JOURNAL OF FINANCIAL AND QUANTITATIVE ANALYSIS Vol. 43, No. 2, June 2008, pp. 299–330
COPYRIGHT 2008, MICHAEL G. FOSTER SCHOOL OF BUSINESS, UNIVERSITY OF WASHINGTON, SEATTLE, WA 98195

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

Investment and Competition

Evrim Akdoğu and Peter MacKay*

Abstract

This paper examines how industry structure affects corporate investment patterns. Real options theory shows that deferring irreversible investment in the face of uncertainty is valuable. Theory also shows that the value of waiting to invest falls if investment opportunities are contestable. Consistent with these theories, we find that firms in monopolistic industries exhibit lower investment-q sensitivity and are slower to invest than firms in competitive industries. However, we find that investment-q sensitivity and investment speed are highest in oligopolistic industries, suggesting that the value of investing strategically can outweigh the value of waiting. Indeed, oligopolistic industries experience less entry and more exit than other industries.

I. Introduction

The value of real options and their optimal exercise are closely tied to industry structure. For instance, although a firm with exclusive property rights to a risky investment opportunity will optimally delay costly adjustments and irreversible capital expenditures, the value of waiting is dissipated if other firms can divert the opportunity to themselves.[1] Aside from this wait-lose trade-off, firms might use investment strategically to deter entry, preempt rivals, or induce exit.[2] Although a large theoretical literature implicitly or explicitly relates real options to industry structure, empirical evidence remains scant.[3] This study provides the

*Akdoğu, eakdogu@mail.cox.smu.edu, Southern Methodist University, Cox School of Business, Dallas, TX 75206, and MacKay, pmackay@ust.hk, Hong Kong University of Science & Technology, Finance Department, Clear Water Bay, Kowloon, Hong Kong. We thank W. Sean Cleary (the referee), Paul Malatesta (the editor), Dong-Hyun Ahn, Venkat Eleswarapu, Chris Hogan, Ayla Kayhan, Robert Kieschnick, Marvin Lieberman, David Mauer, Vassil Mihov, Sara Moeller, Gordon Phillips, Steve Postrel, Greg Sommers, Taeyoon Sung, Kumar Venkataraman, and seminar participants at the 2006 Financial Intermediation Research Society Shanghai Conference, the 2006 European meetings of the Financial Management Association, the 12th Annual conference of the Korea Economic Association, the University of Texas at Dallas, the University of South Carolina, and HEC Montreal for useful comments and discussions. The authors alone are responsible for the work and any errors or omissions.

[1]McDonald and Siegel (1986) and Majd and Pindyck (1987) derive the value of waiting in a monopolistic setting. Williams (1993), Grenadier (1996), (2002) and others show how competition drives this value down substantially.

[2]This point is made by Spence (1977), Dixit (1980), and several others. However, Fudenberg and Tirole (1984) show that strategic investment can also mean that incumbents accommodate entry by investing sparingly.

[3]Williams (1993) notes that housing starts in a market serviced by an oligopolistic group of developers remained surprisingly low despite rapid population growth. Bulan, Mayer, and Somerville

first direct broad sample results on whether industry structure affects the exercise of real options by testing if industry concentration affects the sensitivity of investment to Tobin's q or investment timing patterns.

Our research design follows directly from Grenadier (2002) who shows that the level above which the stochastic state variable must rise to trigger investment falls with competition. Industry structure therefore affects the sensitivity and timing of investment by conditioning the probability that a change in the state variable will trigger investment. We test this hypothesis using two approaches, one rooted in the literature relating investment to Tobin's q, the other a duration analysis that addresses limitations of the first approach while corroborating its results.

Using Tobin's q as a proxy for the stochastic state variable and the Herfindahl-Hirschman Index (HHI) to measure industry concentration, our first approach examines whether industry structure affects investment by estimating investment-q regressions on a large sample of U.S. manufacturing firms. Consistent with a wait-lose trade-off, we find that investment by firms in high-concentration (monopolistic) industries is about half as sensitive to changes in Tobin's q as investment by firms in low-concentration (competitive) industries.

In contrast, but consistent with a strategic role for investment, we find that investment-q sensitivity is highest among firms in mid-concentration (oligopolistic) industries. Firms in these industries also invest more than firms in competitive or monopolistic industries. These findings suggest that the value of investing strategically can outweigh the value of waiting. The importance of strategic investment in oligopolistic industries is supported by our finding that these industries experience less entry and more exit than competitive or monopolistic industries.

Although this first approach links our work to the extensive investment-q literature, investment-q sensitivity might well reflect factors besides real options and strategic interaction. For instance, recent papers show that market power lowers investment-q sensitivity in general (Cooper and Ejarque (2001), Abel and Eberly (2003)) and that measurement error in Tobin's q can bias investment sensitivities (Erickson and Whited (2000), (2002), Gomes (2001)).

Therefore, as a second approach, we perform a duration analysis to avoid these interpretive and econometric problems and test directly how industry structure affects investment timing. Consistent with the regression results, we find that when it comes to large investments (both for fixed and firm-specific investment cutoff levels), firms in competitive industries invest sooner than firms in monopolistic industries. Also consistent with our regression results, we find that firms in oligopolistic industries are quickest to invest and least likely to stage investment.

Alternatively, our findings could simply reflect differences in investment frictions. The HHI might sort industries on the basis of adjustment costs or investment irreversibility because these frictions pose barriers to entry and exit that in turn determine industry structure. We address this concern in several ways. First, we control for industry fixed effects, thus accounting for broad differences in investment frictions. Second, differential investment frictions would cause differ-

(2002) find that competition accelerates development in local real estate markets in Vancouver, Canada. Schwartz and Torous (2003) obtain similar results for a broad cross section of real estate markets in the U.S.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

ences in the lumpiness of investment, yet we find no difference in the lumpiness of investment among competitive, oligopolistic, and monopolistic industries. Finally, we control for capital intensity as a proxy for sunk costs and irreversibility.

This research also has implications for traditional areas of empirical investment analysis. Industry structure is likely to affect investment cash flow sensitivities if profitability increases in concentration.[4] Industry structure can also affect the variance of underlying risk factors and thereby the relation between investment and uncertainty.[5] Accordingly, we find that investment sensitivity to proxies for financial status and risk does indeed depend on industry concentration.

Ours is not the first paper to relate corporate investment to industry structure. Galeotti and Schiantarelli (1991), Sakellaris (1994), Hay and Liu (1998), and Cooper and Ejarque (2001) focus on optimization frameworks that accommodate imperfect competition and stress the empirical detection of market power. However, they do not examine whether conventional measures of industry structure can help explain corporate investment patterns. Ghosal and Loungani (1996) find that competition affects investment risk sensitivity at the industry level. Our study draws on recent theory that shows that industry structure affects firm-level investment not only through its effect on uncertainty but also via the equilibrium investment trigger levels.

This paper makes two contributions. First, we show that industry structure sheds new light on our understanding of corporate investment decisions. Our results show that the basic wait-lose trade-off suggested by standard and strategic real options theories is borne out by the data. Second, we show that strategic considerations beyond those reflected in the wait-lose trade-off also weigh into the equation. This is seen in oligopolistic industries, where investment is even more sensitive to Tobin's q and occurs sooner than in competitive industries.

The paper is organized as follows. Section II discusses the relevant literature, empirical predictions, and research design. Section III describes data sources, variable construction, and sample selection. Section IV presents univariate statistics and investment-q regressions. Section V discusses alternative explanations for our regression results. Section VI presents our duration analysis. Section VII analyses industry structure and Section VIII concludes.

II. Real Options, Industry Structure, and Strategic Investment

This section reviews the literature relevant to our empirical predictions. We begin with the real options literature pertaining to the optimal timing and size of irreversible investment. We then discuss strategic real options studies that show how industry structure bears on investment policy. Because some of our results

[4] A large literature and heated debate have emerged on the relevance of financial constraints to investment (viz. Fazzari, Hubbard, and Petersen (1988), Kaplan and Zingales (1997), Erickson and Whited (2000), (2002), and Abel and Eberly (2003)).

[5] Caballero (1991), Pindyck (1993), Sakellaris (1994) and others model investment under uncertainty (see Dixit and Pindyck (1994)). Galeotti and Schiantarelli (1994), Sakellaris (1995), Leahy and Whited (1996), Minton and Schrand (1999), and Andrade and Stafford (2004) test the empirical relation between risk and investment.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

suggest that investment might also serve a strategic purpose, we survey the industrial organization literature related to strategic investment. Finally, we show how these distinct strands of literature combine to form a set of testable empirical hypotheses.

A. Review of the Literature

McDonald and Siegel (1986) and Pindyck (1988) are among the first studies to use a contingent claims framework to value the option to postpone costly capacity adjustments or irreversible investment in the face of uncertainty. McDonald and Siegel establish the value of waiting to invest by showing that, contrary to the standard NPV decision rule, investment should only proceed if the value of discounted cash flows exceeds the investment outlay by a certain positive amount: "The correct calculation involves comparing the value of investing today with the (present) value of investing at all possible times in the future" (p. 707). For reasonable parameter values, McDonald and Siegel estimate that firms should wait until the benefits are twice the costs before making irreversible investments. Dixit and Pindyck (1994), p. 136 later canonize this view by noting: "Hence the simple NPV rule is not just wrong; it is often very wrong."

Pindyck (1988) extends the McDonald-Siegel framework to endogenize the size of capacity itself. Pindyck shows that although the expected marginal productivity of capital rises with uncertainty, rising uncertainty increases the value of waiting by an even greater amount. The net effect is to lower the optimal size of capacity relative to a deterministic setting. Thus, these papers show that uncertainty lowers irreversible investment in two ways. First, the value of waiting causes firms to defer investing in a given project until uncertainty is resolved. Second, uncertainty lowers investment by reducing the optimal size of risky projects.

Closely tied to this literature are papers that study the staging of investment, such as Baldwin (1982), Majd and Pindyck (1987), and Pacheco-de-Almeida and Zemsky (2003). These papers consider the case where investment proceeds in sequential increments rather than being strictly discrete (McDonald and Siegel (1986)) or perfectly scalable (Pindyck (1988)). Their central message is that the arrival of intervening information allows firms to adjust their investment program midstream. Good news leads firms to accelerate or ramp up investment; bad news leads them to decelerate, scale down, or even abandon ongoing investment projects. These possibilities not only expand the firm's portfolio of real options, but also affect the value of its other real options. For instance, the ability to make interim adjustments assuredly lowers the value of waiting and changes initial capacity size compared to when such adjustments are not possible.[6]

The papers reviewed so far offer a unified message, namely, that investment frictions tend to slow the pace and lower the size of investment under uncertainty.

[6]Trigeorgis (1996) investigates the value effects of real option interactions. Brennan and Schwartz (1985) examine the scope firms have to withdraw by temporarily shutting down operations or eventually abandoning productive capacity. Triantis and Hodder (1990) refine the analysis to model real flexibility within ongoing manufacturing operations. Abel and Eberly (1994), (1996) analyze the joint role of fixed adjustment costs and partial irreversibility. Finally, Abel, Dixit, Eberly, and Pindyck (1996) generalize the real options approach to the case where both the postponement of investment and capacity-in-place are only partially irreversible.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

A maintained assumption of this literature is that firms hold exclusive property rights to their real options, which amounts to assuming that firms face strictly exogenous stochastic state variables. This assumption fails, however, if own-firm investment returns interact with rivals' investment returns. Dixit (1989), Williams (1993), Caballero and Pindyck (1996), and Grenadier (1996), (2002) show how these interactions arise in a dynamic industry setting where investment returns reflect interfirm rivalry and intertemporal dependence. Under this scenario, the state variables are endogenous, which calls into question the partial equilibrium results derived in the standard real options literature.

Recent real options models address these concerns by incorporating strategic interaction. For instance, Williams (1993), Baldursson (1998), Kulatilaka and Perotti (1998), Grenadier (1996), (2002), and Lambrecht and Perraudin (2003) all show that the value of certain real options quickly erodes when investment opportunities are contestable. As Grenadier (2002), p. 693 states: ". . . , with competition the traditional NPV rule becomes approximately correct, even with only a few competitors." However, Leahy (1993) shows that rival action may actually not affect equilibrium investment behavior, which underscores the need for empirical verification.[7]

The strategic real options literature establishes a first linkage between investment policy and industry structure where, by depressing the value of real options, strategic factors can restore the decision rules and investment patterns prevailing under certainty. Even under certainty, industrial organization theory suggests other reasons why strategic interaction might cause investment behavior to deviate from partial equilibrium policies. Spence (1977) and Dixit (1980) exemplify this broad literature on strategic investment.[8] These papers develop a strategic role for investment, where by investing in fixed capacity, research and development, or advertising campaigns incumbents credibly commit to compete aggressively in the product market. This posturing can keep out aspiring entrants, induce rivals to relinquish market share or forgo expansion, and cause marginal players to exit. However, Fudenberg and Tirole (1984) show that under some circumstances, rather than this "fat-cat effect," the best strategy is for incumbents to maintain a "lean and hungry look" by investing sparingly. Thus, investing strategically could mean overinvesting or underinvesting relative to partial equilibrium investment levels.

B. Empirical Predictions and Research Design

The literature offers straightforward predictions and suggests a simple research design. First, the standard real options literature shows that there is value in postponing investment. Second, the strategic real options literature shows that competition might compromise this value. This wait-lose trade-off suggests that

[7] Similarly, Pindyck (1993), p. 273 cautions that "in a competitive market, the key interactions between irreversibility and uncertainty occur at the industry level and can only be understood by making price and industry output endogenous. Doing so restores the positive opportunity cost associated with irreversible investment."

[8] Others include Eaton and Lipsey (1979), (1980), (1981) and Fudenberg and Tirole (1983), (1984), (1986).

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

the value of waiting is highest in monopolistic industries, where firms are presumably least likely to lose investment opportunities to competitors. Thus, the wait-lose trade-off implies that the value of waiting increases with industry concentration.

The strategic investment literature puts an important qualification on this first implication. Specifically, in addition to the wait-lose trade-off, firms also weigh the gains from strategic investment aimed at defending market share and their real option portfolios. These factors could yield richer results than the linear relation implied by standard and strategic real options theories.

We test these implications using two approaches, one relying on investment-q sensitivity, the other examining investment timing. Both approaches follow directly from Grenadier (2002) who shows that the level above which the stochastic state variable must rise to trigger investment falls with competition. We motivate and explain each approach in turn.

First, Grenadier's result implies that competition raises the sensitivity of investment to the state variable by raising the probability that a change in the state variable will trigger investment. We show this formally in the Appendix where we establish that the expected sensitivity of investment to the state variable increases with the number of firms in the industry. This result holds whenever investment is increasing in the state variable, which is the conventional real options assumption, and one that is known to hold for Tobin's q, our proxy for the state variable.[9]

Thus, our first approach is to regress investment on Tobin's q and examine if industry concentration affects investment-q sensitivity. According to the wait-lose trade-off, the value of waiting is highest in monopolistic industries and lowest in competitive industries. As discussed, this implies that investment-q sensitivity should decrease in industry concentration, but if the value of investing strategically offsets the value of waiting, investment-q sensitivity could exhibit no significant relation to industry structure or even increase in industry concentration.

We use duration analysis as a second approach to testing the empirical predictions. There are two benefits to doing so. First, the link to theory is immediate: industry structure affects investment timing by affecting optimal waiting time. Duration analysis allows us to model investment timing directly. Second, it allows us to determine whether factors other than real options and strategic interaction are driving our regression results. Specifically, industry concentration might lower investment-q sensitivity because of the market power argument developed in Cooper and Ejarque (2001) and Abel and Eberly (2003) or estimation bias caused by measurement error in Tobin's q (Erickson and Whited (2000), (2002), and Gomes (2001)). Duration analysis avoids Tobin's q altogether and therefore

[9]Our choice of Tobin's q as a proxy for the state variable is based on two considerations. First, Tobin's q is widely accepted as the theoretically sound measure of the desirability of investment and is commonly used in the empirical investment literature (e.g., Hayashi (1982), Gomes (2001)). Recent theory (Caballero and Leahy (1999), Caballero (1999), and especially Abel and Eberly (2003)) even favors observable average q (Tobin's q) over the unobservable marginal q. Second, because it is constructed from market value Tobin's q reflects the arrival of new information regarding the desirability of investment and thus evolves stochastically. Abel and Eberly (2003) formalize this view by showing how average q depends on stochastic capital depreciation rates and profit growth.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

allows us to determine whether the posited hypothesis or these alternative economic and econometric factors explain our results.

We therefore estimate a proportional hazards model that enables us to examine investment timing patterns and their determinants as a function of industry concentration. The empirical predictions parallel those of the regression analysis. According to the wait-lose trade-off, firms in the highest-concentration industries should be slowest to invest. If the value of investing strategically equals or outweighs the value of waiting, firms in higher-concentration industries could invest at the same pace or even sooner than firms in lower-concentration industries.

III. Data, Controls, and Sample Selection

A. Data Sources

Our sample consists of active and inactive manufacturing firms between 1981 and 2000 in the merged Compustat/CRSP database produced by Wharton Research Data Services (WRDS). We use Compustat for the financial accounting and operating variables and CRSP for historical industry classifications because Compustat only reports current industry classifications. Rather than Compustat's CUSIP, which changes after mergers and name changes, we use the CRSP firm identifier (permno) to track firms over time. We merge in Compustat's business segment files to compute firm-level diversification.

We collect four-digit SIC industry concentration measures (the HHI) from the Census of Manufacturers for 1977, 1982, 1987, 1992, and 1997.[10] The Census of Manufacturers reports the results of the U.S. Census Bureau's Economic Census held every five years. This provides an exogenous and reasonably timely measure of industry concentration. An exogenous measure of industry concentration is preferable for two reasons. First, rather than rely on the availability of Compustat data, the Economic Census offers the broadest coverage available and thus helps minimize selection bias and classification error. Second, the Department of Justice (DOJ) and other agencies use the HHI to set and enforce competition policy. Thus, the HHI is desirable because it guides both government and firm behavior and is observable to all. Because the HHI is only updated every five years, each industry is assigned the same HHI until the next census year, e.g., the 1982 HHI holds for 1982, 1983, 1984, 1985, and 1986.

Most of our analysis involves comparing investment-q sensitivities and investment timing patterns across industries that exhibit varying degrees of industry concentration. Rather than rely on subjective industry classifications, we again turn to an objective source. Specifically, following the U.S. Department of Justice and Federal Trade Commission (1997), we identify three groups of industries: unconcentrated (HHI under 1,000), moderately concentrated (HHI from 1,000 to 1,799), and highly concentrated (HHI of 1,800 and up). Using these HHI cutoffs, we form industry concentration subsamples that we refer to as low-, mid-, and high-concentration industries. For brevity, we also refer to them as competitive,

[10]The Census of Manufacturers' HHI is constructed by summing the squared market shares of the top 50 firms in each industry. Because this index is inherently nonlinear, we linearize it using the natural logarithm of the HHI.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

oligopolistic, and monopolistic industries although we make no claim that these low-, mid-, and high-concentration industries closely match textbook definitions of competitive, oligopolistic, and monopolistic industries.

B. Controls and Variable Construction

The empirical finance literature on corporate investment usually focuses either on the role of financial status or the effect of uncertainty.[11] Whether or how financial status bears on investment is unresolved.[12] The effect that uncertainty has on investment is also debated, both theoretically (Caballero (1991), Pindyck (1993), and Sakellaris (1994)), and empirically (Sakellaris (1995), Leahy and Whited (1996), Minton and Schrand (1999), and Andrade and Stafford (2004)). Consequently, our investment regressions include financial status and risk proxies as controls.

We use the following proxies for financial status: cash flow, cash holdings, financial leverage, and firm size. Cash flow and firm size are common in the investment finance literature. However, as Almeida, Campello, and Weisbach (2004) imply and Whited (2006) shows, a firm's stock of liquid assets and debt financing can also condition its investment. Therefore, we include cash holdings and financial leverage as additional proxies for financial status.

These variables are constructed as follows. Following Minton and Schrand (1999), Whited (2006), and Andrade and Stafford (2004), we measure investment as capital expenditures in property, plant, and equipment normalized by lagged total assets. As in MacKay and Phillips (2005) and Almeida, Campello, and Weisbach (2004), Tobin's q is the market value of equity plus the book value of debt and preferred stock minus deferred taxes, all divided by total assets.[13]

Following Almeida, Campello, and Weisbach (2004), we define cash flow as the ratio of earnings before extraordinary items and depreciation (minus dividends) to total assets, cash holdings as the ratio of cash and marketable securities to total assets, and firm size as the natural logarithm of total assets. We measure financial leverage as total debt divided by total assets.

As proxies for risk, we use cash flow volatility, diversification, and capital intensity. We measure cash flow volatility as the standard deviation of cash flow divided by total assets using up to 10 (minimum four) annual observations. We measure diversification as one minus the Herfindahl of sales across a firm's four-

[11] Industrial economists were initially interested in the adjustment cost function, first assuming convex adjustment costs (e.g., Hayashi (1982), Whited (1992), Bond and Meghir (1994)) then admitting fixed costs (e.g., Abel and Eberly (1994), Barnett and Sakellaris (1998), Doyle and Whited (2001)). See Hamermesh and Pfann (1996) for a survey.

[12] Fazzari et al. (1988), Gilchrist and Himmelberg (1995), and others find a positive relation between investment and cash flow. In contrast, Kaplan and Zingales (1997) and Cleary (1999) find that the investment of ex ante financially constrained firms is *less* sensitive to cash flow than the investment of ex ante financially *unconstrained* firms. Erickson and Whited (2000), (2002) and Gomes (2001) show that accounting for measurement error in Tobin's q restores the independence of investment and cash flow. However, Caballero and Leahy (1999), Alti (2003), and Abel and Eberly (2003) show that investment can depend on cash flow even in the absence of financial constraints. Lastly, Whited (2006) finds that financial constraints lower the probability of investment.

[13] Alternatively, following Alti (2003) and others, we repeat the analysis using net property, plant, and equipment as a divisor for investment and Tobin's q instead of total assets. We find no material difference in results.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

digit SIC industries (computed from segment data). This measure equals zero for single segment firms and tends to one for multi-segment firms. We use fixed capital stock (net property, plant, and equipment, in $millions) divided by the number of employees as a proxy for capital intensity (the capital-labor ratio). Although we view the capital-labor ratio as a proxy for risk (operating leverage), it could also reflect real side flexibility, following the interpretation given by Leahy and Whited (1996) and MacKay (2003).

Finally, our multivariate analyses control for two-digit and year fixed effects. These fixed effects help control for industry or secular shocks and other factors that might enter the firm's optimization problem but escape the analyst. In particular, year effects account for changes in the risk-free rate over time and industry effects help minimize the possibility that the HHI merely reflects differences in investment frictions across industries. Note that controlling for capital intensity as a proxy for sunk costs and irreversibility also serves to alleviate the latter concern.

C. Sample Selection

As in most studies on fixed capacity investment, we limit the sample to firms in manufacturing industries (SIC 2000–3999). Another reason for this restriction is that the Census of Manufacturers' HHI is only available for manufacturing industries. We exclude firms in industries classified as miscellaneous by dropping industries where the last two digits of the four-digit SIC code end in 99. This limits the sample to well-defined industries.

We delete observations with missing data on investment, negative values for sales, assets, or investment, and those with a CRSP permanent number equal to zero. Influential observations are removed as follows. We drop observations where Tobin's q is over 10, asset-normalized cash flow is less (more) than negative (positive) two, and asset-normalized cash holdings or financial leverage lie outside the $[0, 1]$ interval.[14] Once these preliminary screens have been performed, we further trim the sample by excluding observations in the 99th percentiles for Tobin's q and asset-normalized investment, cash flow, and cash flow volatility. Because cash flow can take on large negative values we also exclude cases where asset-normalized cash flow is below the lowest percentile.

The regressions presented in Section IV mitigate endogeneity bias by using lagged values of the regressors as instruments. We also perform a duration analysis requiring several years of data for each firm-year. We therefore require that each firm-year have at least three years of lagged data.[15] The final sample consists of three unbalanced subsamples comprising 4,181 firms (23,927 firm-years) operating in 383 competitive (low-concentration) industries, 1,252 firms (5,113 firm-years) operating in 81 oligopolistic (mid-concentration) industries, and 909 firms (4,725 firm-years) operating in 69 monopolistic (high-concentration) industries.

[14] Only about 1% of the sample has Tobin's q over 10. Including these cases does not change our conclusions.

[15] Because the sample is highly unbalanced, with some firms appearing only a few years and others remaining throughout the entire panel, this number of lags reflects a trade-off between reducing endogeneity bias, forming meaningful hazards, losing observations and statistical power, and introducing large firm and survivor biases.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

IV. Results

A. Univariate Analysis

Table 1 reports summary statistics for the industry concentration subsamples. Although most of the variables differ statistically across these subsamples, we note only a few economically significant differences between firms in each type of industry. Median investment rates are 4.4%, 4.9%, and 4.4% for low-, mid-, and high-concentration industries. In other words, the relation between investment and industry concentration is non-monotonic, with firms in mid-concentration industries investing about 11% more than firms in low- or high-concentration industries, but no detectable difference between firms in low- or high-concentration industries.

TABLE 1

Summary Statistics

Reported are summary statistics for firms in low-, mid-, and high-concentration manufacturing industries, 1981–2000. Industry concentration is measured using the Herfindahl-Hirschman Index (HHI) compiled by the Census of Manufacturers. Subsamples reflect DOJ-FTC guidelines: low-concentration industries (HHI $<$ 1,000), mid-concentration industries (1,000 $\leq$ HHI $<$ 1,800), and high-concentration industries (HHI $\geq$ 1,800). Firm-level data are from Compustat. Our proxy for investment is capital expenditures. Our proxy for investment opportunities is Tobin's *q* (market value of equity plus book value of debt and preferred stock minus deferred taxes, divided by the book value of assets). Our proxies for financial status are: cash flow (earnings before extraordinary item and depreciation minus dividends), cash holdings (cash and marketable securities), financial leverage (total debt divided by total assets), and firm size (log of total assets). Our proxies for risk are: cash flow volatility (standard deviation of cash flow divided by assets), diversification (one minus the Herfindahl of sales across the firm's four-digit SIC industries), and the capital-labor ratio (net property, plant, and equipment per employee). HHI statistics reflect industry-years rather than firm-years. Superscripts show significant differences across subsamples: low versus mid (Panel A), mid versus high (Panel B), and low versus high (Panel C). ***, **, * denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Mean	Median	Std. Dev.	Minimum	Maximum	N
Panel A. Low-Concentration Industries						
Capital Expenditures/Assets	0.054***	0.044***	0.049 ***	0.000	0.287	23,927
Tobin's *q*	1.572	1.246***	1.021***	0.043	7.637	23,927
Cash Flow/Assets	0.026**	0.061***	0.146	−1.013	0.244	23,927
Cash Holdings/Assets	0.117***	0.047***	0.167***	0.000	0.974	23,927
Total Debt/Assets	0.243**	0.217	0.195***	0.000	1.000	23,927
Log of Total Assets	4.294***	4.135***	2.006***	0.050	12.330	23,927
Cash Flow Volatility	0.086***	0.061	0.080***	0.001	0.556	23,927
Diversification	0.286***	0.432***	0.290*	0.000	0.947	23,927
Capital-Labor Ratio	0.041***	0.024 ***	0.051***	0.000	0.433	23,927
Industry Concentration (HHI)	553***	505***	197***	226	1,000	5,079
Panel B. Mid-Concentration Industries						
Capital Expenditures/Assets	0.061***	0.049***	0.050***	0.000	0.285	5,113
Tobin's *q*	1.552***	1.287	0.898***	0.091	7.623	5,113
Cash Flow/Assets	0.031	0.066	0.148***	−1.014	0.243	5,113
Cash Holdings/Assets	0.112***	0.052***	0.145***	0.000	0.994	5,113
Total Debt/Assets	0.236	0.210	0.191	0.000	0.999	5,113
Log of Total Assets	4.544	4.265***	2.191***	0.146	10.857	5,113
Cash Flow Volatility	0.091	0.062	0.088	0.004	0.557	5,113
Diversification	0.245***	0.382***	0.295	0.000	0.910	5,113
Capital-Labor Ratio	0.032***	0.021***	0.037***	0.000	0.430	5,113
Industry Concentration (HHI)	1,309***	1,251***	226***	1,003	1,797	1,091
Panel C. High-Concentration Industries						
Capital Expenditures/Assets	0.054	0.044	0.047***	0.000	0.285	4,725
Tobin's *q*	1.646***	1.284***	1.085***	0.078	7.637	4,725
Cash Flow/Assets	0.028	0.064***	0.156***	−1.013	0.244	4,725
Cash Holdings/Assets	0.128***	0.059***	0.164**	0.000	0.965	4,725
Total Debt/Assets	0.234**	0.217	0.190*	0.000	0.999	4,725
Log of Total Assets	4.526***	3.915***	2.51 ***	0.223	11.999	4,725
Cash Flow Volatility	0.090***	0.060	0.089***	0.005	0.556	4,725
Diversification	0.305***	0.502***	0.293	0.000	0.934	4,725
Capital-Labor Ratio	0.036***	0.024	0.039***	0.000	0.395	4,725
Industry Concentration (HHI)	2,794***	2,660***	675***	1,810	5,098	949

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

Mean Tobin's q is statistically higher in high-concentration than in mid-concentration industries (1.646 and 1.552), however, the medians (1.284 and 1.287) are indistinguishable. We find substantially higher mean and median Tobin's q for high-concentration than low-concentration industries (1.646 versus 1.572 and 1.284 versus 1.246), consistent with greater market power and economic rents accruing to firms in monopolistic industries. This interpretation is bolstered by the fact that median cash flow (profitability) is greater in high-concentration than low-concentration industries (0.064 versus 0.061).

Perhaps the most striking aspect of these findings is the lack of variation in the levels of most variables across industry subsamples. However, as the following analysis shows, although similar equilibrium outcomes might arise across these broad industry types, industry structure does bear directly on the *relation* between investment and its determinants.

B. Multivariate Regression Analysis

Table 2 reports GMM investment-q regression results for low-, mid-, and high-concentration industries. For robustness, in addition to the DOJ cutoffs (Model B), this table also examines the sensitivity of the results to variations in the concentration cutoff scheme by broadening the mid-concentration category to $800 \leq \text{HHI} < 2{,}000$ (Model A) and narrowing it to $1{,}200 \leq \text{HHI} < 1{,}600$ (Model C). These variants are centered on the DOJ cutoffs of $1{,}000 \leq \text{HHI} < 1{,}800$. The key results across these variants are quite similar so we frame our discussion in terms of the base case, the DOJ cutoffs (Model B), and note differences for Models A and C as necessary.

Each model of Table 2 shows results for an investment-q equation estimated with the set of controls for firm financial status and risk described earlier. In all three subsamples (low-, mid-, and high-concentration) our results show similarities with those reported in extant empirical work. For instance, despite its theoretical foundation as a "sufficient statistic" for investment, we find that Tobin's q is not the only significant regressor: many control variables are statistically significant. The coefficients for Tobin's q (0.005, 0.008, and 0.002 for low-, mid-, and high-concentration industries) are substantially lower than the coefficients for cash flow (0.261, 0.225, and 0.146).[16]

These results concur with the importance usually ascribed to finance in explaining investment.[17] In addition, our coefficients are also comparable to those typically found in the literature. Our investment-q sensitivities are of similar magnitude to those reported in such studies as Fazzari et al. (1988) and Alti (2003) but

[16] Technically speaking, we cannot directly compare the coefficients for Tobin's q and cash flow because these variables span very different scales (the minima and maxima for these variables in Table 1 attest to this). To make them comparable, we can standardize the variables by subtracting the sample mean from each observation and then dividing this result by the sample standard deviation. The corresponding standardized regression coefficients are: 0.212, 0.332, and 0.097 for Tobin's q and 0.588, 0.503, and 0.331 for cash flow. This means that cash flow is two to three times more important than Tobin's q in explaining investment rates.

[17] Alternatively, Caballero and Leahy (1999) show that Tobin's q is no longer a sufficient statistic in the presence of fixed costs and Abel and Eberly (2003) show that market power or non-constant returns to scale can cause investment to depend on cash flow even in the absence of financial constraints.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

TABLE 2

GMM Regressions by Level of Industry Concentration

GMM regression results for low-, mid-, and high-concentration manufacturing industries. Industry concentration is measured using the Herfindahl-Hirschman Index (HHI) compiled by the Census of Manufacturers. Model B uses DOJ-FTC HHI cutoffs of 0–999, 1,000–1,799, and 1,800+ to classify industries as low-, mid-, or high-concentration. Model A uses cutoffs of 0–799, 800–1,999, and 2,000+, and Model C uses cutoffs of 0–1,199, 1,200–1,599, and 1,600+. The dependent variable is investment (capital expenditures divided by assets). Our proxy for investment opportunities is Tobin's *q* (market value of equity plus book value of debt and preferred stock minus deferred taxes, divided by the book value of assets). Our proxies for financial status are: cash flow (earnings before extraordinary item and depreciation minus dividends), cash holdings (cash and marketable securities), financial leverage (total debt divided by total assets), and firm size (log of total assets). Our proxies for risk are: cash flow volatility (standard deviation of cash flow divided by assets), diversification (one minus the Herfindahl of sales across the firm's four-digit SIC industries), and the capital-labor ratio (net property, plant, and equipment per employee). All regressions control for two-digit industry and year fixed effects. Heteroskedasticity and autocorrelation-robust Newey-West asymptotic standard errors are reported in parentheses. The Δ columns show the statistical significance levels of difference tests across subsamples: low versus mid (first superscript), mid versus high (second superscript), and low versus high (third superscript). ***, **, * and ^{a}, ^{b}, ^{c} denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Low-Concentration Industries			Mid-Concentration Industries			High-Concentration Industries					
Model:	A	B	C	A	B	C	A	B	C	ΔA	ΔB	ΔC
Tobin's *q*	0.004 (0.001)***	0.005 (0.001)***	0.006 (0.000)***	0.007 (0.001)***	0.008 (0.001)***	0.008 (0.001)***	0.002 (0.001)***	0.002 (0.001)***	0.002 (0.001)***	a,a,b	a,a,a	c,a,a
Cash Flow/Assets	0.248 (0.014)***	0.261 (0.013)***	0.239 (0.012)***	0.273 (0.023)***	0.225 (0.028)***	0.274 (0.044)***	0.143 (0.019)***	0.146 (0.020)***	0.139 (0.019)***	−,a,a	−,b,a	−,b,a
Cash Holdings/Assets	0.018 (0.014)	0.005 (0.014)	−0.021 (0.004)***	−0.145 (0.026)***	−0.243 (0.034)***	−0.016 (0.041)	−0.073 (0.029)**	−0.071 (0.037)*	−0.087 (0.035)**	a,c,a	a,a,c	−,−,c
Total Debt/Assets	−0.016 (0.003)***	−0.012 (0.002)***	−0.014 (0.003)***	−0.015 (0.006)***	−0.031 (0.006)***	−0.019 (0.005)***	−0.016 (0.001)***	−0.018 (0.003)***	−0.011 (0.001)***	−,−,−	a,c,c	−,−,−
Log of Total Assets	0.001 (0.000)**	0.001 (0.000)**	0.001 (0.000)**	0.001 (0.003)	−0.001 (0.002)	−0.002 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	−,−,−	−,−,−	b,b,−
Cash Flow Volatility	0.038 (0.011)***	0.049 (0.011)***	0.032 (0.009)***	0.043 (0.008)***	−0.011 (0.013)	0.032 (0.031)	0.014 (0.015)	0.018 (0.015)	0.003 (0.015)	−,−,−	a,−,c	−,−,c
Diversification	−0.005 (0.001)***	−0.006 (0.001)***	−0.007 (−0.001)***	−0.016 (0.002)***	−0.019 (0.002)***	−0.013 (−0.004)***	−0.011 (0.003)***	−0.011 (0.003)***	−0.012 (−0.003)***	a,−,c	a,b,−	−,−,c
Capital-Labor Ratio	0.098 (0.010)***	0.095 (0.009)***	0.097 (0.009)***	0.100 (0.016)***	0.132 (0.020)***	0.128 (0.031)***	0.110 (0.025)***	0.124 (0.024)***	0.138 (0.022)***	−,−,−	c,−,−	−,−,c
Industry Concentration	0.007 (0.004)*	0.016 (0.003)***	0.026 (0.003)***	0.014 (0.008)*	0.025 (0.013)**	0.009 (0.019)	0.005 (0.007)	0.005 (0.007)	0.020 (0.009)**	−,−,−	−,−,−	−,−,−
Degrees of Freedom	19,910	23,880	26,113	9,320	5,066	2,052	4,394	4,678	5,459			
Wald Test (all $\beta_j = 0$)	1,418***	1,721***	1,932***	698***	481***	287***	259***	281***	374***			
Hansen *J*-Stat (11 dof)	1,529***	1,751***	1,963***	564***	317***	215***	312***	288***	372***			

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

our investment cash flow sensitivities are lower. However, our cash flow sensitivities converge to theirs if, as in those studies, we omit the other covariates (see Table 3).

C. Investment-*q* Sensitivity and Industry Structure

Table 2 shows that the investment-*q* sensitivities differ statistically and economically across all three subsamples. Comparing low-concentration and high-concentration industry subsamples, we find investment-*q* sensitivities of 0.005 and 0.002, indicating that firms in low-concentration industries are about twice as responsive to variations in the investment opportunity set (Tobin's *q*) as firms in high-concentration industries.[18] This result is robust to the concentration cutoff schemes corresponding to Models A and C. These findings support the wait-lose trade-off hypothesis that firms in monopolistic industries are better able to defer investment until additional uncertainty is resolved than are firms in competitive industries.

Another possible explanation for why firms in high-concentration industries might respond less to Tobin's *q* is that they face higher adjustment costs or investment irreversibilities.[19] These frictions would result in lumpier, more volatile investment time patterns. However, Table 1 shows that the standard deviation of investment is actually somewhat *lower* for high-concentration industries and unreported ANOVA results show no difference in within-firm variation in investment across low- and high-concentration industries.[20] The regressions also include two-digit SIC industry dummies to account for industry-specific investment frictions. These factors would seem to rule out differential investment frictions as a potential explanation.

Table 2 shows a clear break from the monotonic relation between industry concentration and investment-*q* sensitivity implied by the wait-lose trade-off hypothesis. Specifically, we find that investment-*q* sensitivity is highest for firms in mid-concentration industries, where the coefficient estimate for Model B is 0.008 (0.007 and 0.008 for Models A and C). Thus, rather than falling somewhere between the investment-*q* sensitivity of low- and high-concentration industries, we find that investment in mid-concentration industries is 62% and 245% (unrounded) more sensitive to Tobin's *q* than it is in low- and high-concentration industries.[21]

[18] Although these regressions are not standardized, and the coefficients are therefore not strictly comparable, the fact is that Tobin's *q* and cash flow span nearly identical scales across the industry concentration subsamples (see the minima and maxima in Table 1). This is because we have applied common screening criteria to the combined sample. As a result, the sample ranges are almost identical and the coefficients are therefore roughly comparable.

[19] Formally, the first-order conditions for quadratic adjustment costs show that marginal *q* is strictly increasing in marginal adjustment costs (see Hayashi (1982), Bond and Meghir (1994), or Erickson and Whited (2000)). However, Whited (1994) shows that inferring the adjustment cost function from investment-*q* estimates is problematic.

[20] We also develop a measure of investment lumpiness and find no difference across industry subsamples (Table 6).

[21] An earlier version of this study established that investment-*q* sensitivity is non-monotonic in HHI by reporting combined sample regressions using interactions of Tobin's *q* and HHI in addition to subsample regressions. Thus, the inverted-U relation we document between investment and industry concentration is quite robust.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

What is less clear is *why* investment is most sensitive to Tobin's q in mid-concentration industries. Theory suggests two strategy-based explanations. First, strategic real options theory stresses a reactive explanation where the threat of losing opportunities to rivals prompts own-firm investment. Second, industrial organization theory stresses a proactive explanation where own-firm investment is used to affect rivals' investment. Although it might not be possible to disentangle them empirically, both explanations point to the importance of strategic interaction.

The reactive explanation holds that the value of delaying risky investment falls rapidly if other firms can divert investment opportunities to themselves. This would hardly apply to firms in monopolistic industries, where various factors conspire to soften competition and afford them more time to develop and exercise options at their leisure. It might also not fully apply to firms in competitively-structured industries where no single firm holds enough sway to threaten the opportunities facing other industry participants. Where strategic interaction might really matter to investment is between these polar extremes, where firms hold neither enough nor too little market power to ignore or be ignored by other industry participants. Firms in such industries surely have overlapping opportunity sets and find that, in a non-cooperative environment, first mover advantage is crucial and outweighs the value of delaying risky investment. This could explain why investment-q sensitivity is greatest in mid-concentration, oligopolistic industries.

The proactive explanation offered by industrial organization theory holds that incumbents might invest strategically to deter entry, preempt rivals, or induce exit. Such attempts are not germane to competitive industries. Even in monopolistic industries, exogenous factors might explain and perpetuate the status quo and lessen the value of strategic action. Oligopolistic industries are arguably where strategic action holds most appeal because the degree of competition, if not the industry structure itself, is bound to be more malleable and thus invite strategic investment aimed at deterrence, preemption, or predation. We later examine the strategic interaction hypothesis by analyzing industry contestability and entry and exit rates.

Table 2 shows that investment is almost twice as cash flow sensitive in low-concentration industries than in high-concentration industries. This result is consistent with the finding that investment-q sensitivity is higher in low-concentration industries: The more pressed a (financially constrained) firm is to invest, the more sensitive its investment will be to the availability of internal funds.

This finding offers new insights on how investment relates to a firm's financial status. While most recent attention has centered on econometric issues, our analysis suggests that economic forces are also part of the equation. In particular, we establish that investment cash flow sensitivity is tied to industry structure. There is no theory to guide us on why investment is more cash flow sensitive in low-concentration than in high-concentration industries. However, it seems reasonable to believe that if monopolistic firms are under less pressure to invest, as evidenced by their lower investment-q sensitivity, then their investment might also be less dependent on the availability of internal funds. Since this finding takes us outside the scope of our study, we leave it as a promising avenue for future research.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

The effect of cash holdings and firm size on investment also depends on industry concentration. In particular, although investment is not significantly related to cash holdings in low-concentration industries, it is *inversely* related to cash holdings in high-concentration industries; this inverse relation is even more pronounced in mid-concentration industries.[22] Also, investment increases in firm size in low-concentration industries, but is insignificantly related to firm size in mid- and high-concentration industries.

Table 2 also sheds new light on how investment relates to uncertainty. However, these findings are quite sensitive to the concentration cutoff scheme (Models A, B, or C). We find a significant positive relation between investment and cash flow volatility in low-concentration industries. This relation is generally insignificant outside these industries and most differences in investment risk sensitivities across the subsamples are not statistically significant.

Based on Model B in Table 2, we find that investment is about three (two) times more negatively related to diversification in mid-concentration than in low- (high-) concentration industries. This result is interesting in that the mean firm in mid-concentration industries is substantially less diversified (0.245) than the mean firm in either low- or high-concentration industries (0.286 and 0.305), suggesting that equilibrium forces might lead to less diversification in oligopolistic industries. Maksimovic and Phillips (2002) show how such an equilibrium might operate. They find that when managerial talent is limited or industry-specific, single segment firms are more productive than conglomerates of the same size. Thus, although higher investment in mid-concentration industries might be strategically motivated, to be sustainable, higher investment must also reflect higher productivity. As Maksimovic and Phillips argue, one way to raise productivity is by specializing. These factors could therefore translate into the observed lower diversification and greater inverse relation between investment and diversification in mid-concentration industries.

Finally, Table 2 shows that industry concentration affects investment, even within industry concentration subsamples. This relation is sensitive to the concentration cutoff scheme (Models A, B, or C) but supports our argument that industry structure matters to investment patterns.

Although our main results on investment-q sensitivity are robust, some of the covariates such as cash holdings and cash flow volatility are quite sensitive to the sample cutoffs (Models A, B, or C) and to the degree of industry concentration (low, mid, or high). Moreover, the coefficient signs for these covariates are in some cases counterintuitive or different from those reported in prior studies. The literature is typically more parsimonious than we are when it comes to including control variables (e.g., Fazzari et al. (1988), Alti (2003)), which raises the possibility that our results are plagued by multicollinearity.

To explore this question, we repeat our base analysis (Model B in Table 2) by staggering the regressors. These results are reported in Table 3 where we first

[22] Fazzari and Petersen (1993) offer a clue to this counter-intuitive result. They find an inverse relation between fixed capital investment and working capital investment, suggesting that working capital competes with fixed capital for a limited pool of internal finance. Given that the imperative for investment appears stronger in mid-concentration industries, it seems possible that, if anywhere, a substitution effect between real side investment and cash holdings would surface in these industries.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

only include Tobin's q and cash flow, then add cash holdings and leverage, and so on. We base our decision on what variables to drop on unreported diagnostics of multicollinearity, namely, correlations between regressors and variance inflation factors (VIF). Only the standard errors for total assets and industry concentration are inflated more than five times (the usual norm); excluding the latter brings the VIF of the remaining variables back below five. Table 3 therefore presents a few variants on our specification and corroborates the results of Table 2.

Table 3 first confirms that the way investment relates to Tobin's q is not affected by our choice of covariates: the relation is a statistically and economically significant inverse U-shape. Second, Table 3 shows the same sign and significance patterns for cash holdings and cash flow volatility as in Table 2. Studies on a firm's internal cash reserves focus more on the link between firm characteristics and cash holdings and less on the relation between cash holdings and investment. Almeida et al. (2004) find that firms facing greater financial constraints build up higher cash balances to fund future investments. Opler, Pinkowitz, Stulz, and Williamson (1999) argue that firms with volatile cash flows and high growth opportunities hold higher cash balances. They find a positive relation between cash holdings and investment in general, but point out that this relation does not hold up in various regressions and is not very reliable.

To the extent that these firm characteristics cluster within certain industry structures, this can also provide a theory for the level of firms' cash holdings within different industry groups, but not necessarily for the relation between cash holdings and investment. In addition, we control for the firm characteristics that prove significant in explaining firms' cash holdings such as cash flow volatility, firm size, and Tobin's q as the proxy for the growth opportunities. That said, the interpretation suggested by Fazzari and Petersen (1993) in footnote 22 remains as a likely explanation as to why the relation switches with industry concentration.

The relation between investment and uncertainty is debated both in theory and empirically. For instance, Leahy and Whited (1996) find that risk becomes insignificant once Tobin's q is included as a covariate. Minton and Schrand (1999) report that the relation between investment and cash flow volatility is positive for low cash flow firms but negative for high cash flow firms. Finally, Andrade and Stafford (2004) find that investment is either insignificantly or marginally positively related to industry shocks.

It is therefore not surprising to find that the corresponding results in our study are also mixed. Indeed, Table 2 shows a statistically significant and positive relation between investment and cash flow volatility for low-concentration industries. This relation becomes negative (positive) but insignificant for mid- (high-) concentration industries. The same pattern obtains in Table 3. However, these industries show a statistically significant and positive relation in unreported regressions whenever we drop industry concentration from the set of covariates. Therefore, the differences we find across subsamples are in this case attributable to multicollinearity, not because the investment risk relation is somehow tied to industry structure.[23]

[23] A previous version of the paper examined if changes in industry structure led to changes in investment-q sensitivity in line with the patterns we find across industry concentration subsamples. That industry evolution analysis generally corroborates our findings but working in terms of changes

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

TABLE 3

GMM Regressions by Level of Industry Concentration with Staggered Regressors

GMM regression results for low-, mid-, and high-concentration manufacturing industries. Industry concentration is measured using the Herfindahl-Hirschman Index (HHI) compiled by the Census of Manufacturers. Model B uses DOJ-FTC HHI cutoffs of 0–999, 1,000–1,799, and 1,800+ to classify industries as low-, mid-, or high-concentration. Model A uses cutoffs of 0–799, 800–1,999, and 2,000+, and Model C uses cutoffs of 0–1,199, 1,200–1,599, and 1,600+. The dependent variable is investment (capital expenditures divided by assets). Our proxy for investment opportunities is Tobin's *q* (market value of equity plus book value of debt and preferred stock minus deferred taxes, divided by the book value of assets). Our proxies for financial status are: cash flow (earnings before extraordinary item and depreciation minus dividends), cash holdings (cash and marketable securities), financial leverage (total debt divided by total assets), and firm size (log of total assets). Our proxies for risk are: cash flow volatility (standard deviation of cash flow divided by assets), diversification (one minus the Herfindahl of sales across the firm's four-digit SIC industries), and the capital-labor ratio (net property, plant, and equipment per employee). All regressions control for two-digit industry and year fixed effects. Heteroskedasticity and autocorrelation-robust Newey-West asymptotic standard errors are reported in parentheses. The Δ columns show the statistical significance levels of difference tests across subsamples: low versus mid (first superscript), mid versus high (second superscript), and low versus high (third superscript). ***, **, * and ^{a}, ^{b}, ^{c} denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Low-Concentration Industries			Mid-Concentration Industries			High-Concentration Industries					
Model:	A	B	C	A	B	C	A	B	C	ΔA	ΔB	ΔC
Tobin's *q*	0.026 (0.002)***	0.016 (0.001)***	0.005 (0.001)***	0.038 (0.001)***	0.025 (0.001)***	0.013 (0.001)***	0.008 (0.000)***	0.004 (0.000)***	0.002 (0.000)***	a,a,a	a,a,a	a,a,a
Cash Flow/Assets	0.577 (0.016)***	0.415 (0.018)***	0.346 (0.018)***	0.538 (0.028)***	0.385 (0.031)***	0.331 (0.036)***	0.369 (0.014)***	0.247 (0.013)***	0.220 (0.019)***	−,a,a	−,a,a	−,a,a
Cash Holdings/Assets		0.022 (0.013)*	0.011 (0.018)		−0.268 (0.035)***	−0.249 (0.039)***		−0.080 (0.032)**	−0.072 (0.036)**		a,a,a	a,a,b
Total Debt/Assets		−0.029 (0.003)***	−0.013 (0.003)***		−0.065 (0.008)***	−0.036 (0.006)***		−0.045 (0.002)***	−0.022 (0.003)***		a,a,a	a,b,b
Log of Total Assets			0.002 (0.001)**			−0.004 (0.003)			0.002 (0.002)			c,c,−
Cash Flow Volatility			0.054 (0.013)***			−0.015 (0.014)			0.018 (0.013)			a,c,b
Degrees of Freedom	23,887	23,885	23,883	5,073	5,071	5,069	4,685	4,683	4,681			
Wald Test (all $\beta_i = 0$)	936***	1,273***	1,549***	213***	292***	377***	106***	163***	224***			
Hansen *J*-Stat	1,913***	1,826***	1,793***	385***	351***	337***	418***	386***	301***			

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

V. Alternative Explanations

Although the results of Section IV link our work to the extensive investment-q literature, investment-q sensitivity might well reflect factors besides real options and strategic interaction. This section discusses alternative economic and econometric explanations for the results reported so far and motivates the duration analysis approach presented in Section VI.

Hayashi (1982) shows that average and marginal q coincide under perfect competition, constant returns to scale, and quadratic adjustment costs. Hayashi demonstrates that marginal q is always less than average q when the profit function is concave, such as when firms have market power. The fact that the gap between marginal and average q increases in industry concentration suggests two alternative explanations for our results, one economic and one econometric.

First, Cooper and Ejarque (2001) and Abel and Eberly (2003) show an economic linkage between industry structure and investment-q sensitivity by demonstrating that market power (or non-constant returns to scale) leads to strict concavity of the profit function which in turn lowers investment-q sensitivity. Thus, the difference in investment-q sensitivity we find across low- and high-concentration industries could reflect this market power argument rather than the wait-lose trade-off. Even so, this alternative explanation still assigns an important role to industry structure in explaining investment. However, like the wait-lose trade-off, this alternative explanation fails to explain why investment-q sensitivity is highest in mid-concentration industries.

Second, Erickson and Whited (2000), (2002) and Gomes (2001) show that measurement error in Tobin's q can bias estimated investment-q sensitivity. Thus, another explanation for our findings is that measurement error in Tobin's q increases as industry concentration rises and marginal q dips ever further below average q. Because this measurement error is non-classical in that it correlates with industry concentration, the resulting bias in estimation is non-signable.

Given this ambiguity in how to interpret the results, we consider two alternative estimation methods. One possibility is to run measurement error robust regressions as outlined in Erickson and Whited (2000), (2002). There are two drawbacks to that approach. First, the Erickson-Whited technique is designed to handle classical measurement error, where the unobserved variable (marginal q) and measurement error are independently and identically distributed. This condition clearly fails if, as discussed, measurement error is correlated with industry concentration.[24] Second, and more fundamentally, even if the Erickson-Whited technique were applicable, ruling out measurement error would still leave open the possibility that the market power argument rather that the real options wait-lose trade-off is the driving force behind our results.

rather than changes in levels is too demanding of the data to draw firm conclusions. The analysis in question is available from the authors.

[24]The i.i.d. requirement might hold within industry concentration subsamples even though it fails across them. However, the fact that the HHI is significant within two subsamples suggests that this is not the case and the Erickson-Whited technique would still be inappropriate in the context of each industry concentration subsample.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

The other method we consider is duration analysis. As we show in the next section, this method bypasses q entirely and thus avoids the related measurement and interpretation problems.

VI. Duration Analysis

To allay concerns with measuring Tobin's q and how to interpret investment-q sensitivity, this section presents a multivariate duration analysis as an alternative method to address the main questions of the paper by modeling investment timing directly without relying on Tobin's q. Because the real option studies on which we base our wait-or-loss trade-off hypothesis model optimal investment waiting time, duration analysis also tightens the link to theory by allowing us to relate industry structure to the timing of investment rather than the rate of investment.

Conceptually, duration analysis models how much time passes until an event happens. In this case, we are interested in how long a firm goes without investing above a certain level. Thus, by analyzing investment speeds (hazard rates) rather than investment levels, duration analysis allows us to circumvent the economic and econometric issues surrounding Tobin's q. This is because, in its most basic form, duration analysis does not require regressors. The approach is all the more appropriate because investment is sporadic and firms can go for long spells without investing, precisely the type of data patterns that duration analysis is suited to handle.

The simplest way to analyze investment speeds is to compute mean times until investment reaches a given level and to compare these statistics across subsamples. Despite its appeal, that simple approach ignores cross-sectional heterogeneity that might bias the hazard rate estimates. Part of the heterogeneity relates to censoring in the data because we do not know the firm's investment time path before or after the observation period, in our case a four-year window, or before or after the sample period, in this case before 1981 or after 2000. Duration analysis handles this problem by specifying a likelihood function that accounts for this left and right data censoring (unobserved investment behavior outside the observation and sample periods).

A second layer of heterogeneity relates to observable determinants of investment such as the covariates used in the regressions of Table 2. Including covariates in a duration analysis further reduces estimation bias by allowing the hazard rates to shift upward or downward, depending on the effect and importance of each covariate. This multivariate duration analysis is known as a proportional hazards model.[25] A final layer of heterogeneity relates to unobserved factors such as firm random effects. This, too, can be accommodated through the likelihood function. Following Whited (2006), we represent our proportional hazards model notationally as:

$$\lambda_i(t) \quad = \quad \omega_i \lambda_0(t) \exp(x_i(t)' \beta),$$

[25]This is the approach used by Leary and Roberts (2005) to analyze financial rebalancing and Whited (2006) to analyze how financial status affects investment. These papers contain detailed descriptions and technical appendices on duration analysis and proportional hazards modeling. To conserve space, we refer the interested reader to those papers, or the text by Kalbfleisch and Prentice (2002), for further insight on these methods.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

where t is the number of years the firm has not reached a preset investment threshold and $\lambda_i(t)$ is the hazard function we seek to approximate by estimating of the right-hand side of the equation. $\lambda_0(t)$ is the so-called baseline hazard function, which may be shifted by $x_i(t)$, the column vector of time-varying covariates and β, the associated vector of unknown coefficients. Unobserved heterogeneity is captured by ω_i, which we assume is independent of $x_i(t)$ and follows a zero mean gamma distribution. The model is partly parametric (through β and the distributional assumption on ω_i) and partly nonparametric (the discrete step function $\lambda_0(t)$): it is therefore semi-parametric.

Table 4 shows proportional hazards model estimates for three fixed investment thresholds (5%, 10%, and 15%) within the low-, mid-, and high-concentration industry subsamples. We use multiple thresholds both as a robustness check and to allow for the possibility that the wait-lose trade-off depends on the size of investment considered. We use a four-year investment horizon to ensure comparability with the regression results presented earlier.[26]

The proportional hazards model contains two types of estimates. The first type, shown at the bottom of Table 4, are baseline hazard rates. The nth-year hazard rate is the probability that a firm will exceed the investment threshold in the current year conditional on it *not* having met the threshold in the previous $n - 1$ years. The set of hazard rates defines the hazard function.

The second type of estimates are shift parameters. These show whether a given variable moves the baseline hazard rates up or down, and by how much. Consistent with our regressions, our covariates include industry and year dummy variables. Our covariates are time varying but lagged to alleviate endogeneity (lagging twice yields similar results). A χ^2 test on the related standard error indicates whether the shift parameter is statistically different from zero.

A. Investment Timing and Industry Structure

Turning first to the baseline hazard rates, Table 4 shows statistically and economically significant differences between low- and high-concentration industries where, except for the 5% investment threshold, all three hazard rates are statistically higher for low-concentration industries. For instance, the probability that a firm will invest at a rate of at least 10% (15%) of lagged total assets if it has not done so in the previous year is 0.117 (0.038) for low-concentration industries and 0.070 (0.011) for high-concentration industries. Thus, in addition to our earlier finding that firms in competitive industries exhibit greater investment-q sensitivity, we find that when it comes to large investment projects, these firms also tend to invest sooner than firms in high-concentration industries. These findings provide some assurance that our regression results are not simply an artifact of measurement error in Tobin's q.

To assess the economic importance of these differences, we average the three hazard rates for each investment threshold and compare these averages across

[26]Unlike Whited (2006), who uses a 10-year horizon, our objective is not to fully characterize a long-run hazard function but rather to examine, within a given broad sample, whether industry structure affects investment hazard rates in a manner consistent with our regression results. Also, as Whited (2006) points out, because the number of firms that go for long spells without investing is low, long-dated hazard rate estimates tend to be imprecise.

TABLE 4

Proportional Hazards Models—Fixed Investment Thresholds

Proportional hazards shift parameter estimates and baseline hazard rates for three investment thresholds (5%, 10%, and 15%) for low-, mid-, and high-concentration manufacturing industries, 1981–2000. The dependent variable is the number of years a firm has not exceeded the investment threshold. All variable definitions as in Table 2, including two-digit industry and year effects. Standard errors are in parentheses. $\Delta 5$, $\Delta 10$, and $\Delta 15$ superscripts show, for each investment threshold, significant differences across subsamples: low versus mid (first superscript), mid versus high (second superscript), and low versus high (third superscript). ***, **, * and [a], [b], [c] denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Low-Concentration Industries			Mid-Concentration Industries			High-Concentration Industries					
	5%	10%	15%	5%	10%	15%	5%	10%	15%	$\Delta 5$	$\Delta 10$	$\Delta 15$
Cash Flow/Assets	0.318 (0.007)***	0.550 (0.035)***	0.642 (0.039)***	0.242 (0.046)***	0.593 (0.119)***	0.372 (0.101)***	0.177 (0.051)***	0.214 (0.052)***	0.293 (0.147)	−,−,a	−,a,a	b,−,b
Cash Holdings/Assets	0.694 (0.050)***	0.302 (0.373)	0.727 (0.149)***	−1.279 (0.372)***	−0.178 (0.460)	−0.003 (0.469)	0.228 (0.677)	−1.162 (1.217)	−1.064 (0.877)	−a,c,−	−,−,−	−,−,b
Total Debt/Assets	−0.195 (0.008)***	−0.013 (0.017)	0.098 (0.003)***	−0.082 (0.011)***	−0.004 (0.074)	0.047 (0.042)	−0.252 (0.055)***	0.048 (0.032)	0.092 (0.126)	a,a,−	−,−,c	−,−,−
Log of Total Assets	0.049 (0.007)***	0.008 (0.013)	−0.007 (0.021)	0.126 (0.025)***	0.014 (0.012)	−0.009 (0.002)***	0.017 (0.014)	−0.022 (0.020)	−0.003 (0.027)	−a,a,b	−,−,−	−,−,−
Cash Flow Volatility	0.043 (0.013)***	0.510 (0.086)***	1.585 (0.228)***	−0.012 (0.066)	0.048 (0.220)	0.318 (0.602)	−0.201 (0.019)***	0.075 (0.586)	0.056 (0.261)	−,a,a	c,−,−	b,−,a
Diversification	−0.027 (0.005)***	−0.094 (0.007)***	−0.022 (0.008)***	−0.034 (0.005)***	−0.063 (0.018)***	−0.117 (0.020)***	−0.007 (0.008)	−0.037 (0.030)	−0.048 (0.029)*	−,a,b	−,−,c	a,c,−
Capital-Labor Ratio	0.232 (0.065)***	0.185 (0.041)***	0.924 (0.012)***	0.713 (0.151)***	1.567 (0.062)***	0.968 (0.042)***	0.943 (0.088)***	0.246 (0.067)***	0.153 (0.136)	a,−,a	a,a,−	−,a,a
Concentration (HHI)	0.030 (0.004)[a]	−0.017 (0.025)	0.008 (0.040)	−0.041 (0.026)	−0.081 (0.004)***	0.150 (0.058)**	0.000 (0.008)	0.154 (0.094)	0.272 (0.013)***	a,−,a	b,b,c	b,b,a
One-Year Hazard, λ_1	0.245 (0.001)***	0.117 (0.005)***	0.038 (0.002)***	0.326 (0.010)***	0.135 (0.007)***	0.035 (0.004)***	0.250 (0.009)***	0.070 (0.006)***	0.011 (0.003)***	a,a,−	c,a,a	−,a,a
Two-Year Hazard, λ_2	0.258 (0.003)***	0.124 (0.000)***	0.053 (0.002)***	0.327 (0.024)***	0.135 (0.007)***	0.051 (0.002)***	0.235 (0.013)***	0.054 (0.008)***	0.020 (0.002)***	a,a,c	c,a,a	−,a,a
Three-Year Hazard, λ_3	0.307 (0.009)***	0.121 (0.002)***	0.057 (0.001)***	0.383 (0.010)***	0.114 (0.004)***	0.054 (0.001)***	0.283 (0.021)***	0.099 (0.002)***	0.021 (0.002)***	a,a,−	−,a,a	c,a,a
Noncensored Obs.	16,552	8,243	3,773	3,925	1,926	958	3,276	1,554	712			
Log Likelihood	−188,987	−79,235	−39,674	−38,505	−22,947	−9,049	−28,933	−13,749	−7,006			
LR Test (all $\beta_i = 0$)	1,349***	941***	773***	633***	737***	523***	662***	767***	467***			

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

industry concentration subsamples. We find that firms in low-concentration industries meet the 10% (15%) threshold about 50% (100%) sooner than firms in high-concentration industries. Although hazard rates are not directly comparable to investment-q sensitivities, we note that these hazard-rate differences are of the same order of magnitude as the differences in investment-q sensitivities across low- and high-concentration industries.

We also find that firms in mid-concentration industries invest much sooner than firms in low- or high-concentration industries. For instance, the probability that a firm will invest at a rate of at least 5% of lagged total assets if it has not done so in the last three years is 0.383 for mid-concentration industries but only 0.307 and 0.287 for low- and high-concentration industries. However, Table 4 shows that, although this pattern is statistically and economically significant for the 5% investment thresholds, mid-concentration industry hazard rates converge to those of low-concentration industries for the 10% and especially the 15% investment thresholds. This result suggests a strategic role for *incremental* investment in mid-concentration industries, where firms might be attempting to defend market share by making continuous small investments rather than occasional large investments.[27] The similarity in hazard rates at the 10% and 15% thresholds for low- and mid-concentration industries suggests that large investments are driven by common, non-strategic considerations.

Following Whited (2006), Table 5 repeats the duration analysis using firm-specific median investment multiples rather than the fixed thresholds used in Table 4. Although the proportional hazards models in both Tables 4 and 5 control for two-digit SIC industry and year, we report these results to account for the possibility that finer, unobservable differences in technology or industry maturity could cause the definition of "large" investment to vary substantially across industries.

Table 5 corroborates the results of Table 4. First, we confirm that hazard rates are higher in low-concentration industries than in high-concentration industries and that the differences are statistically significant for higher investment thresholds (two and three times firm median investment) but not for the lowest investment threshold (single median investment). Second, we confirm that hazard rates are highest in mid-concentration industries, although only for the single median investment threshold. In other words, we continue to find support for the wait-lose trade-off in that firms in monopolistic industries invest slower than firms in competitive industries and support for an overriding strategic role of investment in that firms in oligopolistic industries are quickest to invest overall.

As for the effect of the covariates themselves, we find that some of the shift parameters are sensitive to the type of investment threshold. For instance, based on fixed-investment thresholds (Table 4), we find that cash flow raises the hazard function at every threshold level and in every subsample. However, based on firm-specific investment thresholds (Table 5), we find that cash flow lowers the hazard function for the two highest thresholds (two and three times firm median investment). Thus, although the type of investment threshold (fixed or firm-specific) does not change our conclusions on the effect of industry structure on investment,

[27] This result is also econometrically reassuring as it suggests that the greater investment-q sensitivity we document for firms in mid-concentration industries is not driven by influential observations within that subsample.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

TABLE 5

Proportional Hazards Models—Firm-Specific Investment Thresholds

Proportional hazards shift parameter estimates and baseline hazard rates for three firm-specific investment thresholds (1, 2, and 3 times the firm median investment rate between 1981 and 2000). The dependent variable is the number of years a firm has not exceeded the investment threshold. All variable definitions as in Table 2, including two-digit industry and year effects. Standard errors are in parentheses. $\Delta 1$, $\Delta 2$, and $\Delta 3$, superscripts show, for each investment threshold, significant differences across subsamples: low versus mid (first superscript), mid versus high (second superscript), and low versus high (third superscript). ***, **, * and [a], [b], [c] denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Low-Concentration Industries			Mid-Concentration Industries			High-Concentration Industries					
	1 × Med	2 × Med	3 × Med	1 × Med	2 × Med	3 × Med	1 × Med	2 × Med	3 × Med	$\Delta 1$	$\Delta 2$	$\Delta 3$
Cash Flow/Assets	0.309	−0.135	−0.349	0.887	−0.398	−0.683	0.158	−0.457	−0.523	a,a,−	−,−,a	a,−,−
	(0.071)***	(0.016)***	(0.078)***	(0.098)***	(0.219)*	(0.109)***	(0.135)	(0.106)***	(0.212)**			
Cash Holdings/Assets	0.675	0.520	0.182	0.166	−0.017	0.040	0.577	0.077	−0.062	a,−,−	b,−,−	−,−,−
	(0.046)***	(0.113)***	(0.297)	(0.190)	(0.177)	(0.081)	(0.374)	(0.283)	(0.385)			
Total Debt/Assets	−0.179	0.180	0.030	−0.181	0.362	0.766	−0.018	0.370	0.195	−,c,b	a,−,−	a,a,c
	(0.055)***	(0.036)***	(0.090)	(0.062)***	(0.040)***	(0.022)***	(0.061)	(0.171)***	(0.027)***			
Log of Total Assets	0.004	−0.203	−0.178	0.007	−0.003	−0.284	−0.035	−0.286	−0.023	−,c,b	a,a,a	b,a,a
	(0.008)	(0.008)***	(0.032)***	(0.019)	(0.034)	(0.034)***	(0.014)***	(0.011)***	(0.040)			
Cash Flow Volatility	−0.126	0.530	1.330	0.015	−0.084	−0.377	−0.170	0.006	0.397	−,−,−	b,−,−	a,−,b
	(0.085)	(0.185)***	(0.129)***	(0.066)	(0.249)	(0.050)***	(0.111)	(0.580)	(0.454)			
Diversification	−0.062	−0.109	−0.117	−0.119	−0.328	−0.110	−0.384	−0.364	−0.325	−,−,b	−,−,−	−,−,−
	(0.029)**	(0.084)	(0.030)***	(0.240)	(0.251)	(0.293)	(0.122)***	(0.139)***	(0.240)			
Capital-Labor Ratio	0.238	1.817	4.088	3.393	11.827	17.378	-2.046	13.661	12.083	a,a,−	a,−,a	a,−,a
	(0.164)	(0.109)***	(0.122)***	(0.409)***	(1.621)***	(3.740)***	(1.954)	(0.532)***	(0.157)***			
Concentration (HHI)	0.003	−0.005	0.100	0.000	0.036	−0.022	0.033	0.124	0.096	−,−,−	−,−,−	−,−,−
	(0.022)	(0.035)	(0.050)**	(0.009)	(0.076)	(0.087)	(0.032)	(0.171)	(0.009)***			
One-Year Hazard, λ_1	0.537	0.085	0.022	0.590	0.091	0.016	0.543	0.071	0.014	b,b,−	−,c,b	a,−,b
	(0.010)***	(0.002)***	(0.001)***	(0.019)***	(0.010)***	(0.002)***	(0.012)***	(0.005)***	(0.003)***			
Two-Year Hazard, λ_2	0.523	0.099	0.041	0.582	0.091	0.028	0.514	0.089	0.029	b,a,−	−,−,c	b,−,a
	(0.015)***	(0.002)***	(0.003)***	(0.020)***	(0.008)***	(0.005)***	(0.013)***	(0.005)***	(0.000)***			
Three-Year Hazard, λ_3	0.558	0.116	0.049	0.622	0.096	0.040	0.523	0.082	0.035	b,a,−	b,−,a	b,−,a
	(0.011)***	(0.001)***	(0.002)***	(0.024)***	(0.010)***	(0.004)***	(0.019)***	(0.004)***	(0.000)***			
Noncensored Obs.	19,935	8,355	4,636	4,477	1,814	932	3,918	1,562	860			
Log Likelihood	−182,144	−86,357	−17,042	−58,997	−15,475	−1,865	−28,082	−2,946	−7,547			
LR Test (all $\beta_i = 0$)	694***	1,258***	1,826***	369***	518***	436***	196***	693***	412***			

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

the same cannot be said for the sensitivity of investment to financial status and uncertainty. Additionally, some shift parameters are sensitive to the *level* of investment threshold, suggesting that financial status and uncertainty affect investment differently depending on the magnitude of investment considered.

B. Robustness Checks

Whited (2006) shows that asynchronous decision making across business units within firms can lower estimated hazard rates by smoothing firm-level investment. This aggregation bias would naturally rise with the number of business units within a firm. Thus, given the difference in diversification levels across firms in low-, mid-, and high-concentration industries, the differences we document between the hazard rates of the industry subsamples might simply reflect varying levels of aggregation bias. To investigate this possibility, we repeat the duration analysis on a sample consisting of single segment firms only. Consistent with an asynchronous aggregation bias, our (unreported) results show that excluding multi-segment firms raises *all* hazard rates considerably: by 11% on average for low-concentration industries, 22% for mid-concentration industries, and 16% for high-concentration industries. However, the pattern of results across industry subsamples is essentially unchanged and our conclusions still stand.

We purposely exclude Tobin's q from Tables 4 and 5 because the main reason we turn to duration analysis is to avoid problems in measuring Tobin's q and interpreting investment-q sensitivity. Unreported results show that adding Tobin's q has little bearing on the analysis. Whited (2006) uses sales growth an alternative proxy for the investment opportunity set. Just as for Tobin's q, we find that adding this variable to the model does not change our conclusions.

VII. Industry Structure and the Strategic Role of Investment

Although the differences in investment-q sensitivity and hazard rates between low- and high-concentration industries conform to the predictions of the real options literature, investment behavior in mid-concentration industries is strikingly distinct. We have argued that strategic factors might drive firms in mid-concentration industries to invest more and sooner than firms in low- or high-concentration industries. This section examines whether the data support this claim.[28]

As discussed earlier, theory shows a strategic role for investment in deterring entry, preempting rivals, or inducing exit. If such investment achieves the purported strategic effect, then we might observe differences in entry and exit rates across low-, mid-, and high-concentration industries beyond those explained by natural barriers to entry and exit. To the extent that natural barriers cause industry concentration, we expect monopolistic industries to exhibit lower entry and exit rates than competitive industries. However, if strategic interaction truly dom-

[28]Gilbert and Lieberman (1987), Lieberman (1987a), (1987b), (1990), Christensen and Caves (1997), Hay and Liu (1998), and Ghosal (2004) all report evidence of strategic investment behavior in manufacturing industries.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

inates in oligopolistic industries, we could observe significant departures from such a monotonic relation.

Table 6 examines this question directly by reporting the percentage of entrants, incumbents, and exiters in each subsample. Entrants are firms that appear in the sample between 1991 and 2000 but not between 1981 and 1990.[29] We distinguish these firms from those that enter an industry simply by changing the nature of their operations (switchers). Exiters are firms that appear in the sample between 1981 and 1990 period but not between 1991 and 2000. We distinguish these firms from those that leave an industry through asset sales (sellers). Incumbents are firms that appear at least once in both the 1981 to 1990 and 1991 to 2000 subperiods.

The results support a strategic role for investment in mid-concentration industries. Incumbency rates do not differ significantly across the subsamples. However, entry (exit) rates are statistically and economically lower (higher) in mid-concentration industries than in low- and high-concentration industries. We find entry rates of 4.46% in mid-concentration and 7.97% (8.53%) in low- (high-) concentration industries. Switching rates are less dispersed, but the corresponding total entry rates (entrant plus switcher rates) are 13.28% and 16.63% (18.94%).

Exit rates are equally informative and also support a strategic role for investment in mid-concentration industries. Exiters form 1.70% of the mid-concentration industry subsample but only 1.13% and 0.61% of the low- and high-concentration industries. More telling are the differences in seller rates, which are 14.12% in mid-concentration but 10.64% (9.42%) in low- (high-) concentration industries. The corresponding total exit rates (exiter plus seller rates) are 15.82% and 11.77% (10.03%). Although these entry and exit rates do not prove strategic intent, they are consistent with a greater role for entry deterrence and induced exit in oligopolistic industries.

Table 6 also shows that incumbents in mid-concentration industries invest more (0.062) than incumbents in either low- or high-concentration industries (0.054 and 0.055). Considering the lower entry and higher exit rates noted above, this finding is consistent with an enhanced role for strategic investment by incumbents in mid-concentration industries.

Entrants in low-concentration industries invest more (0.057) than incumbents (0.054), but entrants in mid-concentration industries invest less (0.053) than incumbents (0.062). This finding supports a preemptive role for investment where, through their own investment, incumbents in mid-concentration industries are able to discourage rivals' investment. Also consistent with this finding, mean Tobin's q for entrants in mid-concentration industries (1.788) is substantially lower than for comparable firms in low- or high-concentration industries

[29] Data limitations prevent us from precisely determining the type of firm entry. For instance, we cannot distinguish between privately held incumbents that go public and new firms that actually add productive capacity to their industry. By tracking firms by their CRSP permanent number (permno) rather than by their Compustat CUSIP, we avoid misclassifying firms that undergo mergers and acquisitions or name changes as entrants. By using the historical SIC from CRSP rather than the current SIC from Compustat, we can identify incumbent firms that change industry. Thus, we refer to firms that change two-digit SIC industry between the 1981–1990 and 1991–2000 subperiods as "switchers." Finally, thanks to Compustat's "reason for deletion" variable (footnote 35), we are able to distinguish between firms that exit through Chapter 11 bankruptcy or Chapter 7 liquidation (exiters) and those whose assets are simply redeployed through corporate restructuring (sellers).

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

TABLE 6

Industry Analysis and the Strategic Role of Investment

Sample means by firm type for low-, mid-, and high-concentration manufacturing industries, 1981–2000. Entrants are firms that appear in the sample in 1991–2000 but not in 1981–1990. Switchers are firms that enter by changing two-digit SIC. Exiters are firms that appear in the sample in 1981–1990 but not in 1991–2000. Sellers are firms that exit through asset sales. Incumbents remain in their two-digit SIC and appear at least once in 1981–1990 and 1991–2000. Tobin's *q* is the market value of equity plus book value of debt and preferred stock minus deferred taxes, divided by the book value of assets. Investment lumpiness is the standard deviation of the investment rate (capital expenditures divided by assets) in the four most recent years. Investment staging is the autocorrelation of the investment rate in the four most recent years. Years to invest is the mean time until investment exceeds a given threshold (5%, 10%, 15%). Leading superscripts show significant differences across subsamples: low versus mid (Panel A), mid versus high (Panel B), and low versus high (Panel C). Lagging superscripts show tests of differences between entrants and switchers (column 2), incumbents and all other groups (column 3), sellers and exiters (column 4), and entrants and exiters (column 5). [a], [b], [c] denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Entrants	Switchers	Incumbents	Sellers	Exiters
Panel A. Low-Concentration Industries					
Capital Expenditures/Assets	-0.057	c0.052a	a0.054a,b,-,a	a0.054b	-0.046a
Tobin's *q*	a1.992	-1.592a	-1.567a,-,a,a	a1.281-	-1.252a
Investment Lumpiness	c0.035	-0.030a	-0.026a,a,a,a	a0.030b	-0.035-
Investment Staging	-0.549	-0.583a	a0.591a,-,b,b	-0.574-	-0.552-
Years to Invest (5% threshold)	b1.622	a1.871a	a1.701c,a,b,a	a1.611a	a2.043a
Years to Invest (10% threshold)	-2.982	-3.024-	a2.985-,-,-,-	c2.932-	-3.016-
Years to Invest (15% threshold)	-3.540	-3.523-	a3.572-,c,b,-	a3.516-	-3.538-
Observations (firm-years)	1,908	2,071	17,131	2,547	270
Percent of Subsample Firm-Years	7.97%	8.66%	71.60%	10.64%	1.13%
Panel B. Mid-Concentration Industries					
Capital Expenditures/Assets	-0.053	b0.057-	a0.062b,c,-,b	-0.061c	c0.052-
Tobin's *q*	b1.788	-1.649c	a1.554a,c,a,a	-1.410-	b1.292a
Investment Lumpiness	-0.031	-0.029-	-0.027c,b,a,b	-0.035-	-0.036-
Investment Staging	-0.548	-0.556-	c0.576-,-,-,-	-0.580-	b0.564-
Years to Invest (5% threshold)	-1.870	a1.477a	a1.392a,-,-,-	a1.365-	a1.436b
Years to Invest (10% threshold)	c3.028	-2.934-	a2.846c,-,-,-	-2.814-	-2.953-
Years to Invest (15% threshold)	c3.539	-3.524-	a3.498-,-,a,-	c3.313-	b3.447-
Observations (firm-years)	228	451	3,625	722	87
Percent of Subsample Firm-Years	4.46%	8.82%	70.90%	14.12%	1.70%
Panel C. High-Concentration Industries					
Capital Expenditures/Assets	b0.052	-0.050-	-0.055-,b,-,b	-0.057a	-0.038b
Tobin's *q*	-2.016	c1.686a	a1.642a,-,a,a	-1.353a	c1.121a
Investment Lumpiness	a0.029	-0.031-	-0.026a,a,a,a,-	-0.030-	-0.032-
Investment Staging	-0.557	-0.568-	-0.589c,-,-,b	-0.564b	a0.678a
Years to Invest (5% threshold)	b1.833	-1.790-	-1.672c,-,-,b	-1.638b	-2.432c
Years to Invest (10% threshold)	a3.258	-3.056b	-3.011a,-,b,-	-2.861-	-3.221-
Years to Invest (15% threshold)	a3.696	-3.532b	b3.616b,-,a,-	-3.448a	c3.792-
Observations (firm-years)	403	492	3,356	445	29
Percent of Subsample Firm-Years	8.53%	10.41%	71.03%	9.42%	0.61%

(1.992 and 2.016), suggesting that financial markets are skeptical of entrants' ability to thrive in industries where incumbents pursue aggressive investment programs.

Table 6 also examines investment time patterns. The first time pattern we consider is the lumpiness of investment. We measure investment lumpiness for each firm-year by computing the standard deviation of the investment rate for the four most recent years. We find that entrant and exiter investment is substantially lumpier than the investment of incumbents. However, this pattern obtains in all three industry concentration subsamples and therefore does not offer new insights on why these subsamples differ in other aspects of investment behavior.

Real options theory suggests staging as another way firms can manage investment frictions in the face of uncertainty. Greater risk or investment frictions

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

could lead to more staging, however, strategic pressures could accelerate investment and lead to less staging. We measure staging for each firm-year by computing the autocorrelation of the investment rate for the four most recent years.[30] We find that incumbents in mid-concentration industries stage statistically less than incumbents in low- or high-concentration industries. This again supports the notion that strategic factors might spur incumbents in mid-concentration industries to accelerate investment.

Finally, Table 6 reports mean times until investment reaches three thresholds (5%, 10%, and 15%).[31] Regardless of investment threshold, the quickest incumbents to invest are those in mid-concentration industries, followed by incumbents in high- and low-concentration industries.

The evidence in Table 6 is limited because the analysis is univariate. We therefore report a multivariate version of the analysis in Table 7, where all variables are adjusted for the covariates used in Table 2, namely, cash flow, cash holdings, total debt (all normalized by total assets), total assets, cash flow volatility, diversification, capital-labor ratio, and industry concentration. We make this adjustment for each industry concentration subsample by regressing each variable on these covariates. Table 7 shows the resulting mean regression residuals and their difference tests.

We find that although many of the difference tests are affected, all the key relations discussed above continue to hold at conventional statistical confidence levels. Thus, while the analysis presented in this section remains somewhat exploratory, the differences in investment timing patterns we document across firm types and industry concentration subsamples suggest that strategic factors do indeed condition the relation between investment and industry structure.

VIII. Conclusion

This paper examines whether industry structure affects corporate investment patterns. Real options theory shows that the value of deferring irreversible investment in the face of uncertainty must be weighed against the threat of losing investment opportunities to competitors. Overlaying this basic wait-lose trade-off, industrial organization theory shows a strategic role for investment.

Consistent with these theories, we find that firms in monopolistic industries exhibit lower investment-q sensitivity and are slower to invest than firms in competitive industries. We also find that investment-q sensitivity and investment speed are highest in oligopolistic industries, suggesting that the value of investing strategically can outweigh the value of waiting. Confirming the importance of strategic investment in oligopolistic industries, we find that these industries experience less entry and more exit than competitive or monopolistic industries.

Our regression results support alternative explanations, such as estimation bias caused by measurement error in Tobin's q or that market power generally lowers investment-q sensitivity. However, our duration analysis addresses these

[30] We compute this as the correlation between the first three years and the last three years of this four-year window.

[31] Note that unlike the duration analysis, these mean investment times do not correct for right or left censoring.

TABLE 7

Industry Analysis and the Strategic Role of Investment—Adjusted for Covariates

Sample means by firm type for low-, mid-, and high-concentration manufacturing industries, 1981–2000. Entrants are firms that appear in the sample in 1991–2000 but not in 1981–1990. Switchers are firms that enter by changing two-digit SIC. Exiters are firms that appear in the sample in 1981–1990 but not in 1991–2000. Sellers are firms that exit through asset sales. Incumbents remain in their two-digit SIC and appear at least once in 1981–1990 and 1991–2000. Tobin's *q* is the market value of equity plus book value of debt and preferred stock minus deferred taxes, divided by the book value of assets. Investment lumpiness is the standard deviation of the investment rate (capital expenditures divided by assets) in the four most recent years. Investment staging is the autocorrelation of the investment rate in the four most recent years. Years to invest is the mean time until investment exceeds a given threshold (5%, 10%, 15%). Leading superscripts show significant differences across subsamples: low versus mid (Panel A), mid versus high (Panel B), and low versus high (Panel C). Lagging superscripts show tests of differences between entrants and switchers (column 2), incumbents and all other groups (column 3), sellers and exiters (column 4), and entrants and exiters (column 5). [a], [b], [c] denote statistical significance at the 1%, 5%, and 10% confidence levels, respectively.

	Entrants	Switchers	Incumbents	Sellers	Exiters
Panel A. Low-Concentration Industries					
Capital Expenditures/Assets	-0.002	b−0.003a	a−0.001a,b,-,b	a−0.001b	-−0.009a
Tobin's *q*	b0.405	-0.016a	-−0.010a,-,a,a	a−0.290-	-−0.333a
Investment Lumpiness	c0.007	-0.002a	-−0.002a,a,a,a	a0.002c	-0.008-
Investment Staging	-−0.032	-0.000a	a0.008a,-,b,c	-−0.008-	-−0.031-
Years to Invest (5% threshold)	b−0.040	a0.221a	a0.040c,a,c,a	a−0.047a	a0.384a
Years to Invest (10% threshold)	−0.012	-0.054-	a0.015-,-,-,-	c−0.038-	-0.045-
Years to Invest (15% threshold)	-−0.012	-−0.029-	a0.021-,-,b,-	a−0.037-	-−0.014-
Observations (firm-years)	1,908	2,071	17,131	2,547	270
Percent of Subsample Firm-Years	7.97%	8.66%	71.60%	10.64%	1.13%
Panel B. Mid-Concentration Industries					
Capital Expenditures/Assets	-−0.002	b0.002-	a0.007b,c,-,c	-0.006-	-−0.003-
Tobin's *q*	c0.207	-0.070-	a−0.022a,-,a,a	-−0.163b	b−0.276a
Investment Lumpiness	-0.003	-0.002-	-−0.001c,b,a,b	-0.006-	-0.009c
Investment Staging	-−0.036	-−0.026-	c−0.007-,-,-,-	-−0.003-	a−0.018-
Years to Invest (5% threshold)	-0.214	a−0.176a	a−0.270a,-,-,-	a−0.295-	a−0.229a
Years to Invest (10% threshold)	c0.061	-−0.035-	a−0.129c,-,-,b	-−0.161c	-−0.016-
Years to Invest (15% threshold)	c−0.012	-−0.028-	a−0.054-,-,a,-	c−0.238c	b−0.107-
Observations (firm-years)	228	451	3,625	722	87
Percent of Subsample Firm-Years	4.46%	8.82%	70.90%	14.12%	1.70%
Panel C. High-Concentration Industries					
Capital Expenditures/Assets	b−0.003	-−0.005-	c0.000-,b,-,b	-0.002b	-−0.016c
Tobin's *q*	-0.460	c0.105a	a0.062a,-,a,a	-−0.221a	b−0.478a
Investment Lumpiness	b0.002	-0.003-	-−0.002b,a,a,-	-0.003-	-0.004-
Investment Staging	-−0.027	-−0.014-	-0.007c,-,c,b	-−0.018b	a0.093a
Years to Invest (5% threshold)	b0.169	-0.126-	-0.013c,-,-,b	-−0.022b	-0.768c
Years to Invest (10% threshold)	a0.276	-0.087c	-0.042a,-,b,-	—0.113-	-0.263-
Years to Invest (15% threshold)	a0.141	-−0.019b	b0.062-,c,b,-	-−0.106b	c0.235-
Observations (firm-years)	403	492	3,356	445	29
Percent of Subsample Firm-Years	8.53%	10.41%	71.03%	9.42%	0.61%

concerns by bypassing Tobin's *q* and delivers a consistent set of results. From this we conclude that our findings are robust and cannot be solely attributed to measurement bias or a market power argument of lowered investment-*q* sensitivity.

This research confirms that industry structure is a key determinant of corporate investment. We show that accounting for industry concentration in investment regressions or duration models is important. Our results support many aspects of real options and industrial organization theory. At a broader level, our research identifies an important determinant of investment beyond the well-established roles of financial status and risk in shaping investment policy.

An extension to this research lies in the operation of internal capital markets. For instance, Maksimovic and Phillips (2002) and Whited (2006) show that productivity and financial constraints differentially affect the investment patterns

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

of stand-alone firms and segments within conglomerates. Given the importance of industry structure to investment documented in this study, it seems likely that industry structure would also affect investment of same-firm segments active in different industries. We leave this question as a promising avenue for future research.

Appendix

This appendix formalizes the link between industry structure and investment sensitivity. Let x denote the state variable and $f(x)$ define its probability density function. Let $I \equiv I(x)$ stand for investment and $\overline{x}(n)$ represent the investment trigger. Let $s(x,n)$ denote the sensitivity of investment to the state variable:

$$s(x,n) \quad = \quad \begin{cases} 0 & \text{if } x < \overline{x}(n) \\ \partial I/\partial x > 0 & \text{if } x \geq \overline{x}(n) \end{cases} .$$

We now show that the probability that a change in the state variable triggers investment depends on industry structure by establishing that the expected sensitivity of investment to the state variable increases with the number of firms in the industry, i.e., with competition:

$$\begin{aligned} E\left[s(x,n)\right] &\equiv \int_{-\infty}^{\infty} s(x,n) f(x) dx \\ &= \underbrace{\int_{-\infty}^{\overline{x}(n)} s(x,n) f(x) dx}_{0} + \int_{\overline{x}(n)}^{\infty} s(x,n) f(x) dx = \int_{\overline{x}(n)}^{\infty} s(x,n) f(x) dx. \end{aligned}$$

Grenadier (2002), equation 23 shows that $\partial \overline{x}(n)/\partial n < 0$. Thus, $n' < n'' \Rightarrow \overline{x}(n') > \overline{x}(n'')$ and

$$E\left[s(x,n'')\right] \equiv \int_{\overline{x}(n'')}^{\infty} \left(\frac{\partial I}{\partial x}\right) f(x) dx > \int_{\overline{x}(n')}^{\infty} \left(\frac{\partial I}{\partial x}\right) f(x) dx \equiv E\left[s(x,n')\right] . \square$$

References

Abel, A. B.; A. K. Dixit; J. C. Eberly; and R. S. Pindyck. "Options, the Value of Capital, and Investment." *Quarterly Journal of Economics*, 111 (1996), 753–777.

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

Abel, A. B., and J. C. Eberly. "Optimal Investment with Costly Reversibility." *Review of Economic Studies*, 63 (1996), 581–593.

Abel, A. B., and J. C. Eberly. "Q Theory without Adjustment Costs and Cash Flow Effects without Financing Constraints." Working Paper, University of Pennsylvania (2003).

Almeida, H.; M. Campello; and M. S. Weisbach. "The Cash Flow Sensitivity of Cash." *Journal of Finance*, 59 (2004), 1777–1804.

Alti, A. "How Sensitive is Investment to Cash Flow when Financing is Frictionless?" *Journal of Finance*, 58 (2003), 707–722.

Andrade, G., and E. Stafford. "Investigating the Economic Role of Mergers." *Journal of Corporate Finance*, 10 (2004), 1–36.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

Baldursson, F. "Irreversible Investment under Uncertainty in Oligopoly." *Journal of Economic Dynamics & Control*, 22 (1998), 627–644.
Baldwin, C. Y. "Optimal Sequential Investment when Capital is Not Readily Reversible." *Journal of Finance*, 37 (1982), 763–782.
Barnett, S. A., and P. Sakellaris. "Nonlinear Response of Firm Investment to Q: Testing a Model of Convex and Non-Convex Adjustment Costs." *Journal of Monetary Economics*, 42 (1998), 261–288.
Bond, S., and C. Meghir. "Dynamic Investment Models and the Firm's Financial Policy." *Review of Economic Studies,* 61, (1994), 197–222.
Brennan, M. J., and E. S. Schwartz. "Evaluating Natural Resource Investments." *Journal of Business,* 58, (1985), 135–157.
Bulan, L.; C. Mayer; and C. T. Somerville. "Irreversible Investment, Real Options, and Competition: Evidence from Real Estate Development." Working Paper, Brandeis University (2002).
Caballero, R. J. "On the Sign of the Investment-Uncertainty Relationship." *American Economic Review*, 81 (1991), 279–288.
Caballero, R. J. "Explaining Investment Dynamics in U.S. Manufacturing: A Generalized (S, s) Approach." *Econometrica,* 67 (1999), 783–826.
Caballero, R. J., and J. V. Leahy. "Fixed Costs: The Demise of Marginal q." NBER Working Paper Series w5508 (1999).
Caballero, R. J., and R. S. Pindyck. "Uncertainty, Investment, and Industry Evolution." *International Economic Review*, 37 (1996), 641–662.
Christensen, L. R., and R. E. Caves. "Cheap Talk and Investment Rivalry in the Pulp and Paper Industry." *Journal of Industrial Economics*, 45 (1997), 47–73.
Cleary, S. "The Relationship between Firm Investment and Financial Status." *Journal of Finance*, 54 (1999), 673–692.
Cooper, R., and J. Ejarque. "Exhuming Q: Market Power vs. Capital Market Imperfections." Working Paper 8182, NBER (2001).
Dixit, A. K. "The Role of Investment in Entry-Deterrence." *Economic Journal*, 90 (1980), 95–106.
Dixit, A. K. "Entry and Exit Decisions under Uncertainty." *Journal of Political Economy*, 97 (1989), 620–638.
Dixit, A. K., and R. S. Pindyck. *Investment under Uncertainty*. Princeton, NJ: Princeton University Press (1994).
Doyle, J. M., and T. M. Whited. "Fixed Costs of Adjustment, Coordination, and Industry Investment." *Review of Economics and Statistics*, 83 (2001), 628–637.
Eaton, B. C., and R. G. Lipsey. "The Theory of Market Pre-Emption: The Persistence of Excess Capacity and Monopoly in Growing Spatial Markets." *Economica*, 46 (1979), 149–158.
Eaton, B. C., and R. G. Lipsey. "Exit Barriers Are Entry Barriers: The Durability of Capital as a Barrier to Entry." *Bell Journal of Economics*, 11 (1980), 593–604.
Eaton, B. C., and R. G. Lipsey. "Capital, Commitment, and Entry Equilibrium." *Bell Journal of Economics*, 12 (1981), 593–604.
Erickson, T., and T. M. Whited. "Measurement Error and the Relationship between Investment and *q*." *Journal of Political Economy*, 108 (2000), 1027–1057.
Erickson, T., and T. M. Whited. "Two-Step GMM Estimation of the Errors-in-Variables Model Using High Order Moments." *Econometric Theory*, 18 (2002), 776–799.
Fazzari, S. M.; R. G. Hubbard; and B. C. Petersen. "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity*, 1 (1988), 141–195.
Fazzari, S. M., and B. C. Petersen. "Working Capital and Fixed Investment: New Evidence of Financing Constraints." *RAND Journal of Economics*, 24 (1993), 328–342.
Fudenberg, D., and J. Tirole. "Capital as a Commitment: Strategic Investment to Deter Mobility." *Journal of Economic Theory*, 31 (1983), 227–250.
Fudenberg, D., and J. Tirole. "The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look." *American Economic Review*, 74 (1984), 361–366.
Fudenberg, D., and J. Tirole. "A Theory of Exit in Duopoly." *Econometrica*, 54 (1986), 943–960.
Galeotti, M., and F. Schiantarelli. "Generalized Q Models for Investment." *Review of Economics and Statistics*, 73 (1991), 383–392.
Galeotti, M., and F. Schiantarelli. "Stock Market Volatility and Investment: Do Only Fundamentals Matter?" *Economica*, New Series, 61 (1994) 147–165.
Ghosal, V. "Pre-Emptive Investment Behaviour and Industry Structure." *Economic Issues*, 9 (2004), 47–68.
Ghosal, V., and P. Loungani. "Product Market Competition and the Impact of Price Uncertainty on Investment: Some Evidence from US Manufacturing Industries." *Journal of Industrial Economics*, 44 (1996), 217–228.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

Gilbert, R. J., and M. B. Lieberman. "Investment and Coordination in Oligopolistic Industries." *RAND Journal of Economics*, 18 (1987), 17–33.
Gilchrist, S., and C. P. Himmelberg. "Evidence on the Role of Cash Flow for Investment." *Journal of Monetary Economics*, 36 (1995), 541–572.
Gomes, J. F. "Financing Investment." *American Economic Review*, 91 (2001), 1263–1285.
Grenadier, S. R. "The Strategic Exercise of Options: Development Cascades and Overbuilding in Real Estate Markets." *Journal of Finance*, 51 (1996), 1653–1679.
Grenadier, S. R. "Option Exercise Games: An Application to the Equilibrium Investment Strategies of Firms." *Review of Financial Studies*, 15 (2002), 691–721.
Hamermesh, D. S., and G. A. Pfann. "Adjustment Costs in Factor Demand." *Journal of Economic Literature*, 36 (1996), 1264–1292.
Hay, D. A., and G. S. Liu. "The Investment Behaviour of Firms in an Oligopolistic Setting." *Journal of Industrial Organization*, 46 (1998), 79–99.
Hayashi, F. "Tobin's Marginal Q and Average Q: A Neoclassical Interpretation." *Econometrica*, 50 (1982), 213–224.
Kalbfleisch, J. D., and R. L. Prentice. *The Statistical Analysis of Failure Time Data*, 2nd ed. Hoboken, NJ: Wiley-Interscience (2002).
Kaplan, S. N., and L. Zingales. "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?" *Quarterly Journal of Economics,* 112 (1997), 169–215.
Kulatilaka, N., and E. C. Perotti. "Strategic Growth Options." *Management Science*, 44 (1998), 1021–1031.
Lambrecht, B., and W. Perraudin. "Real Options and Preemption under Incomplete Information." *Journal of Economic Dynamics & Control*, 27 (2003), 619–643.
Leahy, J. V. "Investment in Competitive Equilibrium: The Optimality of Myopic Behavior." *Quarterly Journal of Economics*, 108 (1993) 1105–1133.
Leahy, J. V., and T. M. Whited. "The Effect of Uncertainty on Investment: Some Stylized Facts." *Journal of Money, Credit, and Banking*, 28 (1996), 64–83.
Leary, M. T., and M. R. Roberts. "Do Firms Rebalance Their Capital Structures?" *Journal of Finance*, 60 (2005), 2575–2619.
Lieberman, M. B. "Excess Capacity as a Barrier to Entry: An Empirical Appraisal." *Journal of Industrial Economics*, 35 (1987a), 607–627.
Lieberman, M. B. "Postentry Investment and Market Structure in the Chemical Processing Industries." *RAND Journal of Economics*, 18 (1987b), 533–549.
Lieberman, M. B. "Exit from Declining Industries: 'Shakeout' or 'Stakeout'?" *RAND Journal of Economics*, 21 (1990), 538–554.
MacKay, P. "Real Flexibility and Financial Structure: An Empirical Analysis." *Review of Financial Studies*, 16 (2003), 1131–1165.
MacKay, P., and G. M. Phillips. "How Does Industry Affect Firm Financial Structure?" *Review of Financial Studies*, 18 (2005), 1433–1466.
Majd, S., and R. S. Pindyck. "Time to Build, Option Value, and Investment Decisions." *Journal of Financial Economics*, 18 (1987), 7–27.
Maksimovic, V., and G. M. Phillips. "Do Conglomerate Firms Allocate Resources Inefficiently?" *Journal of Finance*, 57 (2002), 721–768.
McDonald, R., and D. Siegel. "The Value of Waiting to Invest." *Quarterly Journal of Economics*, 101 (1986), 707–728.
Minton, B. A., and C. Schrand. "The Impact of Cash Flow Volatility on Discretionary Investment and the Costs of Debt and Equity Financing." *Journal of Financial Economics*, 54 (1999), 423–460.
Opler, T.; L. Pinkowitz; R. Stulz; and R. Williamson. "The Determinants and Implications of Corporate Cash Holdings." *Journal of Financial Economics*, 52 (1999), 3–46.
Pacheco-de-Almeida, G., and P. Zemsky. "The Effect of Time-to-Build on Strategic Investment under Uncertainty." *RAND Journal of Economics*, 34 (2003), 166–182.
Pindyck, R. S. "Irreversible Investment, Capacity Choice, and the Value of the Firm." *American Economic Review*, 78 (1988), 969–985.
Pindyck, R. S. "A Note on Competitive Investment under Uncertainty." *American Economic Review*, 83 (1993), 273–277.
Sakellaris, P. "A Note on Competitive Investment under Uncertainty: Comment." *American Economic Review*, 84 (1994), 1107–1112.
Sakellaris, P. "Investment under Uncertain Market Conditions." *Review of Economics and Statistics*, 77 (1995), 455–469.
Schwartz, E. S., and W. N. Torous. "Commercial Office Space: Tests of a Real Options Model with Competitive Interactions." Working Paper, University of California, Los Angeles (2003).

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press

Spence, M. A. "Entry, Capacity, Investment and Oligopolistic Pricing." *Bell Journal of Economics*, 8 (1977), 534–544.
Triantis, A. J., and J. E. Hodder. "Valuing Flexibility as a Complex Option." *Journal of Finance*, 45 (1990), 549–565.
Trigeorgis, L. *Real Options: Managerial Flexibility and Strategy in Resource Allocation*. Cambridge, MA: MIT Press (1996).
U.S. Department of Justice and Federal Trade Commission. *Horizontal Merger Guidelines* (1997).
White, H. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica*, 48 (1980), 817–838.
Whited, T. M. "Debt, Liquidity Constraints and Corporate Investment: Evidence from Panel Data." *Journal of Finance*, 47 (1992), 1425–1460.
Whited, T. M. "Problems with Identifying Adjustment Costs from Regressions of Investment on Q." *Economics Letters*, 46 (1994), 339–344.
Whited, T. M. "External Finance Constraints and the Intertemporal Pattern of Intermittent Investment." *Journal of Financial Economics*, 81 (2006), 467–502.
Williams, J. T. "Equilibrium and Options on Real Assets." *Review of Financial Studies*, 6 (1993), 825–850.

https://doi.org/10.1017/S0022109000003537 Published online by Cambridge University Press