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Investment and Market Imperfections in the U.S. Manufacturing Sector

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Abstract

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Abstract

This paper analyzes industry data from the U.S. manufacturing sector to address questions concerning the connection between cash flow and investment. The paper finds that cash flow variables do enter standard investment equations positively and significantly for the full sample of industries, as well as for several subsamples, even after controlling for investment demand. Cash flow's impact on investment spending is larger for durable goods producing industries than for nondurable goods producing industries, and some evidence suggests that cash flow's impact is also larger in those industries with small average firm size. The paper also finds, for some groups of industries, that high levels of seller concentration lessen the impact of cash flow on investment. This suggests that high concentration acts to mitigate the financial market imperfections that presumably underlie the cash flow-investment connection.

1: Introduction

Recent research on investment spending and capital markets has documented the importance of internal funds for financing investment spending by certain classes of firms. This paper uses industry-level data to address two questions. One, is there any evidence that these capital market issues are important in explaining investment behavior at the industry level? Two, is there any systematic relationship between product market and capital market imperfections? The paper analyzes data for over 250 four-digit Standard Industrial Classification (SIC) manufacturing industries from 1964-1986, and three main findings emerge.

First, cash flow variables do enter standard investment equations positively and significantly for the full sample of industries, as well as for several subsamples, even after controlling for investment demand. This result is consistent with previous research that identifies cash flow as an important determinant of investment spending. The paper's second finding is that cash flow's impact on investment spending is larger for durable goods producing industries than for nondurable goods producing industries. Within the durables group, cash flow's effect on investment is greater in industries with average firm sizes below the 75th percentile of the size distribution (industries with small average firm sizes). Thus, industries with small average firm sizes display more investment sensitivity to cash flow movements than do industries with large average firm sizes. This result, too, is consistent with previous research. Finally, among durable goods industries with small average firm sizes, high levels of seller concentration lessen the impact of cash flow on investment. This suggests that high concentration acts to mitigate the financial market imperfections that presumably underlie the cash flow-investment connection. Thus, this paper provides new evidence of the importance of considering imperfections in both product and financial markets when analyzing fixed investment behavior.

Several secondary findings also emerge from this study. I find that a proxy to measure the importance of adjustment costs has a significant effect on investment's response to demand changes. The impact is greater in durable goods industries than in nondurable goods industries. I also find that increases in the relative price of energy have a significant negative effect on investment for all samples of industries studied.

Taken together, these results suggest that the imperfect capital markets hypothesis needs to be considered when examining industry-level investment patterns. The importance of capital market issues appears to be greatest for industries with small average firm size. Perhaps the paper's most interesting finding is that high seller concentration ratios may mitigate financing problems in industries with small average firm sizes. Thus, this paper suggests that interactions between capital market and product market imperfections may be important.

The rest of the paper is organized as follows. Section 2 briefly summarizes previous work on this topic, and Section 3 describes the data and empirical approach used here. Estimation results are in Section 4, and discussion and conclusions are in the final section.

2. Background

A number of recent theoretical and empirical papers have analyzed the consequences of imperfect capital markets for investment behavior.[1] When capital markets are perfect, firms undertake any investment project with a positive net present value, and the choice of financing mix is indeterminate.[2] That is, a firm's cost of capital is the same whether that capital is raised internally, through retained earnings, or externally, through the issuance of debt or equity. Market imperfections potentially arise from several sources, including corporate tax deductibility of interest, scale economies in underwriting, and information asymmetries. These imperfections can decrease the cost of internal funds relative to external funds. In other words, a "financing hierarchy" which favors retained earnings, followed by debt, and, in turn, equity, can develop. Several studies have focused on the empirical importance of this hierarchy and have found that certain classes of firms show excessive investment sensitivity to internal funds (cash flow). This evidence suggests that capital market imperfections can significantly influence investment spending by these firms, which are typically small or zero-dividend paying firms.

3. Empirical Approach and Data Description

I model investment as a function of investment opportunities, relative prices, and cash flow.[3] Developing measures of investment opportunities and cash flow from the industry-level data is difficult. Researchers analyzing firm-level data have used Tobin's q for the

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[1]See Fazzari, Hubbard, and Petersen (FHP; 1988) for a good review of the theoretical literature and some empirical evidence. Hubbard (1990) also contains several papers on this topic.

[2]I ignore considerations based on an options-value approach to investment and the value to waiting; see Pindyck (1991) for a discussion of that approach.

[3]For example, FHP (1988) and Whited (1990) use this approach in their papers.

former, while using various retained earnings measures for the latter. The Census data I use here cannot be used to construct q-based measures, since q measures depend on firm-level valuations of equity and debt, while the Census data pertain to manufacturing plants aggregated up to the four-digit SIC industry. Studies using more aggregate data, e.g., two-digit SIC data, have used sales or output measures in accelerator models to capture the impact of investment opportunities on investment spending (Abel and Blanchard (1988)). One problem with using sales (shipments) or output data in the present study is that these output measures are highly correlated with the cash flow measure I use.[4] Thus, using both output and cash flow measures in a modified accelerator model is not possible. Consequently, I use an alternative measure of investment opportunities, or investment demand, which is described below.

Let IK denote the gross investment rate, S the measure of investment opportunities, P the vector of relative prices, and CFK the ratio of cash flow to capital. Then the gross investment rate is written as:

$$(1) \quad IK_{it} = \alpha + S_{it}\beta + P_{it}\gamma + CFK_{it}\delta + \varepsilon_{it} ,$$

where i and t refer to industry i and time t, respectively.[5] The remainder of this section discusses three issues involved in estimating equation (1): the choice of the variables in S, P, and CFK; the inclusion of other possible control variables; and the econometric techniques

[4]Cantor (1990) notes this problem as well in his study of investment and leverage in U.S. manufacturing firms.

[5]As is standard in the literature, both investment and cash flow are scaled by the beginning of period capital stock.

used. The section closes with a brief description of data sources.

The first task is to develop measures for S, P, and CFK. The S measure used here, denoted CU, is effectively a measure of capacity utilization and is defined as the ratio of production worker wages to total payroll.[6] Since payroll includes payments to quasi-fixed factors (overhead labor), increases in this ratio suggest that variable costs have increased relative to fixed costs; that is, utilization of fixed inputs has risen. Since capacity utilization is itself chosen optimally, short run increases in CU should be followed by increases in investment spending. This is the measure used to control for differences in industry investment opportunities in the regressions reported below.

The relative price of energy, measured by the ratio of the (industry-specific) energy price deflator to the shipments price deflator, will be used for P and will be denoted POIL.[7] Previous research has shown only a limited role for a more conventionally measured relative price of capital goods (whether expressed relative to labor or to output) in the determination of investment spending, especially at annual frequencies; thus, I do not include such a measure in P. However, the relative price of energy may influence the demand for capital, hence investment, through several channels. In a static factor demand framework, for

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[6]Lichtenberg (1988) uses this measure in his study of adjustment costs in U.S. manufacturing sector investment. Two alternative measures, defined as the ratio of manhours to production workers and the ratio of production workers to total employees, respectively, performed similarly to the measure I use here.

[7]The numerator of POIL, the industry-specific energy price deflator, is effectively a weighted average of the prices of several energy sources, with the weights reflecting the input choices of each industry. Thus, the numerator is endogenous to some extent. However, two alternative measures of energy prices in the numerator, the producer price index (PPI) for crude fuel and the PPI for fuels and related products, performed similarly to the industry measure.

example, the desired capital stock will rise (fall) when the relative price of energy rises if capital is a substitute (complement) for energy in production. In addition, Gibbons (1984) and Jorgenson (1984) present evidence from the two-digit SIC manufacturing sector that changes in energy prices and energy usage can influence desired capital stocks and investment through several dynamic channels.[8] In sum, ample evidence suggests that energy prices can influence investment spending.

The cash flow measure used in the numerator of the cash flow/capital ratio (CFK) is defined as the difference between the value of shipments and all non-capital input costs.[9] This measure, then, overstates true cash flow by omitting capital expenses. The capital stock measure is real total stock at the beginning of the period. The coefficient on CFK is expected to be positive if capital markets are not perfect.

The second issue to consider when estimating equation (1) is how to control for additional factors that may influence investment behavior. This paper controls for some of these factors by including interaction terms in (1) and for others by dividing the sample into several subsamples. The first set of factors includes output market competition and adjustment costs, and the second includes type of good produced and average firm size.

Structure and competitiveness in output markets are measured by the four firm

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[8]Gibbons uses a putty-clay perspective to argue that unexpected, permanent increases in oil prices serve to decrease the service lives of existing capital stocks, hence increase investment demand, as firms abandon energy-using capital stocks and replace them with energy-efficient stocks. Jorgenson argues that energy prices influence energy usage, which in turn affects rates of technological progress and, implicitly, desired capital stocks and investment.

[9]Petersen and Strauss (1991) use this measure and find that its correlation with investment spending is quite strong. However, they do not control for other determinants of investment spending in their analysis.

concentration ratio, C4.[10] An interaction, CU*C4, is included because previous research suggests that the market structure and competitiveness of an industry may influence the magnitude of investment responses to exogenous shocks. In particular, I expect investment's responses to shocks to increase with the degree of market power, here proxied by C4.[11] Another interaction, CFK*C4, is included to investigate whether imperfections in output and capital markets are related in any systematic way. Several studies have found that market power, as measured by size and seller concentration, reduces the riskiness of firms, usually measured by the CAPM "β", and, hence, their capital costs.[12] Thus, in the present context, the cost of capital in industries with high C4 values may be lower than in less concentrated industries.[13] However, as Sullivan (1978) notes, this does not necessarily imply that capital markets are imperfect; nor does it imply that market power should affect investment's response to changes in cash flow. Imperfections arise when, for a given firm, the cost of capital differs according to the source of the capital, not when firms have different costs because of differences in systematic risk. Thus, a non-zero coefficient on CFK*C4 suggests that market power is related to the severity of financial market imperfections. A positive

[10]I also report results in the Appendix from using an alternative measure, C4WP, which is C4 adjusted by the Weiss and Pascoe (1986) study. See the Appendix for more detail on these variables.

[11]The intuition is that firms with market power will want to earn their rents sooner rather than later and are willing to incur the extra adjustment costs of rapid investment in order to do so. See Schiantarelli and Georgoutsos (1990) and Worthington (1992).

[12]For example, see Sullivan (1978) and Nguyen and Bernier (1988).

[13]For example, a recent Wall Street Journal article concerning the downgrading of a large corporation's debt rating refers to the deterioration in that corporation's "competitive position." The drop in the debt rating means that the cost of borrowing will rise as investors demand a premium for lending to that corporation. (WSJ, March 5, 1992)

(negative) coefficient on CFK*C4 implies that high concentration exacerbates (dampens) investment's responsiveness to cash flow movements. Section 5 below discusses in more detail how concentration and cash flow sensitivity may be related.

Another interaction variable is suggested by previous research which indicates that firms may bear sizeable adjustment costs when altering their capital stocks. I use the share of equipment investment in total investment, SHREQ, to control for differences in the severity of those costs. Thus the term CU*SHREQ is included in (1) and is expected to enter with a negative coefficient, since high levels of adjustment costs are expected to lessen the impact of CU on investment.[14]

The second set of industry controls relates to goods type and firm size. I control for these factors by estimating (1) over several subsamples. First, I divide the sample into durable goods and nondurable goods producing industries.[15] Next, I divide the sample into groups based on average firm size. I compute the average firm size (shipments per company) and assign industries into the "large" category if their average firm size exceeds the 75th percentile of the size distribution and into the "small" category otherwise.[16] I use this breakdown because the average firm size within an industry may affect the impact of cash flow on investment. In particular, industries with large average firm size may have better

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[14]This variable is suggested by Lichtenberg (1988), who found that adjustment costs are higher for equipment than for structures investment. He estimates that adjustment costs can reach 35 cents on the marginal dollar spent on new plant and equipment, while Chirinko and Fazzari (1991) estimate that marginal adjustment costs range between 2.8% and 43.4% of total investment costs in selected U.S. manufacturing industries.

[15]Previous research has shown that durable and nondurable goods industries differ significantly in their output and investment behavior; see Petersen and Strongin (1991).

[16]See the Appendix for details.

access to capital markets, and their measured sensitivity of investment to cash flow may be lower than that of industries with small average firm sizes.[17,18]

Finally, the last issue to address is the choice of econometric technique. This paper uses fixed effects (FE) estimation procedures to estimate (1); thus, the intercept, α, is permitted to vary across industries and over time.[19] Two different possibilities for the error term, ε_{it}, are considered. The first assumes that it is distributed i.i.d. with mean 0 and variance σ^2; standard FE techniques are used in this case.[20] The second possibility assumes that ε_{it} follows a first-order autoregressive process with parameter ρ. In this case, I follow Kiefer's (1980) suggestion of estimating ρ from the OLS residuals on the mean-differenced data, using the estimate to quasi-difference the mean-differenced data, and estimating the resulting equation using least squares.[21]

The data used in the paper are derived from the Census of Manufactures and the

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[17]Much empirical work on this topic has relied on the belief that new and/or small firms are more likely to suffer from the information asymmetries or other sources of capital market failure than are older and/or larger firms.

[18]This measure of size will tend to understate the true average size of firms to the extent that firms have establishments (plants) in more than one four-digit SIC industry. Thus, the estimation will be biased against finding that investment spending by industries with small firms is highly sensitive to movements in cash flow.

[19]An alternative approach, the random effects (RE) or error components technique, might be appropriate under certain circumstances. This is discussed briefly in Section 4 below.

[20]The FE estimator effectively uses least squares to estimate equation (1) by adding intercept dummy variables for each industry and year. In practice, the raw data are mean-differenced, and least squares techniques are used to estimate the regression. See Judge et al. (1985).

[21]If $\rho=1$, then first-differencing the data will eliminate the industry fixed effect, and using least squares with time dummies will yield efficient estimates. The estimation results presented below reject the hypothesis that $\rho=1$.

Annual Survey of Manufactures; a list of exact variables and definitions is in Table A1 in the Appendix. The final data set contains annual observations on 265 industries over the 1963-1986 period; constructing the IK and CFK variables with the previous year's stock led to a sample period of 1964-1986. Summary statistics for the full sample as well as the durable goods and nondurable goods subsamples are presented in the Appendix's Table A2. The most important thing to note from Table A2 is that the CFK measures are much larger than the IK measures. This is because the measure of CF used overstates true cash flow, since it fails to deduct interest expenses and central office (above the plant level) expenses.

4. Results

Tables 1 and 2 contain the results of estimating equation (1) over the total sample, as well as for several subsamples.[22] In Table 1, the simple FE estimates are presented, while Table 2 contains the results under the assumption that the error term is first-order serially correlated. Fixed industry and year effects are included in each regression but are not reported in the Tables.[23] F-tests strongly rejected pooling of industries by the durables/nondurables distinction (column 1 vs. columns 4 and 7), so this discussion will focus on results using this distinction. Hausman test statistics, computed to test the hypothesis that

[22]Tables A3 and A4 in the Appendix contain the results of repeating the estimations using the C4WP measure of concentration. The results are qualitatively similar to those in Tables 1 and 2, which use the unadjusted Census measure C4.

[23]In each specification, F-tests on the industry and time effects strongly rejected the null hypothesis that the effects were zero. The F-tests were conducted on the effects jointly as well as on the industry (time) effects conditional on the presence of the time (industry) effects.

the industry and year effects are uncorrelated with other right-hand side variables, are presented in Table 1. The statistics reject the null at the .05 level in all samples and at the .01 level for all but one of the samples. Thus, random effects estimation techniques are inappropriate, and I report only fixed effects results.

Serial correlation appeared to be a serious problem in the model; the sample estimates of the correlation coefficient ranged from .37 to over .52.[24] Thus, I focus on the estimates of Table 2; Table 1's results are presented for completeness. As shown in Table 2, the signs of the coefficient estimates are generally as expected. In all specifications save one, the nondurables industries with large average firm size, the CU coefficient is positive and significant. Thus, the CU measure does seem to be a reasonable measure of investment demand.

The CU*C4 interaction term enters positively and significantly in only two of the subsamples, thus providing only weak evidence that high concentration increases investment's responsiveness to demand changes. The CU*SHREQ term enters negatively and significantly for all samples, consistent with Lichtenberg's (1988) study. The coefficients for durable goods industries exceed (in absolute value) those for nondurable goods industries, and the difference is statistically significant at the .01 level.

POIL enters negatively and significantly for all of the samples, with no clear pattern emerging between industry groups. One interpretation of the negative coefficient is that energy and capital are complements in production.

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[24]The coefficient estimates are all statistically different from 0 and from 1 at the .01 significance level.

The overall effect of cash flow on investment is positive, and the cash flow variables are jointly significant at the .01 level for all of the samples. The CFK coefficient alone is positive and strongly significant for all but one of the samples. For the durables industries with small average firm size and, separately, the nondurables industries with small average firm size, the CFK*C4 coefficient is negative and modestly significant, implying that, ceteris paribus, increases in cash flow have a smaller impact on investment spending than they would in the absence of that high concentration. Thus, among industries with small average firm sizes, high concentration appears to mitigate the capital market constraints faced by the firms.

The magnitude of the effects of cash flow on investment varies by industry group. The implied effect of CFK on IK is significantly larger for durable goods industries than for nondurable goods industries, a result also reported by Petersen and Strauss (1991). The effect of average firm size on the CFK coefficients is not as clearcut. In the durable goods industries, the CFK coefficient is significantly (at .01) larger in industries with small average firm size than it is in those with large average firm size. In addition, the CFK*C4 coefficient is smaller in those industries; this means that high concentration acts to limit the responsiveness of investment to cash flow more in industries with small average firm size than in industries with large average firm size.

For the nondurable goods industries, pooling of industries with different average firm sizes is rejected at the .05 level, and the CFK coefficient is significantly larger (at the .06 level) for the industries with large average firm size than for industries with small average firm size, the opposite of the durable goods industries finding. However, examination of the residuals suggested that five industries in the large average firm size group were real outliers, and the CFK coefficient results for that sample proved quite sensitive to these industries' inclusion in the sample. Reestimating equation (1) over the 26 remaining nondurables industries with large average firm sizes led to a coefficient estimate (standard error) on CFK of only .037 (.032), compared to the initial estimate of .098 (.038). Further, once those five industries were excluded and the CFK and the CFK*C4 coefficients were jointly tested between the size groups, equality was not rejected.[25] Thus, the nondurables sample shows little evidence that the average size of firms within industries plays a role in the investment-cash flow relationship estimated here.

5. Discussion and Conclusions

This paper has found that cash flow measures enter industry level investment equations positively and significantly, even after investment opportunities are taken into account. Cash flow's effect is greater in durable goods industries than in nondurable goods industries. Furthermore, in the durable goods industries, cash flow's impact on investment is larger in industries with small average firm size than in those with large average firm size. This is consistent with previous research showing that small firms' investment spending is especially sensitive to internal funds fluctuations. Further, in industries with small firms on average, high concentration ratios decreased the measured coefficients on cash flow, suggesting that high concentration can act to ameliorate the capital market imperfections experienced by firms in those industries. The exact mechanism by which high concentration exerts this influence is not clear. It is possible that high concentration signals to prospective

[25]In addition, overall pooling of the size groups was rejected only at the .10 level.

lenders that borrowing firms' prospects for high and steady profits are good, thus permitting firms access to external funds. However, this argument implies only that the cost of capital may be a function of concentration, not that the "financing hierarchy" itself, for a given industry, depends on concentration.

To explore exactly how concentration may interact with capital market imperfections, more research is needed to examine the role concentration can play in diminishing or increasing the agency costs that many believe are the driving force behind capital market imperfections. I end the paper with some speculation on how these factors are related.

Kessides (1990) has presented evidence that market concentration itself depends positively on entry barriers and sunk costs. Consider first the role of entry barriers in explaining this paper's results. High entry barriers may affect the overall cost of capital but seem unlikely to affect the "wedge" between the costs of different sources of capital. That is, high entry barriers may be associated with high and not very risky expected future profits, meaning a low cost of capital, or they may be associated with destructive price competition, thus making profits riskier (or at least more cyclical), meaning a high cost of capital. Either way, the size of the wedge is not affected. Thus, to the extent that high concentration levels reflect high entry barriers, this does not explain the negative coefficient on CFK*C4.

Now consider the role of sunk costs, which Kessides also found to be positively related to concentration. If high sunk costs mean that lenders have less in recoverable assets should a borrowing firm default, then high sunk costs may worsen the agency problems that cause a "financing hierarchy" to develop. Hence high sunk costs may mean a larger sensitivity of investment to movements in internal funds, suggesting a positive sign on

CFK*C4, the opposite of what was found here.[26] Thus, the negative coefficient on CFK*C4 cannot be explained by the concentration-sunk costs story, and exactly how concentration acts to reduce the impact of financial market imperfections remains unclear.

An alternative explanation of the positive CFK coefficient and the negative CFK*C4 coefficient relies on interpreting the cash flow numerator as a measure of net revenues or profits. Then CFK's positive coefficient merely reflects the idea that industries with high profits attract new inflows of capital. Similarly, the negative coefficient on the CFK*C4 interaction term reflects the idea that high entry barriers and high sunk costs, as reflected by high C4, will serve to lessen the impact of high profits on expansion of the capital stock.

Clearly more research using both firm and industry data is needed to unravel all of these possibilities. In particular, combining firm and industry level data to obtain good measures of the industry's structural characteristics, of the product markets' competitive conditions, and of the firms' real and financial decisions is necessary.

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[26]The argument that high sunk costs increase agency costs may, however, help to explain why the CFK coefficient was greater for durable goods industries than for nondurable goods industries, since the former are more capital intensive than the latter.

Table 1 Regression Results: Fixed Effects[a]

Dependent Variable: Gross Investment Rate, 1964-1986

	Full sample (N = 265)			Durable goods (N = 141)			Nondurable goods (N = 124)		
	All (N=265)	Big (N=66)	Small (N=199)	All (N=141)	Big (N=35)	Small (N=106)	All (N=124)	Big (N=31)	Small (N=93)
CU	.117[a]	.082[c]	.117[a]	.104[a]	.174[a]	.093[a]	.112[a]	.022	.120[a]
	(.018)	(.044)	(.020)	(.025)	(.056)	(.028)	(.026)	(.072)	(.029)
CU*C4	-.007	.078[b]	.009	.069[a]	.019	.079[a]	.006	.194[a]	-.009
	(.017)	(.032)	(.020)	(.024)	(.043)	(.030)	(.023)	(.049)	(.027)
CU*SHREQ	-.146[a]	-.159[a]	-.141[a]	-.176[a]	-.201[a]	-.169[a]	-.117[a]	-.123[a]	-.113[a]
	(.007)	(.018)	(.008)	(.011)	(.025)	(.012)	(.010)	(.026)	(.011)
POIL	-.720[a]	-1.59[a]	-1.37[a]	-1.43[a]	-.918[a]	-2.49[a]	-2.21[a]	-4.25[a]	-1.26[a]
	(.071)	(.155)	(.204)	(.096)	(.180)	(.351)	(.220)	(.404)	(.266)
CFK	.027[a]	.099[a]	.029[a]	.078[a]	.041[a]	.089[a]	.023[a]	.159[a]	.023[a]
	(.003)	(.013)	(.003)	(.006)	(.016)	(.007)	(.004)	(.031)	(.004)
CFK*C4	.012	-.079[a]	-.000	-.037[a]	.010	-.048[a]	-.010	-.172[a]	-.017
	(.008)	(.024)	(.009)	(.013)	(.031)	(.015)	(.010)	(.047)	(.012)
R^2	.13	.17	.14	.22	.19	.24	.12	.22	.11
Hausman statistic	110.19[a]	66.68[a]	78.29[a]	91.27[a]	17.07[b]	93.73[a]	71.69[a]	83.02[a]	32.41[a]

Standard errors are in parentheses under coefficient estimates, and fixed industry and year effects are not reported. CU is the capacity utilization measure; C4 is the four-firm concentration ratio; SHREQ is the share of equipment investment in total investment; POIL is the relative price of energy; and CFK is the ratio of cash flow to the capital stock. See the text and appendix for more details on variable definitions. Significance levels are denoted by a (1%), b (5%), and c (10%), respectively. The Hausman statistic is distributed chi-squared with six degrees of freedom. The estimate and standard error for POIL have been scaled up by a factor of 100.

Table 2 Regression Results: Fixed Effects, Corrected for First Order Serial Correlation[a]

Dependent Variable: Gross Investment Rate, 1964-1986

	Full sample (N = 265)			Durable goods (N = 141)			Nondurable goods (N = 124)		
	All (N=265)	Big (N=66)	Small (N=199)	All (N=141)	Big (N=35)	Small (N=106)	All (N=124)	Big (N=31)	Small (N=93)
CU	.115[a]	.136[b]	.109[a]	.063[b]	.152[c]	.057[c]	.137[a]	.043	.137[a]
	(.023)	(.058)	(.025)	(.031)	(.078)	(.034)	(.032)	(.090)	(.035)
CU*C4	.016	-.008	.045	.075[b]	-.001	.072[c]	.032	.050	.047
	(.024)	(.050)	(.029)	(.033)	(.068)	(.041)	(.033)	(.072)	(.039)
CU*SHREQ	-.128[a]	-.119[a]	-.129[a]	-.149[a]	-.153[a]	-.147[a]	-.107[a]	-.074[a]	-.111[a]
	(.007)	(.015)	(.008)	(.010)	(.022)	(.012)	(.009)	(.022)	(.098)
POIL	-.816[a]	-1.08[a]	-1.51[a]	-1.52[a]	-.788[a]	-2.48[a]	-1.88[a]	-2.45[a]	-1.40[a]
	(.094)	(.188)	(.275)	(.120)	(.225)	(.457)	(.291)	(.509)	(.355)
CFK	.038[a]	.052[a]	.039[a]	.081[a]	.020	.090[a]	.031[a]	.098[a]	.033[a]
	(.004)	(.017)	(.004)	(.008)	(.021)	(.008)	(.005)	(.038)	(.005)
CFK*C4	-.003	-.003	-.017	-.033[c]	.051	-.038[c]	-.028[c]	-.083	-.039[b]
	(.011)	(.031)	(.013)	(.017)	(.040)	(.020)	(.014)	(.060)	(.016)
ρ	.418[a]	.524[a]	.373[a]	.370[a]	.509[a]	.316[a]	.427[a]	.509[a]	.390[a]
	(.012)	(.023)	(.015)	(.017)	(.033)	(.021)	(.018)	(.033)	(.021)

Standard errors are in parentheses under coefficient estimates. CU is the capacity utilization measure; C4 is the four-firm concentration ratio; SHREQ is the share of equipment investment in total investment; POIL is the relative price of energy; CFK is the ratio of cash flow to the capital stock; and ρ is the first order serial correlation coefficient. See the text and appendix for more details on variable definitions. Significance levels are denoted by a (1%), b (5%), and c (10%), respectively. The estimate and standard error for POIL have been scaled up by a factor of 100.

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Appendix

The industry data used in this paper are from various years of the Census of Manufactures (CM) and the Annual Survey of Manufactures (ASM), both conducted by the Commerce Department's Bureau of the Census. The CM is conducted every several years and is based on information collected from every manufacturing establishment in SIC industries 2000-3999. The ASM is conducted annually and is based on only a sample of these establishments. The ASM data is then "scaled up" to give the total data for each industry. This paper's data are compiled from a version of this data prepared by Domowitz, Hubbard, and Petersen (1987) and later updated by William Strauss at the Federal Reserve Bank of Chicago. This dataset uses the 1958 industry definitions. Table A1 lists the variables used in this paper. The price deflators and capital stocks were provided by Wayne Gray, and the rest of the variables are from CM and ASM, unless otherwise noted.

Table A1 List of Variable Definitions

Name	Label	Definition
gross investment rate	IK	total investment in current year/capital stock at end of previous year
capacity utilization	CU	production worker wages/total payroll
cash flow/capital ratio	CFK	((value of shipments - total payroll - cost of materials)/shipments price deflator)/real capital stock
concentration ratio	C4	four-firm concentration ratio[27]
adjusted concentration ratio	C4WP	four-firm concentration ratio adjusted by Weiss and Pascoe (1986)[28]
share of equipment in total	SHREQ	(investment in equipment/equipment deflator)/((investment in equipment/equipment deflator) + (investment in structures/structures deflator))
relative price of energy	POIL	energy price deflator/shipments price deflator
average firm size	SIZE	(value of shipments in 1977/shipments price deflator)/number of companies in 1977[29]

[27]The ratio is defined on the basis of product groups and is available for Census years 1963, 1967, 1972, 1977, and 1982; values for non-Census years were obtained by linear interpolation between Census years.

[28]Weiss and Pascoe (WP; 1986) compute adjusted 1972 and 1977 concentration ratios for 4-digit SIC industries, trying to correct Census figures for problems of over-aggregation, inappropriate geographic markets, and inter-industry competition. I used the 1972 values of ACR4 (from WP's Table V(A)) to compute, for each industry, the difference between the Census value in 1972 and the WP value and then "bump" up or down the entire time series for that industry. WP's figures for 1977 and 1972 were highly correlated ($\rho = .97$), suggesting that the WP adjustments truly reflect time-invariant problems with concentration measures and market definitions.

[29]The number of companies is available for Census years only. I used the 1977 data because 1977 is near the middle of the sample period and because a natural alternative year, 1972, had missing values for some of the industries. The series was collected from the CM and made available by Vivek Ghosal.

Table A2 Summary Statistics

Variable		Total (N=265) Mean (Std)	Durables (N=141) Mean (Std)	Nondurables (N=124) Mean (Std)
IK	gross investment rate	.083 (.041)	.085 (.042)	.080 (.040)
CU	capacity utilization	.666 (.117)	.657 (.100)	.677 (.132)
C4	four firm concentration ratio	.380 (.196)	.382 (.206)	.378 (.184)
C4WP	adjusted four firm concentration ratio	.430 (.195)	.444 (.205)	.413 (.181)
SHREQ	equipment investment/total investment	.771 (.112)	.770 (.108)	.771 (.117)
POIL	relative price of energy	1.44 (.999)	1.42 (1.24)	1.47 (.618)
CFK	cash flow/capital ratio	.848 (.675)	.760 (.528)	.949 (.800)
SIZE	average firm size	8.55*	8.22*	9.00*

*Millions of 1972 dollars; this is the 75th percentile of the 1977 distribution of average firm sizes.

Table A3 Regression Results: Fixed Effects

Dependent Variable: Gross Investment Rate, 1964-1986

	Full sample (N = 265)			Durable goods (N = 141)			Nondurable goods (N = 124)		
	All (N=265)	Big (N=66)	Small (N=199)	All (N=141)	Big (N=35)	Small (N=106)	All (N=124)	Big (N=31)	Small (N=93)
CU	.127[a]	.074[c]	.131[a]	.106[a]	.173[a]	.101[a]	.118[a]	.010	.133[a]
	(.019)	(.045)	(.021)	(.026)	(.059)	(.029)	(.027)	(.071)	(.030)
CU*C4WP	-.029[c]	.104[a]	-.023	.053[b]	.027	.046	-.005	.228[a]	-.037
	(.016)	(.033)	(.021)	(.024)	(.045)	(.031)	(.023)	(.045)	(.027)
CU*SHREQ	-.146[a]	-.160[a]	-.141[a]	-.177[a]	-.201[a]	-.169[a]	-.117[a]	-.123[a]	-.113[a]
	(.007)	(.018)	(.008)	(.011)	(.025)	(.012)	(.010)	(.026)	(.011)
POIL	-.789[a]	-1.59[a]	-1.39[a]	-1.40[a]	-.959[a]	-2.40[a]	-2.20[a]	-4.11[a]	-1.25[a]
	(.074)	(.147)	(.204)	(.097)	(.177)	(.350)	(.221)	(.402)	(.266)
CFK	.022[a]	.130[a]	.022[a]	.073[a]	.053[a]	.078[a]	.022[a]	.199[a]	.019[a]
	(.003)	(.016)	(.003)	(.006)	(.020)	(.007)	(.003)	(.029)	(.004)
CFK*C4WP	.026[a]	-.127[a]	.019[b]	-.021	-.012	-.016	-.006	-.239[a]	-.004
	(.007)	(.027)	(.009)	(.013)	(.035)	(.016)	(.010)	(.044)	(.011)
R^2	.14	.17	.14	.22	.19	.24	.12	.24	.11
Hausman statistic	111.05[a]	77.80[a]	75.17[a]	79.77[a]	16.58[b]	78.50[a]	74.53[a]	95.54[a]	33.00[a]

Standard errors are in parentheses under coefficient estimates, and fixed industry and year effects are not reported. CU is the capacity utilization measure; C4WP is the four-firm concentration ratio adjusted by Weiss-Pascoe (1986); SHREQ is the share of equipment investment in total investment; POIL is the relative price of energy; and CFK is the ratio of cash flow to the capital stock. See the text and appendix for more details on variable definitions. Significance levels are denoted by a (1%), b (5%), and c (10%), respectively. The Hausman statistic is distributed chi-squared with six degrees of freedom. The estimate and standard error for POIL have been scaled up by a factor of 100.

Table A4 Regression Results: Fixed Effects, Corrected for First Order Serial Correlation

Dependent Variable: Gross Investment Rate, 1964-1986

	Full sample (N = 265)			Durable goods (N = 141)			Nondurable goods (N = 124)		
	All (N=265)	Big (N=66)	Small (N=199)	All (N=141)	Big (N=35)	Small (N=106)	All (N=124)	Big (N=31)	Small (N=93)
CU	.123[a]	.131[b]	.120[a]	.063[b]	.148[c]	.067[c]	.142[a]	.039	.148[a]
	(.023)	(.060)	(.026)	(.032)	(.082)	(.036)	(.032)	(.089)	(.035)
CU*C4WP	-.006	.011	.011	.062[c]	.012	.037	.018	.079	.017
	(.024)	(.050)	(.029)	(.034)	(.070)	(.043)	(.033)	(.069)	(.038)
CU*SHREQ	-.128[a]	-.120[a]	-.129[a]	-.149[a]	-.153[a]	-.147[a]	-.107[a]	-.074[a]	-.111[a]
	(.007)	(.015)	(.008)	(.010)	(.022)	(.012)	(.009)	(.022)	(.098)
POIL	-.856[a]	-1.14[a]	-1.53[a]	-1.50[a]	-.857[a]	-2.42[a]	-1.87[a]	-2.42[a]	-1.40[a]
	(.098)	(.178)	(.275)	(.121)	(.219)	(.457)	(.291)	(.506)	(.355)
CFK	.032[a]	.070[a]	.032[a]	.077[a]	.029	.078[a]	.030[a]	.127[a]	.028[a]
	(.004)	(.020)	(.004)	(.008)	(.025)	(.009)	(.005)	(.035)	(.005)
CFK*C4WP	.013	-.036	.006	-.020	.027	-.005	-.022	-.135[b]	-.024[c]
	(.010)	(.034)	(.012)	(.017)	(.044)	(.021)	(.013)	(.055)	(.015)
ρ	.417[a]	.519[a]	.371[a]	.371[a]	.508[a]	.318[a]	.427[a]	.499[a]	.389[a]
	(.012)	(.023)	(.015)	(.017)	(.033)	(.021)	(.018)	(.033)	(.021)

Standard errors are in parentheses under coefficient estimates. Fixed industry and year effects are not reported. CU is the capacity utilization measure; C4WP is the four-firm concentration ratio adjusted by Weiss-Pascoe (1986); SHREQ is the share of equipment investment in total investment; POIL is the relative price of energy; CFK is the ratio of cash flow to the capital stock; and ρ is the first order serial correlation coefficient. See the text and appendix for more details on variable definitions. Significance levels are denoted by a (1%), b (5%), and c (10%), respectively. The estimate and standard error for POIL have been scaled up by a factor of 100.