainty on corporate investment are estimated and presented in Table 7. In all the models, control variables such as Tobin's q, cash flow, and sales growth are positively correlated with investments, as expected. Financial constraints and investment irreversibility are negatively correlated with the capital expenditure ratio.

To see the lag effect of uncertainty on investment, we successively introduced four period lags into the model. The results reveal that the lag effect is negatively significant for the first two lags, and then turn positively significant for the third lag. The fourth lag is statistically insignificant. The lag effect is the greatest in the first lag and then declines in the second lag. Investments rebound in the third lag. In terms of economic magnitude, an increase in uncertainty by one standard deviation (1.43, taken from Table 3, Panel A) reduces the quarterly investment rate (i.e., capital expenditure divided by total assets) by −0.066 (1.43 × −0.046) in the following quarter, and by −0.047 (1.43 × −0.033) two quarters later. With a mean quarterly investment rate of 0.359 in the full sample, this represents declines of 18%

and 13% relative to the normal investment levels. The results are consistent with Bloom (2009), who finds that uncertainty shock causes a sharp drop in output, but says that this negative influence gradually diminishes. Output eventually rebounds after the negative effect subsides due to delays in production. Bloom (2009) suggests that uncertainty shocks are one of the causes of short-run recessions and recoveries.

Table 7: Impact of Uncertainty on Firm Investments, with Lags

Variable	Model 1 capx_ta	Model 2 capx_ta	Model 3 capx_ta	Model 4 capx_ta
unc (-1)	−0.056***	−0.046***	−0.048***	−0.046***
	(−4.879)	(−3.951)	(−4.049)	(−3.956)
unc (-2)		−0.025**	−0.035***	−0.033)
		(−2.219)	(−3.037)	(−2.884)
unc (-3)			0.019*	0.022*
			(1.662)	(1.822)
unc (-4)				−0.018
				(−1.599)
tq	0.004***	0.004***	0.004***	0.004***
	(11.430)	(11.491)	(11.327)	(11.370)
cf_ta	0.023***	0.022***	0.022***	0.021***
	(4.652)	(4.629)	(4.560)	(4.417)
sg	0.001***	0.001***	0.001***	0.001***
	(3.445)	(3.436)	(3.435)	(3.623)
fc	−0.002***	−0.002***	−0.002***	−0.002***
	(−6.495)	(−6.462)	(−6.444)	(−6.363)
ir	−0.027***	−0.027***	−0.027***	−0.026***
	(−7.313)	(−7.337)	(−7.346)	(−7.341)
No. of observations	64,248	64,182	64,075	63,837
Adj. R-squared	0.070	0.070	0.070	0.070

Adj. = adjusted, capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraints, ir = investment irreversibility, No. = number, sg = sales growth, tq = Tobin's q, unc = uncertainty, *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$.

Notes: 1. The dependent variable is capx_ta, while the independent variables include the lagged values of unc, tq, sg, cash flow (cf), financial constraint measured according to the interest coverage ratio (fc1), and investment irreversibility measured according to the capital intensity ratio (ir1). The variable unc (-m) is m-lagged variable of unc.
2. The regressions are based on unbalanced firm panel data for the first quarter (Q1) of 2000 to Q4 2016. They all include unreported estimates of firm-specific fixed-effect dummies and quarterly fixed-effect dummies.
3. The standard errors are clustered with respect to both the firm and time.
4. The t-statistics are shown in the parentheses.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

B. Uncertainty Effect, by Firm Characteristics

In this subsection, we report the results of the empirical analysis of the effect of uncertainty on investment for the firm subsamples based on the characteristics of firm size and age.

(1) Uncertainty Effect, by Firm Size

First, the baseline model is estimated for the subsamples determined by the different firm sizes. The firms are grouped by the number of employees: fewer than 50, 50 to 99, 100 to 299, 300 to 999, and 1,000 and over. The results shown in Table 8 indicate that uncertainty has a negative impact on the investments of firms of all sizes. Interestingly, the negative impact is stronger for the smallest and largest firms than it is for medium-sized firms. The results support Byun and Jo (2018), who find that the uncertainty effect on investments follows an inverted U-shaped curve across the spectrum of firm size. On the other hand, our result differs from that of Ghosal and Loungani (2000), who find that smaller firms are influenced more than larger firms. This nonlinearity of the uncertainty effect will be further investigated later in this paper. We suspect that it can be explained by the combined effect of financial constraints and investment irreversibility.

Table 8: Impact of Uncertainty on Firm Investments, by Firm Size

	Model 1 (≤49 workers)	**Model 2** (50–99 workers)	**Model 3** (100–299 workers)	**Model 4** (300–999 workers)	**Model 5** (≥1,000 workers)
Variable	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**
unc	−0.115**	−0.071**	−0.045**	−0.042**	−0.175***
	(−2.516)	(−2.429)	(−2.445)	(−2.120)	(−3.291)
tq	0.003***	0.002***	0.004***	0.006***	0.004***
	(3.357)	(3.128)	(6.910)	(6.108)	(5.071)
cf_ta	−0.008	0.001	0.034***	0.031***	0.056***
	(−0.642)	(0.108)	(4.227)	(2.643)	(3.301)
sg	0.000	−0.000	0.001	0.003***	0.004**
	(0.731)	(−0.065)	(1.632)	(3.614)	(2.477)
fc	−0.000	−0.003***	−0.002***	−0.001**	−0.003***
	(−0.061)	(−3.853)	(−3.220)	(−2.556)	(−3.255)
ir	−0.039***	−0.035***	−0.029***	−0.013*	−0.021**
	(−3.883)	(−2.744)	(−4.053)	(−1.727)	(−2.172)
No. of observations	3,751	8,530	23,603	16,983	7,279
Adj. R-squared	0.029	0.039	0.069	0.095	0.156

Adj. = adjusted, capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraints, ir = investment irreversibility, No. = number, sg = sales growth, tq = Tobin's q, unc = uncertainty, *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$.

Notes:
1. The dependent variable is capx_ta, while the independent variables include the lagged values of unc, tq, sg, cash flow (cf), financial constraint measured according to the interest coverage ratio (fc1), and investment irreversibility measured according to the capital intensity ratio (ir1).
2. The regressions are based on unbalanced firm panel data for the first quarter (Q1) of 2000 to Q4 2016. They all include unreported estimates of firm-specific fixed-effect dummies and quarterly fixed-effect dummies.
3. The standard errors are clustered with respect to both the firm and time.
4. The t-statistics are shown in the parentheses.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

We focused our attention on the smallest firms (fewer than 50), given the differences in the impact of uncertainty by firm size. The smallest firms are exposed to high levels of uncertainty and are highly sensitive to them. They have a mean reduction of 0.195 (1.695 × −0.115) in their investment rate (capital expenditure divided by total assets) when uncertainty increases by one standard deviation (1.695, taken from Table 3, Panel B). The mean quarterly investment rate for the small firms is just 0.055, so capital expenditures can be negative for small firms when uncertainty is high. That is to say, these firms will dispose of their assets when subject to high uncertainty.

(2) Uncertainty Effect, by Firm Age

We analyzed whether the age of a firm affects the uncertainty effect based on the full sample and on the subsamples of firms based on their ages. In the full sample estimates (model 1), the mature dummy variable takes a value of 1 if the firm is older than 10 years, and 0 otherwise. The interaction term between the mature dummy and uncertainty index is negative and significant. This finding is confirmed in the firm-age subsample regressions in models 2–7. The firms were grouped into age-based subsamples as follows: under 5 years, 5–9, 10–19, 20–29, 30–39, and over 40 years. The subsample regressions for the firm-age groups in models 2–7 showed that older firms are more affected by uncertainty.[2] The difference between mature and non-mature firms with respect to the effect of uncertainty is significant, despite the relatively small sample of non-mature firms. Furthermore, small firms and non-mature firms are not necessarily the same thing. The effect of uncertainty on small firms is highly negative, while the effect on young firms is insignificant.

There are several explanations for the difference in the impact of uncertainty based on the age of the firm. Younger firms have less access to corporate information and have had relationships with external financial institutions for shorter periods; as a result, they have less external financing than do mature firms. The study of German SMEs by Müller and Zimmermann (2009) showed that the younger the company, the greater the financial constraints. However, the subjects of our paper are Korean listed firms. Even when they are young, they are more likely to have a good financial structure and credit ratings than German companies, so we did not observe high financial constraints for these firms. Another explanation is that young firms need to invest more than mature firms to maintain growth, even in the face of high uncertainty. In fact, according to the summary statistics of the young firms in our paper, their average value of uncertainty is 3.35 and their average investment-rate value is 0.612 (taken from Table 3, Panel C), both of which are higher than the average value for the full sample (*unc* = 3.2, investment rate = 0.359, taken from Table 3, Panel A).

[2] A separate regression was done for the full sample, including age cohort dummies interacting with *unc*. Negative coefficients were found for these interaction terms, with age cohort dummies for the age groups of 10–19, 20–29, 30–39, and 40 and over. However, their p-values were slightly over the 10%.

Table 9: Impact of Uncertainty on Firm Investments, by Firm Age

	Model 1 (full sample)	Model 2 (ages ≤4 years)	Model 3 (ages 5–9 years)	Model 4 (ages 10–19 years)	Model 5 (ages 20–29 years)	Model 6 (ages 30–39 years)	Model 7 (ages ≥40 years)
Variable	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**
unc	0.051	−0.159	0.008	−0.076***	−0.048*	−0.044*	−0.052**
	(1.378)	(−1.095)	(0.140)	(−3.240)	(−1.856)	(−1.827)	(−2.348)
mature	0.001						
	(0.584)						
unc × mature	−0.114***						
	(−3.000)						
tq	0.004***	0.014	0.006***	0.005***	0.002***	0.005***	0.003***
	(11.432)	(1.641)	(3.191)	(7.103)	(2.938)	(6.570)	(5.456)
tq	0.004***	0.014	0.006***	0.005***	0.002***	0.005***	0.003***
	(11.432)	(1.641)	(3.191)	(7.103)	(2.938)	(6.570)	(5.456)
cf_ta	0.023***	0.045	0.027	0.019**	0.012	0.032***	0.012
	(4.686)	(0.705)	(1.445)	(2.168)	(1.214)	(2.991)	(1.039)
sg	0.001***	−0.002	−0.001	0.001	0.001	0.000	0.000
	(3.414)	(−0.447)	(−0.550)	(1.237)	(1.466)	(0.435)	(0.764)
fc	−0.002***	0.008**	−0.001	−0.002***	−0.002***	−0.001	−0.002***
	(−6.517)	(2.160)	(−0.450)	(−3.448)	(−3.583)	(−1.077)	(−3.374)
ir	−0.026***	−0.243	−0.108***	−0.052***	−0.027***	−0.042***	−0.028***
	(−7.157)	(−1.624)	(−3.476)	(−4.983)	(−2.877)	(−5.058)	(−4.613)
No. of observations	64,248	550	3,205	15,963	13,589	13,045	17,896
Adj. R-squared	0.071	0.090	0.043	0.053	0.069	0.089	0.096

Adj. = adjusted, capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraints, ir = investment irreversibility, No. = number, sg = sales growth, tq = Tobin's q, unc = uncertainty, *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$.

Notes:
1. The dependent variable is capx_ta, while the independent variables include the lagged values of unc, tq, sg, cash flow (cf), financial constraint measured according to the interest coverage ratio (fc1), and investment irreversibility measured according to the capital intensity ratio (ir1).
2. A dummy variable for maturity has the value of 1 if the firm's age is equal to or greater than 10: otherwise, it is zero.
3. The regressions are based on unbalanced firm panel data for the first quarter (Q1) of 2000 to Q4 2016. They all include unreported estimates of firm-specific fixed-effect dummies and quarterly fixed-effect dummies.
4. The standard errors are clustered with respect to both the firm and time.
5. The t-statistics are shown in the parentheses.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

C. Uncertainty Effect, by Period: Pre- versus Post-Global Financial Crisis

We analyzed how the uncertainty effect has evolved over time, especially in the period before the GFC versus the period after. The pre-GFC period is defined as Q1 2000 to Q2 2008 and the post-GFC period is defined as Q1 2010 to Q4 2016. We excluded the period from Q3 2008 to Q4 2009, as this was during the GFC. The uncertainty effect slightly declined from the pre-GFC period to the post-GFC period in models 1 and 2. When we divide the sample into subsamples for SMEs and large firms, we see that uncertainty effect is greater for large firms. The effect rose for SMEs in the post-GFC period, but it fell for large firms during that time. However, these differences are not statistically significant.

Table 10: Impact of Uncertainty on Firm Investments—Pre- versus Post-Global Financial Crisis

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	(full sample)		(SMEs)		(large firms)	
	Before GFC	After GFC	Before GFC	After GFC	Before GFC	After GFC
Variable	capx_ta	capx_ta	capx_ta	capx_ta	capx_ta	capx_ta
unc	−0.075***	−0.065***	−0.053**	−0.060***	−0.104***	−0.070**
	(−4.271)	(−3.930)	(−2.392)	(−3.116)	(−3.655)	(−2.182)
tq	0.005***	0.003***	0.004***	0.003***	0.004***	0.004***
	(6.900)	(8.822)	(5.174)	(6.422)	(3.978)	(4.753)
cf_ta	0.024***	0.016**	0.018**	0.015*	0.043***	0.021
	(3.221)	(2.361)	(2.032)	(1.714)	(3.003)	(1.609)
sg	0.000	0.001*	−0.000	0.000	0.002	0.002***
	(0.306)	(1.845)	(−0.140)	(0.738)	(1.300)	(2.671)
fc	−0.002***	−0.001***	−0.002***	−0.001**	−0.001*	−0.001**
	(−3.973)	(−3.608)	(−3.493)	(−2.485)	(−1.711)	(−2.361)
ir	−0.042***	−0.072***	−0.052***	−0.054***	−0.036***	−0.045***
	(−4.927)	(−9.684)	(−3.830)	(−6.386)	(−3.203)	(−3.513)
No. of observations	24,948	32,858	14,026	18,476	10,249	12,018
Adj. R-squared	0.061	0.067	0.044	0.048	0.098	0.105

Adj. = adjusted, capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraints, GFC = global financial crisis, ir = investment irreversibility, No. = number, sg = sales growth, SMEs = small and medium-sized enterprises, tq = Tobin's q, unc = uncertainty, *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$.

Notes:
1. The dependent variable is capx_ta, while the independent variables include the lagged values of unc, tq, sg, cash flow (cf), financial constraint measured according to the interest coverage ratio (fc1), and investment irreversibility measured according to the capital intensity ratio (ir1).
2. The regressions for the pre-GFC period are based on unbalanced firm panel data for the first quarter (Q1) of 2000 to Q2 2008, and the post-GFC regressions are for Q1 2010 to Q4 2016. They all include unreported estimates of firm-specific fixed-effect dummies and quarterly fixed-effect dummies.
4. The standard errors are clustered with respect to both the firm and time.
5. The t-statistics are shown in in the parentheses.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

D. Robustness regarding Different Measures of Financial Constraints and Investment Irreversibility

We examined whether the two channels through which the uncertainty effect works are significant forces in explaining corporate investment behavior. In Table 11, we added two separate interaction terms reflecting the two channels to the baseline model. Models 1–3 use *fc1* and models 4–6 use *fc2* as the indices of financial constraint. For investment irreversibility, we use *ir1* in models 1 and 4, *ir2* in models 2 and 5, and *ir3* in models 3 and 6. All the results show that the interaction terms for both channels are significant and negative, as expected. The key economic message from Table 11 is that when uncertainty increases, firms with more irreversible assets and firm facing high financial constraints will significantly reduce their investments. In terms of economic magnitude, an increase of one standard deviation (0.112, taken from Table 3, Panel A) in asset irreversibility leads to a 0.054 decrease (0.112×1.43×−0.335) in the investment rate after a surge of uncertainty (1 SD = 1.43, where "SD" stands for "standard deviation," taken from Table 3, Panel A). In addition, if uncertainty increases by one standard deviation (0.473, taken from Table 1, Panel A) a company with financial constraints will reduce its investment rate by 0.041 (0.473 × 1.43 × −0.060).

Table 11: Uncertainty Effect on Firm Investments—Investment-Irreversibility and Financial-Constraint Channels

	Model 1 (fc1 and ir1)	Model 2 (fc1 and ir2)	Model 3 (fc1 and ir3)	Model 4 (fc2 and ir1)	Model 5 (fc2 and ir2)	Model 6 (fc2 and ir3)
Variable	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**	**capx_ta**
unc	0.066**	−0.011	−0.004	0.068**	−0.008	0.001
	(2.210)	(−0.777)	(−0.226)	(1.978)	(−0.413)	(0.065)
fc	−0.000	−0.000	−0.000	−0.001**	−0.001**	−0.001**
	(−0.154)	(−0.051)	(−0.089)	(−2.070)	(−2.091)	(−2.009)
unc × fc	−0.060***	−0.062***	−0.061***	−0.023*	−0.023*	−0.024*
	(−3.433)	(−3.550)	(−3.489)	(−1.673)	(−1.728)	(−1.796)
ir	−0.016***	0.000	0.016***	−0.016***	0.000	0.015**
	(−3.325)	(0.855)	(2.684)	(−3.360)	(0.708)	(2.547)
unc × ir	−0.335***	−0.031**	−0.180*	−0.326***	−0.028**	−0.179*
	(−3.307)	(−2.430)	(−1.908)	(−3.220)	(−2.235)	(−1.892)
tq	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***
	(11.343)	(11.581)	(11.629)	(11.167)	(11.406)	(11.447)
cf_ta	0.021***	0.021***	0.021***	0.025***	0.025***	0.025***
	(4.417)	(4.401)	(4.353)	(5.331)	(5.296)	(5.238)
sg	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(3.340)	(3.547)	(3.523)	(4.377)	(4.589)	(4.561)
No. of observations	64,248	64,248	64,248	64,248	64,248	64,248
Adj. R-squared	0.071	0.069	0.069	0.070	0.069	0.069

Adj. = adjusted, capx_ta = firm-level quarterly capital investments over total assets, cf_ta = cash flow over total assets, fc = financial constraints, GFC = global financial crisis, ir = investment irreversibility, No. = number, sg = sales growth, SMEs = small and medium-sized enterprises, tq = Tobin's q, unc = uncertainty, *** = p < 0.01, ** = p < 0.05, * = p < 0.10.

Notes:
1. The dependent variable is capx_ta, while the independent variables include the lagged values of unc, tq, sg, and cash flow (cf); financial constraint measured according to the interest coverage ratio (fc1) and according to credit ratings (fc2); and investment irreversibility measured according to the capital intensity ratio (ir1), sunk costs (ir2), or firms' sales cyclicality (ir3).
2. The variable unc × ir is an interaction term between uncertainty and investment irreversibility.
3. The regressions for the pre-GFC period are based on unbalanced firm panel data for the first quarter (Q1) of 2000 to Q4 2016. They all include unreported estimates of firm-specific fixed-effect dummies and quarterly fixed-effect dummies.
4. The standard errors are clustered with respect to both the firm and time.
5. The t-statistics are shown in bold.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

V. MAGNITUDE OF THE UNCERTAINTY EFFECT ON CORPORATE INVESTMENT

We measured the impact of uncertainty on corporate investments in the ROK since 2000. Table 12 provides the averages of the uncertainty indices, averages of the capital expenditure ratios, and estimates of the effect of uncertainty on corporate investment, using subsamples for selected years between 2000 and 2016. The uncertainty-effect estimates were calculated based on the parameter estimates obtained from the regressions in Section IV.

As seen in Panel A, uncertainty is greater for SMEs than for large firms, but the indices have declined since 2000 for both groups. The capital expenditure ratios were higher for SMEs than for large firms in 2000, but lower in 2016, as shown in Panel B. The ratios for both groups declined during the sample period.

Corporate investment would have fallen more dramatically had the uncertainty indices not also been falling since 2000. Panel C indicates that uncertainty reduced investment by 0.24 percentage points in 2000, but only by 0.11 percentage points in 2016. This implies that the decline in uncertainty contributed positively to investment; that, without the decline in uncertainty, the actual fall in investment that did occur may have been even worse.

Table 12: Estimated Impact of Uncertainty on Corporate Investments

Panel A: Averages of Uncertainty Indices

Sample Type		2000	2005	2010	2016
Full sample		4.6	2.3	2.2	2.0
Subsamples by size	Large	4.6	2.2	2.1	2.0
	SMEs	5.5	3.3	2.7	2.6
Subsamples by industry	Manufacturing	4.6	2.2	2.2	2.1
	Nonmanufacturing	4.6	2.4	2.1	2.0

Panel B: Averages of Capital Expenditure Ratios (%)

Sample Type		2000	2005	2010	2016
Full sample		1.10	0.57	0.52	0.15
Subsamples by size	Large	0.82	0.49	0.56	0.22
	SMEs	1.40	0.62	0.39	0.11
By industry	Manufacturing	1.11	0.58	0.58	0.18
	Nonmanufacturing	1.05	0.55	0.40	0.12

Panel C: Estimates of the Uncertainty Effect on Capital Expenditure Ratios (percentage point)[a]

		2000	2005	2010	2016
Full sample		−0.24	−0.12	−0.11	−0.11
By size	Large	−0.25	−0.12	−0.12	−0.11
	SMEs	−0.28	−0.16	−0.14	−0.13
By industry	Manufacturing	−0.29	−0.14	−0.14	−0.13
	Nonmanufacturing	−0.14	−0.07	−0.06	−0.06

SMEs = small and medium-sized enterprises.

[a] Using the average value of the uncertainty index by year, we calculated the changes in the investment rate based on the extent of uncertainty. We used the regression coefficients unc, unc × fc, and unc × ir. They are presented in Table 11.

Source: Authors' calculations using data from NICE Information Service. KISVALUE Database. https://www.kisvalue.com/web/index.jsp (accessed 7 November 2018).

VI. CONCLUSION

In this paper, we found that financial uncertainty has a significant negative effect on corporate investment, based on Korean firm-level panel data. We can summarize our key findings are as follows: The effect of uncertainty is heterogeneous, differing across firms of different ages and sizes. Small and large firms are more exposed to the effect than are medium-sized firms. The effect slightly declined after the GFC period for large firms, but they have increased somewhat for SMEs. We have included two key channels of the uncertainty effect suggested in the literature: investment irreversibility and financial constraint. This paper is the first to include both channels to simultaneously identify their unbiased effects. The regression results indicate that the two channels amplify the negative effect of uncertainty on investment. Lastly, our paper finds that, contrary to the presumption that uncertainty has contributed to the decline in corporate investments in the ROK, it actually fell, and as a result dampened the drop in investments.

The two channels can help explain the observed non-linearity in the uncertainty effect across firm size. One possible explanation for the inverted U-shape curve of the uncertainty effect across firm sizes is that small firms are the most financially constrained and the large firms' investments are the most irreversible.

The heterogeneous effect of uncertainty may reinforce the performance gap among firms of different sizes. SMEs are the dominant type of Korean firm, accounting for 78% of employment in the ROK in 2016. It is a well-known fact that Korean SMEs substantially lag behind large Korean firms in terms of labor productivity, sales growth, and profitability. Moreover, the labor productivity gap between the two groups of firms has gradually widened since 2000. Since investment is a critical factor in enhancing labor productivity and achieving competitiveness, it is important for policymakers to find ways to mitigate the negative effect of uncertainty on SMEs, so as to boost their investments.

It is notable that, for SMEs, financial constraint is a key factor that channels the negative effect of uncertainty on investment. This implies that investments in countries with a large share of SMEs and underdeveloped capital markets may be significantly influenced by a rise in uncertainty. Better access to capital and bond markets for SMEs would help to ease the financial constraints they face. Furthermore, policies in the ROK concerning SMEs should be redirected toward improving their competitiveness, thus leading to growth, and away from the current focus on protecting SMEs from competition, which does nothing to improve their competitiveness.

Lastly, our evidence indicates that uncertainty levels have dropped for all subsamples of firms. This bodes well for investment. However, the sluggishness of corporate investment since 2000 suggests that the overall investment environment has worsened even more severely than previously thought. Policy reforms to counter the deterioration in the investment environment are urgently needed.

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Heterogeneous Effect of Uncertainty on Corporate Investment

Evidence from Listed Firms in the Republic of Korea

This paper analyzes the effect of financial uncertainty on corporate investment using panel data on firms in the Republic of Korea. The authors find that financial uncertainty has a significant negative effect on corporate investment and the effects are heterogeneous across firms of different sizes. Small firms and large firms are more exposed to the negative uncertainty effects than medium-sized firms. Financial constraints and investment irreversibility amplify the negative effects of uncertainty. The inverted U-shaped effects along the firm size spectrum can be understood as follows. Small and medium-sized firms are more financially constrained and large firms' investments are more irreversible in nature.

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