INVESTMENT AND MARKET POWER

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Working Paper Series
Macro Economic Issues
Research Department
Federal Reserve Bank of Chicago
April, 1991 (WP-91-7)

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Abstract

This paper argues that the degree of market power within an industry is an important determinant of interindustry differences in investment behavior. A neoclassical investment model is analyzed to show that market power is positively associated with capital stock flexibility. The intuition for the result is that firms adjust their stocks and investment plans quickly in response to new conditions so as to capture the rents associated with their market power.

*I would like to thank Ellen Gaske, Bruce Meyer, Bruce Petersen, Robert Porter, Sherrill Shaffer, Steve Strongin, and seminar participants at several institutions for helpful comments. All errors are my own.

Abstract

This paper argues that the degree of market power within an industry is an important determinant of interindustry differences in investment behavior. A neoclassical investment model is analyzed to show that market power is positively associated with capital stock flexibility. The intuition for the result is that firms adjust their stocks and investment plans quickly in response to new conditions so as to capture the rents associated with their market power.

1. Introduction

Considerable empirical evidence suggests the existence of important differences in fixed investment patterns across industries in the U.S. manufacturing sector. Some industries display highly volatile investment series, while others display relatively stable investment paths; some industries appear to adjust capital stocks rapidly to new conditions, while others adjust stocks more slowly. Researchers have pointed to technological and financial factors as explanations, yet substantial differences between industries remain unexplained.

This paper argues that the degree of market power within an industry is an important determinant of these differences in investment behavior. I analyze a neoclassical investment model and relate investment to an index of market power at the industry level, and I show that market power is positively associated with capital stock flexibility. This general result is derived from the model in three distinct but related ways. First, I write the model as a partial stock adjustment model and show that the "stickiness" parameter declines as market power increases. I next show that the change in investment rates due to a change in factor prices or demand is larger the greater the degree of market power in an industry. Finally, I derive an expression for the variability of investment relative to output and show that it, too, is an increasing function of the degree of market power.

The model analyzed here is simple, but its predictions and inplications are powerful. Industries with market power will display more capital stock and investment flexibility, ceteris paribus, than industries without it. Market power creates economic rents, and firms in industries with rents respond faster to changes in their environment than those without the appeal of such rents.

The rest of the paper is organized as follows. The next section briefly reviews previous work related to the issues addressed here and places this paper in proper perspective. Section 3 contains the formal model, and Section 4 discusses the results and concludes the paper.

2. Related Work

Perhaps the two strongest characteristics of aggregate fixed investment spending in the United States are its cyclicality and its high volatility relative to that of output (see Shapiro [1986]). Studies using less aggregate data have confirmed these patterns and have also documented interindustry differences in investment patterns that remain unexplained after accounting for technological and financial differences between industries. For example, Abel and Blanchard [1988] present evidence that investment variability and capital stock adjustment speeds differ substantially across 2-digit Standard Industrial Classification (SIC) manufacturing industries, and von Furstenburg et al. [1980] find significant differences across industries in both the level and adjustment speed of a Tobin's q measure to a long run equilibrium value. Petersen and Strauss [1989, 1991] analyze manufacturing sector investment at both the 2- and 4-digit SIC levels over the 1962-1986 time period. They find that investment is especially volatile in durables goods industries and in industries with volatile cash flow patterns. The interindustry differences in investment patterns documented in these studies no doubt reflect many factors, including differences in financial market constraints, production technologies, and output demand characteristics. Little attention has been directed to the role that competitive factors may play in accounting for these differences.[1]

Many researchers have used the neoclassical investment model to analyze the roles of technology, output demand, and factor prices in determining investment behavior. In its simplest form, the model explains how these factors operate in an environment of perfectly competitive product markets and perfect capital markets. Recent theoretical work, however, emphasizes the role that information asymmetries in capital markets may play in investment and financing decisions.[2] Information problems may affect investment both indirectly, through their influence on factor prices (cost of capital), and directly, through some sort of credit-rationing. Indeed, recent empirical work suggests that financing constraints due to information asymmetries substantially affect the investment choices of several classes of firms.[3]

Another strand of the literature explores the relationships between product market competition, capital investment, and the financing of that investment. Numerous authors have studied how physical capital or financial capital structure may be used to precommit to certain types of product market competition.[4] Other researchers have examined the process from the other direction and have analyzed how market power, or product market competition, influences the cost of capital and, hence, via the neoclassical model, investment decisions.[5] This paper retains the neoclassical framework and argues that market power also affects investment through its influence on the perceived demand curve faced by the industry. Thus the model focuses exclusively on how market power determines investment in the presence of perfect capital markets.

3. A Linear-Quadratic Investment Model

This section of the paper uses a linear-quadratic model of investment with adjustment costs to derive a relationship between the degree of competition in an industry and the industry's investment behavior. Entry by new firms is not considered; only expansion by existing firms is treated.[6] Assuming that all n firms within the industry are behaviorally and technologically identical allows direct consideration of the industry's investment problem.[7] The industry's problem is to select a sequence of industry capital stocks $\{K_t\}$, t = 1,2,...., to maximize the expected present value of its profits:

$$E_0 \sum_{t=0}^{\infty} \beta^t [p_t q_t - p_t^k I_t - \frac{c}{2}(I_t)^2] , \tag{1}$$

subject to

$$I_t = K_{t+1} - (1-\delta)K_t , \tag{2}$$

$$p_t = a_t - bq_t , \tag{3}$$

and

$$q_t = \alpha K_t, \tag{4}$$

given initial stock K_0, where β is a discount factor satisfying $0 < \beta < 1$; p_t is output price; α is the industry's technological coefficient;[8] p_t^k is the price of capital goods; I_t is gross investment; K_t is capital stock; q_t is output; δ is the depreciation rate satisfying $0 < \delta < 1$; b and c are positive constants; $\{a_t\}$ is an unspecified stochastic process; and E_t denotes the expectations operator conditional on information available at time t. Following previous researchers, I assume that convex adjustment costs are incurred for gross investment expenditures; the third term in (1) reflects these costs. Equation (2) embodies the assumption that capital becomes productive one period after its acquisition costs have been incurred.

Following Bresnahan [1982], I use a simple index of market power, denoted λ, to measure the degree of competition in the industry. The index ranges from 0 to 1, and its extreme values can be interpreted as evidence of competitive and collusive behavior, respectively. λ effectively measures the perceived degree of market power in the industry;[9] it enters the first order conditions characterizing the industry's optimal capital stock path because it affects the industry's perceived marginal revenue product of capital.

Since the industry is assumed to choose a capital stock sequence to maximize (1) subject to (2), (3), and (4), its optimal capital stock sequence satisfies the following first order conditions:

$$E_{t-1}[-p^k_{t-1} - c(K_t - (1-\delta)K_{t-1}) + \beta(\alpha p_t - \lambda b\alpha^2 K_t + (1-\delta)p^k_t + c(1-\delta)(K_{t+1} - (1-\delta)K_t))] = 0 \quad t = 1,2\ldots \tag{5}$$

The industry equates expected current period marginal cost of capital with expected discounted next period marginal revenue product of capital plus marginal cost savings. Following Bresnahan [1982], I call the expression $[\alpha p_t - \lambda b\alpha^2 K_t]$ the industry's perceived marginal revenue product. This expression differs from the simple product of output price and capital's marginal product if λ differs from 0, i.e., if the industry is imperfectly competitive. Solving this second order difference equation yields the industry's equilibrium equation of motion for its capital stock:

$$K_{t+1} = \mu_1 K_t + \frac{\mu_1}{c(1-\delta)} \sum_{s=0}^{\infty} (\beta\mu_1)^s \, E_t[\beta\alpha a_{t+s+1} - p^k_{t+s} + \beta(1-\delta)p^k_{t+s+1}] \ , \tag{6}$$

where

$$\mu_1 + \mu_2 = \frac{c(1 + \beta(1-\delta)^2) + \beta b\alpha^2(1 + \lambda)}{\beta c(1-\delta)} \tag{7a}$$

and

$$\mu_1\mu_2 = \frac{1}{\beta} \ . \tag{7b}$$

Equation (6) says that current capital stock depends on its lagged value as well as the current and expected future values of the forcing variables, a_t and p^k_t. Equations (7a) and (7b) may be solved to obtain explicit expressions for μ_1 and μ_2, which depend on the model's structural parameters, c, β, b, δ, λ, and α. In particular, it is easy to show that

$$\frac{\partial \mu_1}{\partial \lambda} < 0 \qquad \text{and} \qquad \frac{\partial \mu_2}{\partial \lambda} > 0 \tag{8}$$

The remainder of this section develops three implications of the relationship between λ and the difference equation roots. Note that for these efforts to be meaningful, λ must be considered exogenous. That is, the degree of competition within the industry must be treated as fixed and determined by factors not considered in this paper.[10]

First, note that equation (6) may be rewritten as a partial adjustment model as follows:

$$K_{t+1} - K_t = (1-\mu_1)(K_t^* - K_t), \tag{9}$$

where K_t^* is desired or optimal capital stock at time t and is defined as the level of capital that would obtain in the industry after all stock adjustments had been made, given all current and lagged values of the forcing processes and knowledge of the forms of the forcing processes themselves. The value $1-\mu_1$ may be interpreted as the speed of adjustment, and it represents the fraction of the difference between actual and desired levels of capital that the industry actually invests (net) in any given period. Since μ_1, the stock "stickiness" coefficient, falls as λ rises, the model predicts faster capital stock adjustment speeds in imperfectly competitive industries than in perfectly competitive ones.[11]

A second implication of the model is that the size of capital stock (and gross and net investment) responses to exogenous demand or factor price shocks varies with the degree of competition. This result holds for permanent, persistent, or transitory price shocks, which affect the optimal capital stock sequence through their effects on the expected future sequence of demand and cost parameters. For example, consider an unanticipated permanent increase in the price of capital goods at time t. Equation (6) may be used to derive the effect on capital stock at time t+1 as follows:

$$\frac{dK_{t+1}}{dp_t^k} = \frac{-\mu_1(1-\beta(1-\delta))}{c(1-\delta)(1-\beta\mu_1)} < 0 \qquad (10)$$

An unexpected, permanent increase in the price of capital goods, caused by a tax rate or credit change, for example, decreases the capital stock. The magnitude of that decrease depends on λ through μ_1's dependence on λ. Differentiating the expression in (10) and using (8) yields the following:

$$\frac{\partial}{\partial\lambda}\left[\frac{dK_{t+1}}{dp_t^k}\right] > 0 \qquad (11)$$

Equation (11) says that the capital stock response to a factor cost shock declines in absolute value as market power increases. Similar results hold for the effects of persistent or transitory shocks. Since the capital stock response is equivalent to the investment response via application of (2), the capital accumulation equation, equation (11) predicts larger investment responses to factor price shocks in competitive than in collusive industries.[12]

Since imperfect competition results in an output reduction in the long run in this model, this result is not surprising. The interesting result is that the investment response <u>relative to the current capital stock</u> is greater in collusive than in competitive industries. Consider the effect of this factor cost shock on the rate of gross investment, defined as:

$$\frac{I_t}{K_t} = \frac{K_{t+1} - (1-\delta)K_t}{K_t} \tag{12}$$

Using equations (8) and (10)-(12) and the chain rule, it can be shown that an unexpected factor price increase causes the investment rate to decrease and that the magnitude of that rate decrease rises as λ rises.[13] Thus imperfect competition is associated with smaller units of investment responses but larger rates of investment responses to factor price shocks.[14] Again, the degree of market power positively affects capital stock flexibility.

Finally, this model can be used to show that market power directly influences investment variability relative to output variability. Recall that aggregate investment is highly procyclical and that its variability exceeds that of aggregate output (Shapiro [1986]). Further, Abel and Blanchard [1988] and Petersen and Strauss [1989, 1991] have measured interindustry differences in these relationships. This model demonstrates that one potential source of these differences is the presence of market power at the industry level. Consider an example in which the price of capital goods, p_t^k, is constant and the demand intercept, a_t, follows the following process:

$$a_t = a' + u_t, \tag{13}$$

where u_t is a first order autoregressive process with parameter ρ. Substituting (13) into (6), using the infinite order moving average representation of $\{u_t\}$, and manipulating lag operators permits computation of the variance of investment[15]:

$$\text{var}(I_t) = \left[\frac{\beta\mu_1\rho\alpha}{c(1-\delta)(1-\beta\mu_1\rho)}\right]^2 \left[1 + \frac{(1-\delta-\mu_1)^2}{(1-\mu_1^2)}\right]\left[\frac{\sigma_\varepsilon^2}{1-\rho^2}\right] \tag{14}$$

where σ_ε^2 is the variance of the white noise process underlying $\{u_t\}$. Clearly an increase in demand variability, measured by an increase in σ_ε^2, increases investment variability; thus investment is procyclical.

To derive an expression for output variability, I use equation (4), the production technology, and proceed along the same lines as above to obtain

$$\text{var}(q_t) = \left[\frac{\beta\mu_1\rho}{c(1-\delta)(1-\beta\mu_1\rho)}\right]^2 \left[\frac{1}{1-\mu_1^2}\right]\left[\frac{\sigma_\varepsilon^2}{1-\rho^2}\right] \tag{15}$$

The ratio of $\text{var}(I_t)$ to $\text{var}(q_t)$ is given by

$$\frac{\text{var}(I_t)}{\text{var}(q_t)} = \alpha^2[(1-\mu_1^2) + (1-\delta-\mu_1)^2] \tag{16}$$

Market power influences the ratio of $\text{var}(I_t)$ to $\text{var}(q_t)$ through its influence on μ_1. It is straightforward to compute

$$\frac{\partial(\mathrm{var}(I_t)/\mathrm{var}(q_t))}{\partial\lambda} = -2\alpha^2(\partial\mu_1/\partial\lambda)(1 - \delta) > 0. \qquad (17)$$

This value is positive since $\partial\mu_1/\partial\lambda < 0$. Equation (17) shows that investment variability relative to output variability is an increasing function of market power. Thus all three measures of capital stock flexibility, the stock adjustment speed, investment rate response to shocks, and the ratio of investment variability to output variability, are increasing functions of market power.

4. Discussion and Conclusions

This paper has used a neoclassical investment model to show that market power influences investment behavior through its effect on perceived market demand: higher degrees of market power are associated with greater capital stock flexibility. Market power creates rents, and this gives firms in industries with market power incentives to respond quickly to changes in conditions, thus accounting for the capital investment flexibility results derived here.

Future theoretical work should focus on how product and financial market factors interact to influence investment choices, and future empirical work to test the model's implications should aim to disentangle several sets of relationships. The intensity of product market competition influences investment through both demand and factor price channels, while investment choices themselves may feedback to influence outcomes in the product market. Similarly, information problems in capital markets may affect investment directly, by causing credit rationing, and/or indirectly, by raising the financing cost of investment.

Analysis of firm level data is probably best suited to distinguish the influences of demand strength, competition, and financial market access on investment behavior, but industry level analysis could also prove fruitful. For example, Lebow [1990] studies output and employment variability in 4-digit SIC industries and finds that highly concentrated industries tend to exhibit higher output and employment variability than do less concentrated industries. If high concentration levels are associated with high degrees of market power, then an adapted version of this paper's model may help explain Lebow's results. Future empirical work should attempt to distinguish explanations based on market power from alternatives based on capital markets and factor prices.

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Appendix

Combining equation (6) with a lagged version of (6) yields:

$$I_t = \mu_1 I_{t-1} + \frac{\mu_1}{c(1-\delta)} \sum_{s=0}^{\infty} (\beta\mu_1)^s [E_t(\beta\alpha a_{t+s+1}) - E_{t-1}(\beta\alpha a_{t+s})] + N_1 \quad \text{(A1)}$$

$$= \mu_1 I_{t-1} + \frac{\beta\alpha\rho\mu_1}{c(1-\delta)(1-\beta\mu_1\rho)}(u_t - (1-\delta)u_{t-1}) + N_2$$

where N_j are appropriately defined functions of the model's structural parameters. Manipulating lag operators and simplifying yields

$$I_t = \frac{\beta\alpha\rho\mu_1}{c(1-\delta)(1-\beta\mu_1\rho)} \sum_{s=0}^{\infty} \mu_1^s (u_{t-s} - (1-\delta)u_{t-s-1}) + N_3 \quad \text{(A2)}$$

Since $\{u_t\}$ is AR(1), it has an infinite order moving average representation:[16]

$$u_t = \sum_{i=0}^{\infty} \rho^i \varepsilon_{t-i} \quad , \quad \text{(A3)}$$

where $\{\varepsilon_t\}$ is an i.i.d. white noise process with variance σ_ε^2. Substituting (A3) into (A2) and simplifying yields an expression for gross investment as a function of current and past realizations of ε_t:

$$I_t = \frac{\beta\alpha\rho\mu_1}{c(1-\delta)(1-\beta\mu_1\rho)}[\sum_{s=0}^{\infty} \rho^s \varepsilon_{t-s} - (1-\delta-\mu_1) \sum_{i=0}^{\infty} \mu_1^i (\sum_{s=0}^{\infty} \rho^s \varepsilon_{t-s-i-1})] + N3 \quad \text{(A4)}$$

The variance of I_t is computed as

$$\text{var}(I_t) = \left[\frac{\beta\mu_1\rho\alpha}{c(1-\delta)(1-\beta\mu_1\rho)}\right]^2 \left[1 + \frac{(1-\delta-\mu_1)^2}{(1-\mu_1^2)}\right]\left[\frac{\sigma_\varepsilon^2}{1-\rho^2}\right] . \quad \text{(A5)}$$

This is equation (14) in the text.

Endnotes

1. However, see Schiantarelli and Georgoutsos [1990] for related empirical evidence using aggregate data on fixed investment, and see Amihud and Mendelson [1989] for firm-level analysis of inventory investment. The latter authors find that inventory volatility is positively correlated with several measures of market power.

2. See, for example, Gertler [1988], Gertler and Hubbard [1988], and the works cited therein.

3. For example, see Fazzari and Athey [1987]; Fazzari et al. [1988]; Blundell et al. [1989]; Hoshi et al. [1989]; and Whited [1989]. These studies find that the investment of firms likely to face borrowing constraints displays greater sensitivity to cash flow than does that of unconstrained firms.

4. For example, see Dixon [1985], Brander and Lewis [1988], and the references cited therein.

5. See Sullivan [1978], Nguyen and Bernier [1988], and Liang and Wolken [1989].

6. But see footnote 11 below.

7. An equivalent approach is to begin at the firm level and exploit the symmetry assumptions when aggregating up to the industry level.

8. Modelling production as a fixed coefficient technology permits me to derive simple, closed form expressions for desired capital stock investment but precludes consideration of input substitutability when examining the effects of factor price shocks later in this section.

9. The index can be directly related to quantity-based conjectural variations: values of 0, 1/n, and 1 for λ correspond to quantity conjectural variations of -1, 0, and n-1, respectively. Interpreting λ (or the conjecture) in a game-theoretic context requires some care, since the current problem is a dynamic one. A conjecture of 0 corresponds to the Cournot-Nash assumption of taking one's opponents' actions as given. Solving the model

with $\lambda = 1/n$ (or the conjecture = 0) is thus equivalent to solving the noncooperative game of choosing capital stocks when only open loop strategies are permitted. This paper, then, does not consider feedback or other closed loop strategies. See Karp and Perloff [1988] and Worthington [1990] for further discussions of these issues, and see Bresnahan [1982, 1989] and Shaffer [1983] for more on the standard interpretations of the index λ.

10. See Worthington [1990] for a treatment that endogenizes the degree of competition.

11. Karp and Perloff [1989] and Worthington [1989] obtain related results in similar models. The latter paper distinguishes between the degree of competition (price-taking, Cournot, collusive, etc.) and the number of firms, n, in the industry. Increases in n are shown to increase the adjustment speed. The intuition is straightforward: increases in n mean that any given increase in capital stock can be spread over a larger number of firms. Since stock adjustment costs are convex, this lowers the total cost of any given stock addition and serves to raise the industry's adjustment speed.

12. See Hubbard and Weiner [1986] for related results. The analysis of demand shocks is identical to that given above, since both demand and technology are linear in this model.

13. Specifically, the relationship is

$$\frac{\partial}{\partial\lambda}\left[\frac{d(I_t/K_t)}{dp_t^k}\right] = \frac{\partial}{\partial\lambda}\left\{\left[\frac{1}{K_t}\right]\left[\frac{dK_{t+1}}{dp_t^k}\right]\right\} = \frac{1}{K_t}\left[\frac{\partial}{\partial\lambda}\left\{\frac{dK_{t+1}}{dp_t^k}\right\}\right] + \frac{dK_{t+1}}{dp_t^k}\left[\frac{\partial}{\partial\lambda}\left\{\frac{1}{K_t}\right\}\right].$$

Since K_t falls as λ rises, this expression is positive.

14. Startz [1989] obtains qualitatively similar results in a quite different setting. Using a model of monopolistic competition, Startz derives Keynesian rigidities and analyzes short and long run multipliers in a macroeconomic model. He shows that "the greater the degree of monopolistic competition, the more that short-run movements exceed long-run movements....[and not that] the absolute size of movements is greater under monopolistic competition than in a [perfectly competitive] neoclassical economy." Similarly, in the present model, the size of capital responses, when measured in rates (units), is larger (smaller)

under imperfect competition than under competition.

15. See the Appendix for details.

16. See Fuller [1976, p. 36].