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PRODUCT MARKET COMPETITION AND THE IMPACT OF PRICE UNCERTAINTY ON INVESTMENT: SOME EVIDENCE FROM U.S. MANUFACTURING INDUSTRIES

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ABSTRACT

We estimate the impact of price uncertainty on investment using a panel of U.S. manufacturing industries. When we pool the data for all industries, uncertainty has no impact on current investment. However, this pooled estimate conceals an interesting difference across industries. For industries with a high degree of product market competition, the estimated impact is negative, reasonably large, and significantly different from zero. For relatively non-competitive industries, the impact is always small and not significantly different from zero. The finding of a negative relationship between investment and price uncertainty in competitive industries is broadly consistent with the predictions of models that incorporate irreversibility of capital investment.

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Vivek Ghosal and Prakash Loungani[1]

I. INTRODUCTION

Understanding the impact of price uncertainty on a firm's investment decisions has been an important item on the research agenda of economists for many years. Early work in this area by Hartman [1972] and Abel [1983] suggested that an increase in price uncertainty may increase a firm's current investment; this result holds because of the convexity of the marginal revenue product of capital function with respect to price. Recent theoretical work, however, shows that departures from the Hartman-Abel framework can attenuate the positive correlation between price uncertainty and investment, and, in certain cases, even generate a negative relationship between the two.

The recent literature takes into account the degree of irreversibility of capital investment, and the extent of product market competition. For ***competitive*** industries, and with irreversible investment, Pindyck [1993] and Dixit and Pindyck [1994] deliver a clear prediction: an increase in price uncertainty will lower current investment. The basic intuition is that when investment is irreversible, uncertainty generates an "option value" to waiting, and hence investment is delayed in response to an increase in uncertainty. However, under ***imperfect competition***, the impact of price uncertainty on investment is indeterminate, in general, since the outcome depends both on the degree of irreversibility and the nature of strategic interaction among firms in the industry.

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This paper provides some empirical evidence on the impact of price uncertainty on investment. The data set used is a balanced panel, consisting of annual data from 1958 to 1989 for 4-digit SIC manufacturing industries. When we pool all the data, our estimate of the impact of price uncertainty on investment is essentially zero. However, this pooled estimate conceals an interesting difference across industries. For our most competitive group of industries, the estimated impact is negative, reasonably large, and significantly different from zero. For the relatively non-competitive industries, the impact is always small and insignificantly different from zero. The finding of a negative relationship between investment and price uncertainty in competitive industries is at odds with the predictions of the Hartman-Abel framework. Instead, the results seem broadly consistent with models that incorporate irreversibility of capital investment.

This paper is one of a handful of recent empirical studies of the impact of uncertainty and irreversibility on investment, two of which use the same data set as the one used in this paper. Caballero and Pindyck (1992) analyze the effects of uncertainty on a "threshold" level of investment, instead of on the level of investment itself, and hence conduct a more indirect test than the one in this paper. Huizinga [1993], in his industry-level analysis, looks only at the cross-section relationship between investment and uncertainty; in contrast, a contribution of our approach is that we develop a time series of price uncertainty for each industry, which allows us to exploit both the cross-section and the time-series variation in the data. Finally, using annual firm-level data from Compustat, Leahy and Whited [1995] find that uncertainty about stock returns depresses investment through its effects on "Tobin's q."[1]

Section II surveys the theoretical results on this topic. In Section III we describe the construction of our measures of price uncertainty, and define the industry categories based on product market competition. The empirical results are presented in Section IV and summarized in Section V.

II. A REVIEW OF THEORY

In this section we review some of the key results in the literature. Since our empirical work uses the "industry" as the unit of analysis, we are particularly interested in predictions about the investment-uncertainty relationship at the *industry* level (as opposed to the *firm* level).

Under the assumptions of competitive product markets and symmetric adjustment costs for capital, Hartman [1972] demonstrated that an increase in price uncertainty, defined by a mean-preserving spread in prices, will increase the quantity of current investment undertaken by a firm (or leave it unchanged). The result follows from the convexity of the profit function with respect to prices. Abel [1983] proved that the results of Hartman's discrete-time model continue to hold in continuous-time models.

The recent theoretical literature has focused on examining the relationship between investment and price uncertainty in the presence of "asymmetric" adjustment costs, where the costs of reducing the capital stock far exceed the costs of augmenting it.[2] The results in Dixit and Pindyck [1994] and Pindyck [1991, 1993] show that if installed capital represents an irreversible commitment, as indicated by the presence of high of "sunk" costs, an increase in price uncertainty is likely to lower a firm's current investment. The intuition is that if there are large sunk costs embedded in new capital investment, the presence of uncertainty implies an option value of waiting and, therefore, the firm is likely to postpone its investment decisions in the face of increased uncertainty. At first blush, it may appear that competition among firms would erode any one firm's incentive to wait, and hence the effects of irreversibility would not be important at the industry level. However, Caballero (1991), Caballero and Pindyck (1992) and Dixit and Pindyck (1994) show that when entry and exit are considered, as long as the industry demand is less than infinitely elastic, there is a negative relationship between industry investment and industry uncertainty.

Introducing imperfect competition adds to the complexity of the problem. As Dixit and Pindyck [p.309-314] point out, the intuition behind the irreversibility argument remains intact. Even in oligopolistic industries, firms have an incentive to delay investment in the presence of uncertainty; thus, via the irreversibility channel, greater uncertainty is expected to decrease investment. However, fear of preemption by a rival and the consequent need to act quickly, which play a more important role in oligopolistic industries, may counter-act the desire to wait. As an example, consider a noncooperative capacity choice game, in which asymmetries in initial conditions or leader/follower roles affect the outcomes. In this game, a firm's own response to an increase in industry-wide uncertainty may be to decrease its investment; however, if the firm expects that its rival plans to decrease its investment, the firm may re-consider its own original plan to cut investment. In this example, therefore, the two forces (irreversibility and strategic considerations) act in opposite directions, and the net effect of the increase in industry uncertainty on the firm's current investment is unclear. In general, the eventual impact of an increase in industry uncertainty on industry investment will depend on potential asymmetries in initial conditions and the nature of leader/follower roles among the rival firms. Hence, without specifying the nature of strategic interaction among the oligopolists, it appears very difficult to predict the sign of the investment-uncertainty relationship under imperfect competition.[3]

III. DATA DESCRIPTION AND EMPIRICAL APPROACH

The source of industry data is the Annual Survey of Manufactures and Census of Manufactures (see Gray [1990]). From this source we obtain annual data on investment, capital stocks, sales, cash flow, product prices and costs for 4-digit SIC manufacturing industries over the period 1958 to 1989. Data on industry market structure variables (output concentration and the number of firms) are from various issues of the Census of Manufactures. The exclusion of "miscellaneous" industries, and industries for which a consistent time series on output concentration could not be obtained, leaves us with 254 industries in our full sample.

Measuring price uncertainty

An industry's relative product price is measured as the industry shipments price index divided by the GDP deflator. We assume that firms attempt to forecast their product price and, to the extent that the price is forecastable, this reduces the uncertainty that they face. The residual from the forecasting equation is used as the measure of price uncertainty. The basic idea of measuring uncertainty as a conditional standard deviation is consistent with suggestions from the theoretical work (see Dixit and Pindyck) and with previous empirical work on the quantification of uncertainty.[4] Though variants of the forecasting equation will be entertained later, our benchmark case assumes that firms use equation (1) to forecast prices, where $P_{i,t}$ is the *logarithm* of the industry product price and "t" is a linear trend:

$$(1) \qquad P_{i,t} = \alpha_0 + \alpha_1 t + \alpha_2 P_{i,t-1} + \alpha_3 P_{i,t-2} + \epsilon_{i,t}$$

We use the following procedure to create a time-series for the uncertainty variable. For *each* industry in the sample, we estimate equation (1) using annual data over the fifteen-year overlapping periods starting with 1958; i.e. 1958-72, 1959-73,..., 1975-89. The standard deviation of the residuals from these regressions is the measure of price uncertainty $UNCER_{i,t}$, where "i" and "t" index the industry and time period. As mentioned above, UNCER has a straightforward interpretation: it is the conditional standard deviation of the industry relative price. Using this procedure, we obtain 18 time-series observations (1972-89) on UNCER for each industry.[5] Our ability to entertain more complicated forecasting equations is limited by the length of the time-series. However, since we are using annual data, equation (1) at least embeds sufficient lags to capture industry price dynamics. Experimentation showed that additional lags of $P_{i,t}$ were insignificant in virtually all industries.

Since reporting the details on all industry regressions used to obtain UNCER would be prohibitively time- and space-consuming, we only present some summary statistics on the regressions for the first 15-year period, 1958-72. The overall fit of the regressions is quite good; the mean adjusted-R^2 (standard deviation) of the regressions is 0.78 (0.28). [This mean and standard deviation is across the 254 industries in our sample.] The means (standard deviations) of the estimated coefficients α_2 and α_3 are 0.595 (0.472) and -0.323 (0.376), respectively. Serial correlation was quite low, in general, with the cross-industry mean (standard deviation) being -0.06 (0.1). Similar conclusions emerged when we examined the regression characteristics for each 15-year period over which equation (1) was estimated.

Segmentation based on product market competition

Following the practice in many applied industrial organization studies, we use the four-firm concentration ratio, CR4, to measure the extent of product market competition in the industry.[6] In the empirical analysis we consider three groups: (i) "ALL" industries, (ii) industries with "LOW" CR4, and (iii) industries with "HIGH" CR4. The "LOW" and "HIGH" CR4 groups are defined as follows. A "LOW" concentration industry is one that has CR4≤20% for every year over 1972-89. The 20% value corresponds approximately to the cross-industry mean (39.5%) minus one-standard-deviation (20%). We impose this cutoff over the entire sample period as some industries have a distinct trend in CR4; hence any one year's CR4 values may not be representative of the entire period. There are 27 industries with CR4≤20% over the entire sample period. A "HIGH" concentration industry is one with CR4≥60% over the sample period 1972-89. This corresponds to approximately the cross-industry mean plus one-standard deviation. Domowitz *et al.* [1987] use CR4=50% to partition industries into competitive and non-competitive groups, while White [1987] suggests that the split is somewhere between 50%-60%. Thus, a cutoff of CR4≥60% imposed over the entire sample period is quite conservative and consistent with the literature. There are 24 industries with CR4≥60% over the entire sample period.

The two groups, LOW and HIGH, differ considerably in their market structure. The representative industry in the LOW concentration group has a CR4 of 11% and contains 2600 firms (on average over the period 1972-89). With such low concentration and large number of firms, it would be difficult to argue that there is significant market power within this group of industries. The representative industry in the

HIGH concentration group has CR4 of 79% and 76 firms over the period 1972-89. Structurally, this is a significantly more concentrated group of industries. Hence, the segmentation achieves our basic purpose of creating two polar sub-samples based on industry concentration.

To provide some evidence on how sensitive the conclusions are to the choice of cutoff values, we consider an alternate definition of LOW and HIGH using a cutoff value of CR4=40%.

IV. RESULTS

We include our measure of price uncertainty, UNCER, in an empirical investment model. Consistent with the literature, the dependent variable is the ratio of gross industry investment, scaled by the beginning-of-period capital stock, (I/K). The independent variables included are the following: (i) current and lagged values of industry sales, also scaled by the capital stock, (S/K). In alternate specifications we substitute measures of cash flow, (CF/K), as has been suggested in the literature on financial market imperfections. Our conclusions are robust to these alternate controls;[7] (ii) current and lagged values of the manufacturing capacity utilization rate, CU, to capture economy-wide influences on investment that are common to all industries. None of our conclusions are not affected if we replace capacity utilization rate by year-time dummies; (iii) an industry-specific fixed-effect, μ_i, to capture time-invariant influences on an industry's mean level of investment over the sample period. Hence, the investment model is:

$$(2) \qquad (I/K)_{i,t} = \gamma UNCER_{i,t} + \xi(S/K)_{i,t} + \delta CU_t + \mu_i + \omega_{i,t}$$

The industry sales variable, the aggregate CU variable and the industry fixed-effect, taken together, proxy for the "investment opportunities" available to the industry.[8] While not shown above, equation (2) contains one lag each of (I/K), (S/K) and CU to allow for persistence in the response of investment spending.[9]

We estimate equation (2) for the groups--ALL, LOW and HIGH--defined in Section III; since we entertain two alternate cutoffs for LOW and HIGH, the total number of industry groups is five. Summary statistics for the industry variables for each of these five groups are given in Table I.

Benchmark Results

We use the fixed-effects OLS estimator to obtain estimates of the parameters in equation (2).[9] The top row of Table II indicates the industry group. Column 1 presents estimates for the full sample of industries. As shown, the estimate of UNCER is positive but insignificant at conventional levels, and the magnitude of the effect is small. The full sample estimate, however, conceals important differences between the LOW and HIGH concentration industries. Examining the coefficient estimates of UNCER in Column 2, we see that in our most competitive sample of industries (CR4≤20%), the estimate is *negative*, quantitatively large, and statistically significant. The point estimate gets quantitatively smaller, but remains negative and marginally significant in the sample with CR4≤40% [(see column (3)]. In contrast, the point estimates for the relatively non-competitive group of industries, shown in columns 4 and 5, are *positive*, but the magnitudes are small, and statistically insignificant. To get a feel for the quantitative magnitude of the effect of price uncertainty, we compute elasticities. Evaluated at mean values of the variables, the price uncertainty elasticity is -0.134 for the sample with CR4≤20%, and -0.034 for the sample with CR4≤40%. For the samples with CR4>40% and CR4≥60%, the elasticities are approximately 0.02. An F-test easily rejects the null hypotheses that the coefficients are equal for the CR4≤20% and CR4≥60% groupings.

To summarize, our results show that greater price uncertainty adversely affects investment only in the most competitive group of industries. For the full sample and for the highly concentrated sample of industries, the impact of price uncertainty on investment is insignificant. The result for the competitive industries appears to be supportive of models with irreversible investment, as discussed in section 2.

Additional Results

We conduct several checks of robustness. First, the literature on financial market imperfections suggests that since many firms face credit constraints, "cash flow" may be the appropriate proxy for investment opportunities (see Fazzari *et al.* [1988]). The cash flow variable used in the regressions, CF/K, is defined as value of shipments minus the sum of payroll and materials and energy costs, deflated by beginning of period capital stock. For the five groups specified in Table II, the estimated coefficients (standard errors) of UNCER are -0.017 (0.029), -0.374 (0.16), -0.099 (0.068), 0.030 (0.048) and 0.062 (0.068), respectively. Hence, using cash flow as a measure of investment opportunities (instead of sales) does not affect our conclusions about the impact of uncertainty on investment.

Second, we construct an alternate measure of price uncertainty by modifying the price forecasting equation to include lagged values of unit variable cost--an obvious candidate for inclusion in industry price equations (see Domowitz *et al.* [1987] and Ghosal [1995a, 1995b]). The new price equation takes the form:

$$(3) \qquad P_{i,t} = \beta_0 + \beta_1 t + \beta_2 P_{i,t-1} + \beta_3 AVC_{i,t-1} + \beta_4 AVC_{i,t-2} + \upsilon_{i,t}$$

where AVC is the logarithm of industry unit variable cost (relative to the GDP deflator). Following the same procedure as before, the standard deviation of the residuals from estimating the above equation is our second measure of price uncertainty, $UNCER(a)_{i,t}$. Using UNCER(a), and (S/K) as the control variable, the estimates (standard error) are 0.038 (0.031), -0.251 (0.151), -0.081 (0.070), 0.045 (0.064), and 0.058 (0.075), respectively, for the five groups in Table II. Hence, the results with UNCER(a) are similar in spirit to those using our previous measure UNCER.

Third, we construct the price uncertainty measure by estimating equation (1)--the price forecasting equation--in growth rates instead of log-levels; this is intended as a check on whether our conclusions are sensitive to alternate assumptions about the stationarity properties of prices. We get the following estimates (standard errors) of UNCER for the five groups: -0.033 (0.025), -0.371 (0.134), -0.123 (0.065), -0.027

(0.042), and -0.023 (0.054). We note that: (i) the overall impact (ALL industries) is now negative and marginally significant, but the magnitude of the effect is quite small; (ii) the impact on the group with CR4≤20% remains negative, large in magnitude, and is now more precisely measured, (iii) the impact on the group with CR4≤40% is now quantitatively larger and significant, and (iv) the point estimates for the HIGH concentration groups are now negative, but they remain statistically insignificant and the magnitudes are very small. Hence our conclusions about differences between the competitive group of industries and non-competitive group in the impact of uncertainty remain unaltered.

We examined two additional issues. First, we examined whether there was any difference between durables goods industries and nondurable goods industries in the impact of uncertainty on investment. Second, using the approach of Kessides [1990], we partitioned the sample into industries with "high" sunk costs, and industries with "low" sunk costs. In both cases, our preliminary evidence did not indicate ant systematic differences in the response of uncertainty to investment.[10]

V. CONCLUSIONS

We find that an increase in uncertainty does not have an appreciable impact on investment when data for all industries are pooled together. However, there are differences across industries in the investment-uncertainty relationship based on the extent of product market competition, as measured by the industry four-firm concentration ratio (CR4). For a set of industries characterized by a high degree of product market competition (i.e. industries with CR4≤20%), an increase in price uncertainty lowers investment. The estimated impact is reasonably large, and is statistically significant. This result is robust across alternate measures of price uncertainty and to using sales or cash flow as the control variable. For the group of industries with CR4≤40%, the impact of uncertainty on investment remains consistently negative, but the magnitude of the effect is smaller. These findings are at odds with the predictions of the Hartman-Abel framework in which adjustment costs of capital are assumed to be symmetric. Instead, the findings provide support for models in which investment is assumed to be "irreversible"; in such models, current investment is dampened by an increase in uncertainty, because uncertainty increases the option value of waiting.

In contrast, for industries characterized by imperfect competition (CR4>40% or CR≥60), we find the impact of uncertainty to be always very small and, statistically, it is never significantly different from zero. As stated in our review of the theory, such a result can arise under imperfect competition if strategic considerations influence the sign of the investment-uncertainty relationship. However, this conjecture needs to be verified by further theoretical work.

Table I
Panel Data Summary Statistics

Statistic	UNCER	(I/K)	(S/K)	(CF/K)
		Variable		
		Group 1: ALL Industries		
Mean	0.037	0.077	3.070	0.820
Standard Deviation	0.034	0.035	2.110	0.560
		Group 2: CR4 ≤ 20%		
Mean	0.028	0.075	3.580	0.921
Standard Deviation	0.019	0.032	3.061	0.750
		Group 3: CR4 ≤ 40%		
Mean	0.032	0.078	3.100	0.841
Standard Deviation	0.028	0.033	2.430	0.680
		Group 4: CR4 > 40%		
Mean	0.049	0.077	2.280	0.690
Standard Deviation	0.050	0.037	1.242	0.412
		Group 5: CR4 ≥ 60%		
Mean	0.045	0.079	2.140	0.691
Standard Deviation	0.041	0.039	1.142	0.390

Table II Estimation Results Dependent Variable: $(I/K)_{i,t}$					
	Group 1 **ALL**	Group 2 **CR4≤20%**	Group 3 **CR4≤40%**	Group 4 **CR4>40%**	Group 5 **CR4≥60%**
$UNCER_{i,t}$	0.013 (0.028)	-0.358*** (0.143)	-0.084* (0.066)	0.031 (0.052)	0.045 (0.066)
$(S/K)_{i,t}$	0.013*** (0.001)	0.009*** (0.003)	0.013*** (0.003)	0.019*** (0.003)	0.024*** (0.007)
$(S/K)_{i,t-1}$	-0.003*** (0.001)	-0.006*** (0.003)	-0.007*** (0.003)	-0.006* (0.004)	-0.015** (0.008)
CU_t	0.017* (0.011)	0.094*** (0.033)	0.031* (0.023)	-0.003 (0.045)	0.005 (0.043)
CU_{t-1}	0.034*** (0.010)	-0.045* (0.030)	0.023 (0.022)	0.067*** (0.029)	0.081** (0.043)
$(I/K)_{i,t-1}$	0.396*** (0.025)	0.334*** (0.083)	0.457*** (0.052)	0.471*** (0.026)	0.452*** (0.060)
OBS	4572	486	1044	792	432
Adj-R^2	0.2427	0.1595	0.2426	0.2772	0.2074

Notes:

(i) Heteroscedasticity-consistent standard errors are in parentheses.

(ii) Coefficients marked with ***, **, or * are statistically significant at the 1%, 5% or 10% level, respectively.

(iii) There are 18 time-series observations per industry in all samples; hence, dividing "OBS" by 18 gives the total number of industries in each group. Note that the number of observations in columns 3 (1044) and 4 (792) do not add up to the number of observations in column 1 (4572). This is because the sample with CR4≤40% (column 3) includes industries which had CR4≤40% for *every* year over the sample period and the sample with CR4>40% (column 4) contains industries which had CR4>40% for *every* year over the sample period. Therefore, for example, if an industry started with CR4=35% during early part of the sample and had its CR4 increase to, say, 55% during the latter part of the sample, this industry would not be included in either column 3 or column 4. See section III for further details on our procedure.

REFERENCES

Abel, A.B., 1983, "Optimal Investment under Uncertainty," American Economic Review, 73, pp.228-233.

Bresnahan, T.F., 1989, "Empirical Studies of Industries with Market Power," in Schmalensee, R., and Willig, R., (eds.), Handbook of Industrial Organization, (North Holland: Amsterdam).

Caballero, R.J, and Pindyck, R.S., 1992, "Investment, Uncertainty, and Industry Evolution," National Bureau of Economic Research working paper 4160.

Caballero, R.J., 1991, "On the Sign of the Investment-Uncertainty Relationship," American Economic Review, 81, pp.279-288.

Chirinko, R.S., 1993, "Business Fixed Investment Spending: A Critical Survey of Modeling Strategies, Empirical Results, and Policy Implications," Federal Reserve Bank of Kansas City working paper 93-01.

Dixit, A.K., and Pindyck, R.S., 1994., Investment under Uncertainty, (Princeton University Press: Princeton).

Domowitz, I., Hubbard, R.G., and Petersen, B.C, 1987, "Oligopoly Supergames: Some Empirical Evidence on Prices and Margins," Journal of Industrial Economics, 35, pp.379-398.

Fazzari, S.M, Hubbard, R.G., and Petersen, B.C, 1988, "Financing Constraints and Corporate Investment," Brookings Papers on Economic Activity, 1, pp.141-195.

Fazzari, S.M, and Petersen, B.C., 1993, "Working Capital and Fixed Investment: New Evidence on Financing Constraints," RAND Journal of Economics, 24, pp.328-342.

Ghosal, V., 1995a, "Input Choices under Price Uncertainty," Economic Inquiry, 33, pp. 142-157.

Ghosal, V., 1995b, "Price Uncertainty and Output Concentration," Review of Industrial Organization, forthcoming.

Gray, W., 1990, "The Productivity Database, National Bureau of Economic Research.

Hartman, R., 1972, "The Effects of Price and Cost Uncertainty on Investment," Journal of Economic

Theory, 5, pp.258-266.

Hsiao, C., 1986, Analysis of Panel Data, (Cambridge University Press: Cambridge).

Hubbard, R.G., 1994. "Investment under Uncertainty: Keeping One's Options Open," Journal of Economic Literature, 32, pp.1816-1831.

Huizinga, J., 1993, "Inflation Uncertainty, Relative Price Uncertainty and Investment in U.S. Manufacturing Industries." Journal of Money, Credit, and Banking, 25, pp.521-549.

Kessides, I.N., 1990, "Market Concentration, Contestability and Sunk Costs," Review of Economics and Statistics, 72, pp.614-622.

Leahy, J.V., and Whited, T.M., 1995, "The Effect of Uncertainty on Investment: Some Stylized Facts," National Bureau of Economic Research working paper 4986.

Pindyck, R.S., 1991, "Irreversibility, Uncertainty and Investment," Journal of Economic Literature, 29, pp.1110-1148.

Pindyck, R.S., 1993, "A Note on Competitive Investment under Uncertainty," American Economic Review, 83, pp.273-277.

Pindyck, R.S, and Solimano, A., 1993. "Economic Instability and Aggregate Investment," National Bureau of Economic Research working paper 4380.

Weiss, L.W., and Pascoe, G., 1981, "Adjusted Concentration Ratios in Manufacturing-1972," mimeograph, University of Wisconsin-Madison.

White, L.J., 1987, "Symposium on Mergers and Antitrust," Journal of Economic Perspectives, 1, pp.13-22.

Endnotes

1. It is interesting to note that the two approaches used by Huizinga yield different results. In the industry-level cross-section analysis, he finds a positive correlation between uncertainty and investment. However, in aggregate level time-series data he finds a negative relationship between the two variables. Since we use industry data in a way that also permits time-series variation, we are able to combine the two approaches used by Huizinga. Leahy and Whited's approach is useful in that they are able to distinguish firm-specific from industry-wide uncertainty. However, Compustat data has some limitations because firms are defined as financial entities, and also the multi-product nature of firms poses a potentially serious measurement problem. Hence, our industry-level analysis can serve as a useful complement to their work.

2. See Caballero [1991], Dixit and Pindyck [1994], Pindyck [1991, 1993] and Hubbard (1994).

3. Caballero [1991] examines the impact of changes in a markup coefficient, similar to Bresnahan's (1989) index of market power, on the sign of the investment-uncertainty relationship, but he does not consider more complicated forms of strategic behavior.

4. It is fairly common to use the conditional standard deviation of a variable as a measure of its uncertainty; for example Huizinga [1993] constructs a measure of inflation uncertainty in this manner. See Ghosal [1995a, 1995b] and Pindyck and Solimano (1993) for additional references.

5. There is a substantial amount of time-series variation in UNCER. For the representative industry, the coefficient of variation of UNCER is 26.3%, with the range being from 8.3% to 71.8%.

6. For example, Domowitz et al. [1987] use CR4 to segment industries. Weiss and Pascoe [1981] adjust

Census CR4's for some biases, but their data are for 1972 and of limited use in our time-series study. Instead of using CR4, some authors (see Bresnahan [1989]) treat market power as an unobservable that has to be estimated.

7. We have not attempted to measure industry cost-of-capital or Tobin's q because previous studies suggest that they do not out-perform simpler measures such as sales or cash flow. See Chirinko [1993] for evidence along these lines from time-series studies and Fazzari *et al.* [1988] for evidence from panel data studies.

8. If uncertainty is correlated with omitted measures of investment opportunities (for example, if fast-growing industries experience greater price fluctuations), then the estimate of UNCER may be biased.

9. Hsiao [1986, Ch.4] shows that, with fixed effects, coefficient estimates may be biased in the presence of lagged dependent variables, but the bias is likely to be very small here because the time-series dimension of the panel is fairly long (T=18) by the standards of panel data studies. In any event, none of our conclusions are altered if we exclude $(I/K)_{i,t-1}$ from equation (2)--a robustness check employed in many previous studies (see Fazzari *et al.* [1988] and Fazzari and Petersen [1993]).

10. Though there are many well-known differences between durables and nondurables (e.g., in their cyclical sensitivity), we are not aware of theoretical work that investigates how such differences might cause the sign of the investment-uncertainty relationship to be different across the two groups. The results on sunk costs are more problematic since theory suggests that the magnitude of these costs is important in determining the sign of the investment-uncertainty relationship. As suggested by a referee, perhaps one needs specifications in which both the degree of sunk costs and product market competition vary.

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