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Tobin's *q* Ratio and Industrial Organization*

This paper examines the relationship between accounting data and financial market data to determine the extent, distribution, and history of monopoly and quasi-rents in the industrial sector. Our basic idea is to use Tobin's q ratio—the ratio of the market value of a firm to the replacement cost of its assets—as a measure of, or bound for, the monopoly rents of that firm. We develop a data base of q ratios for a sample of firms and relate q both theoretically and empirically to other traditional measures of monopoly power.

I. Introduction

The use of modern financial economics and of financial data to explore issues in industrial organization is just beginning. Financial price data provide a viewing window into the firm through the market's valuation of the securities issued by the firm and the changes in these values over time. Accounting data, on the other hand, provide information on the resources used by the firms. Thus, comparing accounting data and financial valuation data offers the opportunity to examine performance, the difference between inputs, on one hand, and output, on the other.

This paper develops such a comparison between accounting data and financial data to examine the extent, distribution, and history of monopoly rents and quasi-rents in the industrial sector.[1] The basic idea of our approach is to use the difference between the market value of the firm and its replacement cost as a measure of or bound for monopoly rents. The analysis is based on the pioneering insights of Tobin, who introduced the variable q, the ratio of market value to replacement cost, into macroanalysis (see Tobin and Brainard 1968, 1977; and Tobin

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1. Other papers discussing this subject from somewhat different approaches include Thomadakis (1976, 1977) and Sullivan (1977*a*, 1977*b*).

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1969, 1978). Tobin's intent was to examine a causal relationship between q and investment. He argued that if, at the margin, q exceeded unity, firms would have an incentive to invest, since the value of their new capital investment would exceed its cost. It is clear that if all such investment opportunities were exploited, the marginal value of q should tend toward unity.

We will employ this argument peripherally below, but our focus is somewhat different. Our interest is in the cross-sectional value of q and its implications for industrial organization in general, and the measurement of monopoly power in particular. The essence of the argument is that for a competitive firm, one would expect q to be close to one, and as we examine firms with increasing monopoly power (increasing ability to earn above a competitive return), q should increase. If a firm's q is greater than one, the market value of the firm is in excess of its replacement cost. If there is free entry, other firms could enter the industry by purchasing the same capital stock as the existing firm. Furthermore, they would anticipate an increase in value over their investment because its market value would exceed its cost. Thus, in the absence of barriers to entry and exit, q will be driven down to one as new firms enter (or existing firms expand if average and marginal q coincide). Similarly, a firm which is regulated so as to earn no monopoly rents would also have a q close to one.[2] A monopolist, however, who can successfully bar entry and is not adequately regulated will earn monopoly rents in excess of the ordinary returns on the employed capital. The market will capitalize these rents, and the market value of the firm will exceed the replacement cost of its capital stock, that is, q will persist above one.

But the actual q value of even a competitive firm may differ from unity. There are two principal reasons for this. First, the firm may possess factors of production on which it earns ordinary Ricardian rents, and these may not be captured in its replacement cost figures. To the extent that the firm possesses factors which lower its cost function relative to that of the marginal firm, it will be inframarginal to the industry and will have q in excess of one. Of course, such factors should be capitalized in replacement cost as well as in market value, but this omission, which tends to bias q upward, is avoidable only to the extent that the market value of these factors is carried on the books. For some firms, though, this effect will be mitigated by an opposite tendency. If the firm is not investing in its existing capital stock, for example, if the firm is "dying," perhaps part of a dying industry, or if there have been particular types of technical progress which make its capital stock obsolescent, its q can fall short of unity

2. Leland (1974) has also discussed the relationship between replacement cost and fair rate of return within a regulatory framework. Of course, if the factors which constitute entry barriers are completely capitalized, replacement cost would rise to market value and q would be unity.

even if it is earning monopoly or Ricardian rents. To put it simply, a firm whose capital stock is simply not worth replacing can have $q < 1$.[3]

In general, though, for firms engaged in positive investment, in equilibrium we expect q to exceed one by the capitalized value of the Ricardian and monopoly rents which the firm enjoys. Since the former cannot be negative, the q value of the firm will provide an upper bound to its monopoly rents. This paper will develop the arguments outlined above and compare this new measure of monopoly power with more traditional approaches to the problem. Section II develops the theory in an analytic framework which makes specific the relationship between q and monopoly rents. In Section III, we develop a procedure for constructing a data base of q for a large sample of firms. We also discuss the issues which arise in implementing the theory and, in particular, the sources of the differences between measured q values and equilibrium values. In Section IV, we use this data base to examine empirically several alternative q-based measures, or bounds on monopoly power for the firms in the sample. In Section V, we test the theory by comparing these measures with two traditional approaches to the measurement of monopoly power: the Lerner index and the four-firm concentration ratio. The final section briefly concludes the paper and suggests some further applications of the q measures in industrial organization and policy problems.

II. A Theory of q and Monopoly Profits

In this section we develop a theory of q which links this variable to the firm's stream of revenues and costs. We begin by specifying the net revenues of the firm, since this is the stream which a competitive securities market will capitalize to obtain the firm's market value, M.

If p denotes the price (vector) of the firm's output and Q denotes its output (vector), total revenue is given by pQ. If we let L denote the use of variable factors of production (e.g., labor) and w is the current rental cost of these factors, the firm's net revenue is given by

$$R = pQ - wL. \tag{1}$$

It is this net revenue stream which the securities market values, presumably on the assumption that firms are attempting to maximize this value subject to the constraints under which they operate. Such constraints are of a technological, an economic, and a regulatory nature. The resulting value assigned by the market is the valuation of the fixed factors embedded in the firm, and these include invested capital (and land) and all of the intangible factors on which the firm earns rents. The

3. The reverse is also possible, and a firm which is growing so rapidly that it is outpacing its capital goods supply sources, i.e., its factor markets are not clearing at existing capital goods prices and a demand queue is forming, may have $q > 1$ even though it is earning no excess rents.

firm's assets fall into three broad categories. First, there are those which are sold in the market and which make up what is traditionally thought of as the capital stock of the firm. In this category would fall plant and equipment, inventory, and so forth. The second category is composed of those special factors which the firm possesses which lower its costs relative to those of competitive or marginally competitive firms. These factors would presumably be valued for their cost-reducing abilities. For example, a firm might have special access to a river whose waters are so cold that it can provide industrial coolant more efficiently than that of its competition. The third category of capital is subtler still, and it is made up of those special factors of production which the firm possesses which act as barriers to the entry of competitors. Without being unduly specific about what forms these could take, for example, patents or scale economies, we will identify the net revenues attributable to them as monopoly rents.

In sum, then, the total market value can be represented as

$$M = M_K + M_A + M_N, \tag{2}$$

where M_K, M_A, and M_N are the capitalized values of the rents attributable to invested capital or replacement capital K, firm-specific factors A, and, finally, monopoly profits N, respectively. To examine this breakdown in detail, we will have to look closely at the investment behavior of the firm, since this is the prime endogenous determinant of the intertemporal behavior of net revenue R.

A firm making additions to its capital stock at time t will do so up to the point at which the marginal value of a further addition is equal to its unit cost c_t. For simplicity, we assume that capital depreciates at a true economic exponential rate δ. Technical progress is assumed to be capital augmenting and to occur at a rate θ, and we measure capital in efficiency units, that is, K_t will denote the amount of time 0 capital stock units to which the total capital stock at time t is productively equivalent. With these assumptions, the marginal value of an investment increment at time t is given by its present discounted marginal contribution to the net revenue stream[4]

$$PV_t \equiv \int_t^\infty e^{\theta t} R_K(K_\tau, \tau) e^{-(\delta + r)(\tau - t)} d\tau, \tag{3}$$

where r is the firm's discount rate and $R_K(K_\tau,\tau)$ is the marginal net revenue contribution at time τ from an increment to investment. The first-order condition which characterizes the optimum level of investment is simply

4. While we are not explicitly treating taxes as an expense in this argument, they can be incorporated without too much difficulty. Equations (3) and (5) will be modified to account for the firm's marginal tax bracket, its rate of investment tax credit, and its depreciation rate for tax purposes. The theory that follows can also be modified to include tax effects, but the essential message remains the same.

$$c_t = PV_t, \tag{4}$$

for all t at which investment is positive.

Differentiating (4) with respect to time, we obtain the marginal pricing relationship[5]

$$\dot{c}_t = (\theta + r + \delta)c_t - e^{\theta t}R_K(K_t, t). \tag{5}$$

Notice that this relation is satisfied by firms which are engaged in positive investment, but not, in general, by firms which are not expanding their productive capacity. For such firms

$$c_t > PV_t = e^{\theta t}\int_t^\infty R_K(K_\tau, \tau)e^{-(\delta + r)(\tau - t)}d\tau.$$

We will refer to capital goods and firms for which (5) holds with inequality as "dying," and they will be treated separately.

Ignoring tax effects, we can use the marginal pricing relation to determine the share of total market value attributable to currently installed capital. In fact, with investment anticipated in the future, the current value of the share of return imputed to capital, net of future investment, is simply the current replacement cost of capital. To see this, we evaluate the return imputed to capital, KR_K, minus the cost of new investment, cI, making use of the capital growth equation

$$\dot{K} = e^{\theta t}I - \delta K. \tag{6}$$

From (5), the imputed current value of the existing capital stock and of future investment prospects is given by[6]

$$\begin{aligned}
&\int_t^\infty (KR_K - cI)e^{-r(\tau - t)}d\tau \\
&= \int_t^\infty \{[(\theta + \delta + r)c - \dot{c}]Ke^{-\theta\tau} - cI\}e^{-r(\tau - t)}d\tau \\
&= \int_t^\infty \{[(\theta + \delta + r)c - \dot{c}]K - c\dot{K} - \delta cK\}e^{-\theta\tau}e^{-r(\tau - t)}d\tau \\
&= \int_t^\infty \left[rcKe^{-\theta\tau} - \frac{d}{d\tau}\left(cKe^{-\theta\tau}\right)\right]e^{-r(\tau - t)}d\tau \\
&= r\int_t^\infty cKe^{-\theta\tau}e^{-r(\tau - t)}d\tau - (cK)e^{-\theta\tau}e^{-r(\tau - t)}\Big|_t^\infty \\
&\quad - r\int_t^\infty (cKe^{-\theta\tau})e^{-r(\tau - t)}d\tau \\
&= cKe^{-\theta t}.
\end{aligned} \tag{7}$$

5. The dot over a variable indicates a derivative taken with respect to time.

6. To ease the notation, we will refer to marginal net revenue as simply R_K, recognizing that it depends on time and on the level of capital employed at that time.

Since $Ke^{-\theta t}$ is the number of new units of capital which would be required to replace the existing capital in the firm at time t, this is simply the current replacement cost RC_t, where we will define replacement cost as the cost of the most efficient technology which can produce the output flow. (See the Appendix for a further discussion of the influence of technical progress on replacement cost.)

The market value of the firm, which is the present worth of all receipts less expenditures, can now be decomposed as

$$\begin{aligned} M_t &= \int_t^\infty (R - cI)e^{-r(\tau-t)}d\tau \\ &= \int_t^\infty (KR_K - cI)e^{-r(\tau-t)}d\tau + \int_t^\infty (R - KR_K)e^{-r(\tau-t)}d\tau \\ &= RC_t + \int_t^\infty (R - KR_K)e^{-r(\tau-t)}d\tau. \end{aligned} \tag{8}$$

From our earlier decomposition, then, M_K, the portion of value attributable to the existing capital stock is simply the replacement cost RC_t, and the remaining value

$$\int_t^\infty (R - KR_K)e^{-r(\tau-t)}d\tau = M_A + M_N,$$

is the sum of the values of ordinary and monopoly rents. Notice that, for a growing firm, market value will never fall below true replacement cost since ordinary and monopoly rents cannot be negative, although they can be zero. Notice, too, that this result does not assume competition in the market for new capital goods. Given the prices of such goods, the result hinges only on the existence of a competitive securities market. (While free entry also supports this result, it is not required.)

Of course, for a firm which is not currently investing or will cease investing in the future, we have $c > PV$, and we can actually have $M_t > RC_t$. Such a firm may well be earning rents but not to a degree sufficient to offset the differential between the present value of the capital stock $K \cdot PV_t$, and RC_t.

We can now turn to the evaluation of that portion of market value which is net of capital payments, that is, $M_A + M_N$. At the margin, capital is chosen so that the reduction in short-run operating costs is equal to the rental rate. Since R denotes revenue net of variable costs, it follows that $R - KR_K$ is simply revenue minus long-run costs. Letting AC stand for long-run average costs, from our previous analysis we have

$$\begin{aligned} M_t &= RC_t + \int_t^\infty (R - KR_K)e^{-r(\tau-t)}d\tau \\ &= RC_t + \int_t^\infty (P - AC)\, Qe^{-r(\tau-t)}d\tau. \end{aligned} \tag{9}$$

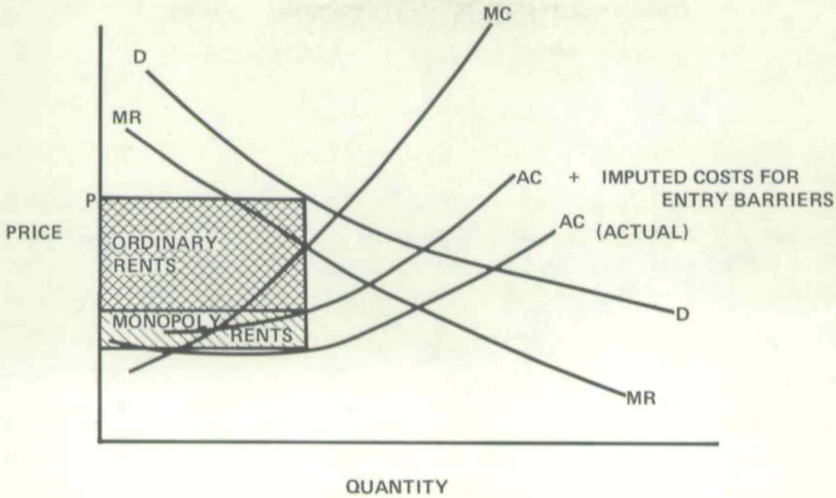

FIG. 1.—Components of a firm's rent

This confirms our intuition that the difference between M and RC is the capitalized difference between revenues and long-run costs. Of course, to the extent that costs are imputed but not actually expensed to owned factors, AC will understate true opportunity costs. The difference measures the true monopoly profits attributable to barriers to entry and the remainder is ordinarily rent.

Figure 1 illustrates this breakdown for a firm with upward-sloping costs. In a long-run stationary equilibrium, as M approaches RC, P approaches AC. To put the matter differently,

$$q_t \equiv 1 + \frac{1}{RC_t} \int_t^\infty (P - AC)Qe^{-r(\tau - t)} d\tau, \tag{10}$$

and $q - 1$ is the capitalized value of both the monopoly and Ricardian rents scaled by replacement cost. In this sense it is an upper bound to the value of monopoly rents earned by the firm. Notice, too, that since $P \geqslant AC$ in equilibrium, we must have $q \geqslant 1$.

Proceeding with the analysis, from (10) we have

$$q_t = 1 + q_t \frac{\int_t^\infty (P - AC)Qe^{-r(\tau - t)} d\tau}{\int_t^\infty (R - cI)e^{-r(\tau - t)} d\tau}$$

$$\geqslant 1 + q_t \left[\int_t^\infty (P - AC)Qe^{-r(\tau - t)} d\tau\right] \Big/ \left[\int_t^\infty PQe^{-r(\tau - t)} d\tau\right],$$

which implies that

$$q_t \geqslant \left[\int_t^\infty PQe^{-r(\tau-t)}d\tau\right] \Big/ \left[\int_t^\infty (AC)Qe^{-r(\tau-t)}d\tau\right]$$
$$= \frac{P}{AC}.^7$$

We can summarize this result in the following proposition, which makes use of Lerner's index of monopoly power, the percentage difference between price and marginal cost (see Scherer [1971], p. 50, for a discussion of the use of Lerner's index in measuring monopoly power).

Proposition

Let S denote the ratio of average to marginal cost, that is, the elasticity of the cost function. A firm has decreasing costs if $S > 1$ and increasing costs if $S < 1$. A firm engaged in positive (gross) investment has a Lerner's index,

$$L \equiv (P - MC)/P \leqslant 1 - 1/Sq, \tag{11}$$

where q is "Tobin's q." Equivalent statements of this result are $(P - AC)/AC \leqslant q - 1$ and $q \geqslant (1/S)\,[1/(1 - L)]$, and with constant returns to scale ($S = 1$), we have the simple result that $L \leqslant 1 - (1/q)$ and $q \geqslant 1/(1 - L)$.

The intuition behind the effect of scale, that is, the ratio of average to marginal cost, on these bounds is straightforward. In the constant returns to scale case, average and marginal costs coincide. As we have already seen, q capitalizes the difference between price and average cost, which, in the case of constant returns, equals the difference between price and marginal cost. With scale economies, average cost is declining and marginal cost lies below average cost. As a consequence, q will only be an upper bound on the price/marginal cost ratio if it is augmented by S, the ratio of average to marginal cost. Similarly, with increasing costs (decreasing returns), the bound can be tightened because marginal cost is greater than average cost. Consequently, we might expect that the Lerner index inadequately measures monopoly power because of its omission of the influence of scale on the competitive return level.

Over time, the rents attributable to factors not included in replacement costs, that is, A, will fluctuate, grow, or decay depending on how A depreciates, on technical progress, and on how capital and variable factors substitute for A. But for a monopolist there will be a persistent wedge driven between price and average cost and this, in turn, will

7. This last result follows rigorously from the twin assumptions of homotheticity in production and constant elasticity of demand. Notice that these variables are current, i.e., time t values.

drive a wedge between q and unity. Correcting for scale effects, a similar gap persists between price and marginal cost.

Notice, though, that for a perfect competitor we may still have $q > 1$, with the excess being the valuation of the ordinary rents earned on specific factors. A similar result can hold for a regulated firm insofar as Ricardian rents in excess of those included in replacement cost are earned on specific factors. (This is equivalent to an underestimate of replacement cost.) The value of q only provides an upper bound to monopoly power; a firm may have a true index below the bound. Of course, for a firm which is not currently investing or which foresees significant periods of no gross additions to its capital stock, this proposition need not hold. For such a firm, as we have already seen, market value can be less than replacement cost, that is, $q < 1$. Furthermore, this can hold whether the firm is earning monopoly rents or specific ordinary rents.[8]

Finally, we should note that the analysis could be further complicated by explicitly introducing uncertainty and using a competitive valuation operator (see Ross 1978) to relate the profit stream to market value, but it can be shown that the basic proposition is reasonably robust to these considerations as well.[9]

The rest of the paper is devoted to using the theory of q developed in the analysis above to measure the aggregate Ricardian and monopoly rents of a collection of publicly traded firms. The next section will describe the transition from the theory to the data.

8. A modification must also be made for the firm with a stock of nonproductive assets, e.g., an excess cash or securities position. Such a stock would add equally to both M and RC and tend to bias q toward unity. The extent to which firms hold such nonproductive assets, though, is somewhat problematic; the line between productive and nonproductive assets is arbitrary. As a consequence, the effect will be minor, and we will ignore it.

9. To verify this in the simplest fashion assume that random net revenues are distributed independently over time as $\tilde{\Pi}_t = \Pi_t \tilde{y}_t$, where $\tilde{y}_t$ is identically distributed with $E(\tilde{y}_t) = 1$. From the mean-variance capital-asset pricing model or the arbitrage pricing theory, with no intertemporal changes in the market price of risk, λ, we have the pricing relationship

$$
\begin{aligned}
M_t &= \frac{E(\tilde{M}_{t+1} + \tilde{\Pi}_{t+1}) - \lambda \operatorname{cov}(\tilde{M}_{t+1} + \tilde{\Pi}_{t+1}, \text{market returns})}{1+r} \\
&= \frac{E(\tilde{M}_{t+1})}{1+r} + \frac{\Pi_t}{1+r} - \frac{\lambda\beta\Pi_t}{1+r} \\
&= (1-\lambda\beta)\frac{\Pi_t}{1+r} + \frac{E(\tilde{M}_{t+1})}{1+r} \\
&\to (1-\lambda\beta)\sum_{T=0}^{\infty} \pi_{t+T}\left(\frac{1}{1+r}\right)^{T+1},
\end{aligned}
$$

where β is the covariance between $\tilde{y}_t$ and the market return. In continuous time we would have $M_t = \int_t^{\infty} (1-\lambda\beta)\Pi_{t+s}\, e^{-r(s-t)} ds$, which simply scales all of our previous results by $(1-\lambda\beta)$ as indicated in the text. This constant scaling leaves the basic proposition unchanged.

Table 1 Data Sources

Variables	Source
TA, HINV, HNP, DEP, I, inventory valuation method, year-end common stock price, shares outstanding, $D1$, DL	COMPUSTAT Expanded Industrial and Utility Tapes (Standard and Poor's COMPUSTAT Services, Inc.)
GNP deflator-gross private nonresidential fixed investment, wholesale and retail prices indices	National income and product accounts, U.S. Department of Commerce
Preferred stock yield index, bond ratings and yields	Standard & Poor's, Moody's industrial and utility manuals
RNP, RINV	SEC 10-K reports (computerized file supplied by Standard & Poor's COMPUSTAT Services, Inc.)

NOTE.—TA = total assets as reported, HINV = inventories at historical book value, HNP = net plant at historical book value, DEP = current book depreciation expense, I = gross investment (book) in plant and equipment, $D1$ = total debt maturing in 1 year, DL = long term debts maturing beyond 1 year, RNP = net plant at replacement cost, and RINV = inventories at replacement cost.

III. Procedures for Calculating q Ratios

To implement the theory, we will construct a data base of q's for individual firms. The actual data base descriptions and their sources are given in table 1. In this section we will consider the methods by which q is calculated and why the q measured from this data differs from the actual q of the theory.

The calculation of q requires separate calculations for market value and replacement cost.

Market Value

The financial paper representing ownership claims on the firms in our sample are, for the most part, well traded (or have well-traded substitutes), and, in principle, by suitable adjustments, time series of market values can be computed. Insofar as securities markets are as close to perfectly competitive markets as we can find, the sum of the values of these claims should provide an accurate measure of the market value of the firm.

The firm's securities fall into three broad groups:[10] (a) common stock, (b) preferred stock, and (c) debt. Throughout, we will assume that recorded year-end common stock market values represent true market values, and these, in turn, fully reflect the information used in valuing the returns of the firm by equity holders. Because of the difficulty of obtaining complete price quotes for preferred stocks, we calculate a firm's aggregate preferred stock market value by dividing its

10. We are implicitly assuming homogeneity within groups. Thus all preferred stock is straight preferred and all debt is straight debt. Considerations of convertible securities, call provisions, etc., are omitted. While each of these subcategories could be priced out and dealt with separately, the data requirements and availability make the task beyond the scope of this paper.

total preferred dividends by Standard & Poor's preferred stock yield index. (This procedure follows that used by Tobin and Brainard [1977].)

This market value of debt is even more difficult to obtain from recorded price data. Much bond trading is done off the floor of the exchanges, so that published exchange data need not fully reflect investors' valuations. One possible way to handle this is to price out the individual issues using yields associated with the bond ratings of the firm. While this is ideal, the enormity of the task is complicated by the lack of computer tapes with the necessary data. As a compromise we have used the following procedure. In any year t, total recorded book debt, D_t, can be broken down as[11]

$$D_t \equiv D1_t + DL_t, \tag{12}$$

where $D1_t$ is the debt that will mature before year $t + 1$ (including short-term debt) and DL_t is the long-term debt maturing beyond $t + 1$. We assume that the market value of the debt maturing by time $t + 1$ equals its book value, $D1_t$. Long-term debt, however, will have a market value that depends, significantly, on the maturity distribution of the firm's bonds, their coupon rates, and the current yield to maturity. As a first step we estimate the maturity distribution of each firm's debt using the following assumptions: (1) All new debt is issued for n years. (2) In any year, t, the firm moves long-term debt issued in year $t - n + 1$ into its short-term account. It then may retire additional debt or add new long term debt. (3) In any year, t, the total long-term debt is the sum of all new debt (N_j) issued in the years $j = t - n + 2, t - n + 1, \ldots, t - 1, t$. (4) Before some initial year, t_0, $N_j \simeq (1/n)\, D_{t_0}, j = t_0 - n + 2, \ldots, t_0$. (5) No new debt is issued unless total long-term debt is increased. Under these assumptions it follows that all $t > t_0$,

$$N_t = DL_t - DL_{t-1} + N_{t-n+1} \text{ if } DL_t > DL_{t-1}, \tag{13}$$

and $N_t = 0$ if $DL_t \leq DL_{t-1}$. Thus the firm first retires (moves into the short-term account) its oldest debt first, then either issues some new debt if net long-term debt is to be increased or retires more if desired.

It should be recognized that formula (13) may not satisfy exactly the equation $D_t = \Sigma_{j=0}^{n-2} N_{t-j}$ for all t.[12] Instead of using the values of N_j directly, we obtain the maturity distribution by first estimating the fraction of reported long-term debt, $f_{t,t-j}$, that was issued new at time $t - j$ as

$$f_{t,t-j} = N_{t-j} \Big/ \sum_{k=0}^{n-2} N_{t-k}, \quad j = 0, \ldots, n-2. \tag{14}$$

11. Ideally we would like to break the debt down into year-by-year maturities, but such data are unavailable in computerized form.

12. A check was made for a sample of 10 firms each of the years 1965, 1970, and 1975. The sum of the estimated new issues deviated from DL_t by an average 10%.

Having established the maturity distribution of the firm's long-term debt, we next proceed to calculate its market value. We employ the following assumptions: (6) The yield to maturity of a firm's debt at time t, when the firm's bond rating is Z, is denoted as ρ_t^Z. (7) All new debt at time t, of a firm with bond rating Z, is issued at par with a coupon rate equal to ρ_t^Z. (8) The market value, at time t, of a bond is calculated using its coupon rate and the current yield to maturity associated with that firm's bond rating. With these additional assumptions, it follows that the market value of a firm's debt (MVD_t) can be calculated from $D1_t$ and DL_t by the following formula

$$MVD_t = D1_t + DL_t \sum_{j=0}^{n-2} f_{t,t-j}\left\{(\rho_{t-j}^Z/\rho_t^Z)[1 - (1+\rho_t^Z)^{-(n-j)}] + (1+\rho_t^Z)^{-(n-j)}\right\}. \quad (15)$$

Summarizing the procedures described above, the firm's total market value is given by

$$M_t = MVD_t + MV_t(\text{common stock}) + MV_t(\text{preferred stock}). \quad (16)$$

Replacement Costs

The measurement of replacement cost is a more difficult matter because of the lack, in most cases, of active markets for old capital goods.[13]

By definition, replacement cost is the dollar outlay needed to purchase the current productive capacity of the firm at minimum cost and with the most modern technologies available (see Appendix). This concept is more complex and more difficult to measure than is reproduction cost, which measures only the inflation-adjusted cost of plant if reproduced in kind. To determine replacement cost we must also adjust for varying levels of technological advance across plant categories and product types, and for varying rates of "real" (versus book) depreciation. Nevertheless, the Securities and Exchange Commission in 1976 began requiring large companies to disclose replacement-cost data on their SEC 10-K filings (Securities and Exchange Commission 1976). In particular, replacement-cost estimates were required in the categories of plant and equipment (gross and net), inventories, depreciation expense, and cost of goods sold. Unfortunately, for our purposes, the SEC gave broad leeway to firms in the methodology used for the calculations. We use this source to calculate overall replacement costs

13. For the effect of inflation accounting on individual firms, see Davidson and Weil (1975, 1976) and Falkenstein and Weil (1976, 1977). For some work constructing aggregate estimates, see Ciccolo (1975), Tobin and Brainard (1977), von Furstenberg (1977), and President of the United States (1978, 1979).

for the years 1976 and 1977.[14] In addition, we construct a series of individual firm replacement costs prior to 1976 using the 1976–77 numbers along with past balance sheet information taken from the COMPUSTAT Expanded Industrial and Utility Tapes supplied by Standard and Poor's COMPUSTAT Services, Inc.

The assets of a firm fall into three broad categories: (*a*) plant and equipment, (*b*) inventories, and (*c*) other assets. Category *c* contains liquid assets such as cash and securities as well as land. Some of these assets are traditionally carried on the books at market value while others are carried at original cost. For our purposes we will assume that the assets in this category have replacement value approximately equal to book value. Categories *a* and *b* are the categories for which the SEC has required replacement-cost information. In constructing the time series of replacement costs, we use the following notation:

TA_t = total assets as reported in year t,
HNP_t = net plant at its historical value in year t,
RNP_t = net plant at replacement cost in year t,
HINV_t = inventories at historical value in year t, and
RINV_t = inventories at replacement value in year t.

Total replacement cost (RC_t) is defined as

$$RC_t \equiv \mathrm{TA}_t + \mathrm{RNP}_t - \mathrm{HNP}_t + \mathrm{RINV}_t - \mathrm{HINV}_t \qquad (17)$$

for the years of SEC reported data, 1976 and 1977. Prior to 1976, we will consider plant and equipment and inventories separately.

The replacement cost of net plant and equipment will change over time as a consequence of four major effects: (1) price level changes (increase RNP), (2) technological change (decrease RNP), (3) real economic depreciation (decrease RNP), and (4) investment in new plant (increase RNP). Given the investment in new plant and equipment series I_t, the following recursive relation was developed:

$$\mathrm{R\hat{N}P}_t = \mathrm{R\hat{N}P}_{t-1}\left[\frac{1+\phi_t}{(1+\delta_t)(1+\theta_t)}\right] + I_t,\ t \geq 1, \qquad (18)$$

where 0 is the base year (in our case 1952),[15] ϕ_t is the rate of growth of capital goods prices (for this firm), δ_t is the rate of (real) depreciation, θ_t is the rate of cost-reducing technical progress, and the hat above RNP implies that the value is estimated.

14. The accuracy of these data and the variability in the methods used to construct the figures is discussed at length in reports by the accounting firms of Arthur Anderson & Co. (1977) and Arthur Young & Co. (1977). For example, the SEC does not put stringent requirements on the reporting of foreign assets at replacement cost.

15. Although COMPUSTAT begins its data series in 1946, it is necessary to begin at a later date in order to guarantee complete data series for a sufficiently large sample of firms.

Continuing the recursion, we obtain

$$\hat{\mathrm{RNP}}_t = \sum_{\tau=0}^{t} \prod_{s=t+1}^{t} \left[\frac{1 + \phi_s}{(1 + \delta_s)(1 + \theta_s)}\right] I_\tau + \mathrm{HNP}_0 \prod_{s=0}^{t} \frac{1 + \phi_s}{(1 + \delta_s)(1 + \theta_s)}, \quad (19)$$

where HNP_0 is the book value of net plant in year 0.[16] Since no satisfactory and sufficiently complete measures of technical progress at the firm level could be found, these were computed endogenously in one of two ways. First, by using the formula (18) for the years 1976 and 1977 we obtain

$$\mathrm{RNP}_{1977} = \mathrm{RNP}_{1976} \frac{1 + \phi_{1977}}{(1 + \delta_{1977})(1 + \theta_{1977})} + I_{1977}. \quad (20)$$

If we assume the rate of technical progress was constant for a sufficient period prior to 1976, the solution for θ_{1977} can be used as an estimate for $t < 1976$. The difficulty with this method is that it uses depreciation, inflation, and investment information for 1 year only in order to estimate θ for many years. An alternative is to calculate θ directly from the formula (19) for each of the years 1976 and 1977 by solving

$$\mathrm{RNP}_t = \sum_{\tau=0}^{t} (1 + \theta)^{\tau-t} \prod_{s=t+\tau}^{t} \frac{1 + \phi_s}{1 + \delta_s} I_\tau + \mathrm{HNP}_0 (1 + \theta)^{-t} \prod_{s=0}^{t} \frac{1 + \phi_s}{1 + \delta_s} \quad (21)$$

(t = 1976, 1977) and then averaging the two solutions.[17] These measurements of technical progress at the firm level could be aggregated to the industry level and might be of some independent interest.

To obtain an estimate of the capital goods price index, ϕ_t, we use the GNP deflator for nonresidential fixed investment. The depreciation rate was computed in our study by the formula

$$\delta_t = \frac{\mathrm{DEP}_t}{\mathrm{HNP}_{t-1}}, \quad (22)$$

where DEP_t is book depreciation. This formula assumes that the *real* fraction of the (net) assets which depreciate in a given year is equal to the *book* fraction. This has the virtue of eliminating much of the difference between measured and tax-adjusted replacement values that

16. To be precise, HNP_0 should be replaced by RNP_0. However, for years of interest sufficiently later than the base year, the difference between the real value of the undepreciated part of the base year capital and its book value will be negligible.

17. In reality, the value of θ calculated by this procedure represents not only an estimate of technical progress but includes other factors, such as inflationary effects that differ from the price index, omitted factors influencing replacement costs, and errors in measurement of variables. We refer to θ as the rate of technical progress in that we believe that this is its major component.

comes from differences between exponential and straight-line depreciation schedules. Using these estimates, a time series of $\hat{RNP}_t$ can be constructed for each firm from (18).

The other component of replacement cost is the inventory value, RINV. Since different firms use different methods for inventory accounting (e.g., first in, first out [FIFO]; last in, first out [LIFO], or average cost methods), in principle, different adjustments to book numbers must be considered for each one. In practice, the differences in FIFO and LIFO methods, for example, have a substantial effect on the estimated investment series for firms with large inventory positions. In an inflationary period, LIFO will underestimate the change in inventory value and, as a consequence, the true inventory investment and total actual investment will be understated by the difference in book values. The following adjustments were made for the major methods of inventory valuation reported to Compustat by individual firms.[18]

LIFO. In this system, units of output sold are assumed to be the most recently purchased units. Consequently, the book value of units of inventory still on the shelf will reflect prices that understate the cost of replacement in inflationary times. Our adjustment takes account of the larger undervaluation of old inventory and a smaller underpricing of more recent increments:

$$\mathrm{RINV}_t = \mathrm{RINV}_{t-1}\left(\frac{P_t}{P_{t-1}}\right) + (\mathrm{HINV}_t - \mathrm{HINV}_{t-1})\left[\frac{.5(P_t + P_{t-1})}{P_{t-1}}\right], \quad (23)$$

where P_t is the price index appropriate to inventories.

FIFO. In this system, inventories are assumed to be used up in the order in which they were produced. Thus, remaining inventories will be priced on the books at the most recent prices. In fact, if remaining inventories were all produced during the most recent period, a reasonable approximation is

$$\mathrm{RINV}_t = \mathrm{HINV}_t. \quad (24)$$

Average cost method. In this method, inventory is reported at time t at roughly an average of the prices at $t - 1$ and t. Thus our approximation to replacement cost of inventories in this case is

18. Other methods infrequently used by firms are specific identification, standard cost methods, and current replacement costs. In these cases, we used the method described in the text closest in description to the infrequently used method. Also, where several methods were cited for a given firm, the method cited as dominant was used.

$$\mathrm{RINV}_t = \mathrm{HINV}_t \cdot \frac{2P_t}{(P_t + P_{t-1})}. \tag{25}$$

Retail cost method. In this method inventory quantities are priced at the expected retail prices. Since producers normally sell at wholesale, our correction is

$$\mathrm{RINV}_t = \mathrm{HINV}_t \frac{\text{Wholesale Price Index}}{\text{Retail Price Index}}. \tag{26}$$

Using equations (23)–(24) where appropriate, we can find $\hat{\mathrm{RINV}}_t$ for all years prior to 1976. We can then compute the total replacement-cost series, $\hat{RC}_t$, by combining $\hat{\mathrm{RINV}}_t$ $\hat{\mathrm{RNP}}_t$ in equation (17). To avoid any errors introduced by using HNP_0, we will discard the beginning period of the sample for each firm, from 1952 through 1959, and confine our analysis to the 1960–77 period.

Letting $\hat{M}_t$ denote the estimated market value of the firm (from [16]), we can now construct the series of $\hat{q}_{it} = \hat{M}_{it}/\hat{RC}_{it}$, $t = 1960, \ldots, 1977$, where i indexes firms.

We have already noted that the idiosyncracies of the accounting conventions make economic interpretation of inventory and investment difficult. The principal problem with the investment and capital price series, though, is less one of measurement errors and more one of the significance of recorded transactions prices generated in the capital goods market itself. The capital goods industry is highly procyclical, but there is little evidence of this cyclicity in the actual movement of capital goods prices. In an industry with large fixed costs, it is only natural that quoted prices will misstate the true costs of acquiring new capital goods. Cost considerations lead the industry to insulate itself from the cycle by producing for the long run. Thus, explicit and implicit long-run contracts will be important components of the capital goods price index. When the demand for capital falls off, actual transactions prices for spot transactions will decline and longer-term prices will be more sluggish. In periods of high demand, whether the market clears by having demanders queue at posted prices or whether there is a dual system of high spot and lower long-term prices, the effect will again be to smooth the capital goods price index below the true current spot price. This suggests, of course, that for rapidly growing firms, we might have growth outpacing investment and entry. In this case, $\hat{q}$ would be biased upward, overstating the true bound for monopoly power. What we would really like to have is a series of the "gray" or shadow prices rather than the posted transactions prices.

This inherent sluggishness in the recorded price index is, of course, reflected in $\hat{RC}$, making it much less responsive to market forces than is $\hat{M}$. Another source of the relative slow variation in $\hat{RC}$ is the presence of delivery and order lags. In industries with "sticky" capital which is not adjusted to meet current economic effects of the cycle, spot prices will be biased away from the true replacement value of the assets. The quoted price may be a spot price, and the relevant current price for evaluating replacement cost is not current spot price but a price for forward delivery. In this sense, in a period of rising prices, spot prices will understate the relevant prices for evaluating replacement cost. Not only will there be a timing problem, but the lags imply the presence of real costs to the acquisition of new capital equipment that are understated in current capital prices. As a consequence, $\hat{RC}$ will tend to understate true RC. Furthermore, to the extent to which shifts in demand and supply conditions are accommodated by changes in the order and delivery lags, prices will respond with a dampened lag and will move less rapidly than true replacement costs.

The sluggishness in $\hat{RC}$ implies that $\hat{q}$ will display a greater amplitude than q. This property underlines much of the hope that $\hat{q}$ will have explanatory power as an independent variable in determining investment. (It is ironic that if $\hat{q}$ exactly tracked q—and if there were no distinction between marginal q and average q—it would lose its value as a determinant of investment.) But, for our purposes, we are interested in true q itself and not in $\hat{q}$, and we will use $\hat{q}$ as an estimate of q.

Two other problems deserve mention. First, the treatment of advertising expenditures has been in accordance with standard accounting principles, which is to say that we have expensed them. To some extent, though, advertising is a capital investment and to omit it will bias replacement costs downward and q upward. If advertising capital depreciates rapidly, we would expect this effect to be relatively minor. Furthermore, since overall advertising expenditures are small relative to replacement costs, for most firms such a correction would be small, and we have chosen to ignore them. Similar qualifications apply with regard to expensing research and development expenditures.

Perhaps a more serious omission is the understatement of firm-specific training costs in investment. Firms which engage in specific training must offer their workers a premium over jobs which have a higher component of general training. This premium is largely expensed in the wage bill but properly should be added to total investment. Here, too, we tend to bias q's upward.

IV. Empirical Analysis

The averages of $\hat{q}$, denoted as $\bar{\hat{q}}_i = 1/18 \sum_{t=1960}^{1977} \hat{q}_{it}$ are reported for each firm in table 2. Our sample selection will be described a bit later. If there are no systematic biases, $\bar{\hat{q}}_i$ will provide an adequate measure of

Table 2 Firms and Average q Values

Company	1960–77 Average q Ratio	Company	1960–77 Average q Ratio
ACF Industries	1.14	Cone Mills Corp.	.45
AMF, Inc.	1.43	Congoleum Corp.	1.17
Abbott Laboratories	2.35	Continental Group	1.15
Akzona	1.02	Continental Oil Co.	1.69
Alcan Aluminum, Ltd.	.79	Cooper Industries, Inc.	1.24
Allegheny Ludlum Industries	.97	Copperweld Corp.	.69
Allied Chemical Corp.	1.26	Corning Glass Works	3.75
Allied Products	1.07	Crane Co.	.72
Allied Stores	1.17	Crown Cork & Seal Co., Inc.	1.41
Allis-Chalmers Corp.	.76	Crown Zellerbach	1.08
Alpha Portland Industries	.68	Culbro Corp.	1.07
Aluminum Co. of America	.85	Cummins Engine	1.35
Amcord, Inc.	.92	Curtiss-Wright Corp.	.95
American Brands, Inc.	1.23	Cutler-Hammer, Inc.	1.35
American Can Co.	1.09	Dan River, Inc.	.67
American Cyanamid Co.	1.46	Dart Industries	1.41
American Greetings Corp.	1.94	Diamond International Corp.	1.50
American Telephone and Telegraph	1.09	Diamond Shamrock Corp.	1.55
Ametek, Inc.	1.46	Dome Petroleum, Ltd.	2.94
Anchor Hocking Corp.	1.17	Dow Chemical	1.62
Anheuser-Busch, Inc.	1.95	Du Pont (E. I.) De Nemours	2.47
Armstrong Cork Co.	1.70	Duquesne Light Co.	.90
Asarco, Inc.	.91	Eastern Gas & Fuel Assoc.	1.11
Avon Products	8.53	Eaton Corp.	1.17
Bausch and Lomb, Inc.	2.37	Ethyl Corp.	1.48
Beatrice Foods Co.	1.65	Exxon Corp.	1.05
Bell & Howell Co.	1.64	FMC Corp.	1.47
Bethlehem Steel Corp.	.68	Fairchild Camera & Instrument	2.12
Borden, Inc.	1.26	Federal-Mogul Corp.	1.35
Borg-Warner Corp.	.97	Federal Paper Board Co.	.52
Bristol-Myers Co.	3.76	Federated Department Stores, Inc.	2.06
Brunswick Corp.	1.23	Ferro Corp	.97
Bucyrus-Erie Co.	1.08	Flintkote Co.	.86
Carter Hawley Hale Stores	1.28	Foote Mineral Co.	1.07
Caterpillar Tractor Co.	1.52	Foster Wheeler Corp.	.86
Ceco Corp.	.84	GAF Corp.	1.27
Celanese Corp.	1.24	GATX Corp.	1.10
Certain-Teed Corp.	.95	Gamble-Skogmo	.97
Champion International Corp.	1.35	Gardner-Denver Co.	1.57
Chicago Pneumatic Tool Co.	1.13	General Cable Corp.	1.64
Chrysler Corp.	.90	General Electric Co.	2.07
Cincinnati Milacron Inc.	1.17	General Foods Corp.	2.10
Cities Service Co.	1.21	General Motors Corp.	1.59
Clark Equipment Co.	1.51	General Portland, Inc.	1.09
Cleveland-Cliffs Iron Co.	1.17	General Refractories Co.	.70
Cluett, Peabody & Co.	1.12	General Telephone & Electronics	1.32
Coca-Cola Co.	4.21	Georgia-Pacific Corp.	1.63
Colgate-Palmolive Co.	1.34	Gillette Co.	3.92
Collins & Aikman Corp.	1.13	Goodrich (B. F.) Co.	.89
Combustion Engineering, Inc.	1.14		
Commonwealth Edison	1.01		

Table 2 (Continued)

Company	1960–77 Average *q* Ratio	Company	1960–77 Average *q* Ratio
Goodyear Tire & Rubber Co.	1.05	Mead Corp.	.97
Grace (W. R.) & Co.	1.16	Medusa Corp.	.60
Graniteville Co.	.55	Melville Corp.	2.21
Great Northern Nekoosa Corp.	.79	Mercantile Stores Co., Inc.	1.27
Grumman Corp.	1.06	Midland-Ross Corp.	1.02
Gulf Oil Corp.	1.25	Minnesota Mining & Manufacturing Co.	4.87
Halliburton	1.86	Mobil Corp.	1.20
Hammermill Paper Co.	.68	Monsanto Co.	1.38
Hercules, Inc.	1.86	Motorola, Inc.	1.97
Hershey Foods Corp	1.83	NCR Corp.	1.74
Holly Sugar Corp.	.50	NI Industries	1.56
Honeywell, Inc.	2.28	Naico Chemical Co.	3.69
Ideal Basic Industries, Inc.	1.08	National Distillers & Chemicals	.94
Imperial Oil, Ltd.-CL A	1.67	National Gypsum Co.	.92
Ingersoll-Rand Co.	1.76	National Steel Corp.	.53
Inland Steel Co.	.95	National Tea Co.	.97
Insilco Corp.	1.39	Owens-Corning Fiberglass Corp.	1.71
Interco, Inc.	.98	Owens-Illinois, Inc.	1.30
Interlake, Inc.	.75	PPG Industries, Inc.	1.05
International Business Machines Corp.	4.21	Pabst Brewing Co.	1.31
International Paper Co.	1.17	Pennwalt Corp.	1.36
Iowa-Illinois Gas & Electric	.85	Pepsico, Inc.	2.31
Iowa Power & Light	.73	Pfizer, Inc.	2.49
Johns-Manville Corp.	1.24	Phelps Dodge Corp.	1.71
Johnson & Johnson	3.64	Philip Morris, Inc.	1.45
K Mart Corp.	1.99	Phillips Petroleum Co.	1.74
Kaiser Aluminum & Chemical Corp.	.80	Pitney-Bowes, Inc.	1.92
Kaiser Cement & Gypsum Corp.	.96	Polaroid Corp.	6.42
Kaiser Steel Corp.	.78	Potlatch Corp.	.82
Kellogg Co.	3.20	Public Service Electric & Gas	1.12
Kimberly-Clark Corp.	1.51	Publicker Industries, Inc.	.59
Koppers Co.	.88	Pullman, Inc.	.91
Kraft, Inc.	1.35	Quaker State Oil Refining	1.92
Libbey-Owens-Ford Co.	1.47	RCA Corp.	1.67
Liggett Group	1.02	Revere Copper & Brass, Inc.	1.17
Lilly (Eli) & Co.	4.02	Reynolds (R. J.) Industries	1.90
Lone Star Industries	.89	Reynolds Metals Co.	.81
Long Island Lighting	1.28	Robertshaw Controls	1.11
Lowenstein (M.) & Sons, Inc.	.61	Robertson (H. H.) Co.	.89
Lucky Stores, Inc.	1.58	Rohm & Haas Co.	2.09
Lukens Steel Co.	.74	Rubbermaid, Inc.	2.03
Mallory (P. R.) & Co.	1.22	SPS Technologies, Inc.	.80
Marathon Oil Co.	1.81	Safeway Stores, Inc.	1.14
Maremont Corp.	1.24	St. Joe Minerals Corp.	1.91
Marshall Field & Co.	1.14	St. Regis Paper Co.	.98
Maytag Co.	2.71	Schering-Plough	4.30
McGraw-Edison Co.	1.28	Scott Paper Co.	1.46
McLouth Steel Corp.	.74	Scovill Manufacturing Co.	1.05
		Searle (G. D.) & Co.	5.27

Table 2 (Continued)

Company	1960–77 Average q Ratio	Company	1960–77 Average q Ratio
Sears Roebuck & Co.	2.04	Trane Co.	1.82
Shell Oil Co.	1.68	Trans Union Corp.	1.47
Signal Cos.	.99	UV Industries, Inc.	1.48
Signode Corp.	1.69	Union Camp Corp.	1.43
Simmons Co.	.90	Union Carbide Corp.	1.67
Singer Co.	1.22	Union Oil Co. of California	1.24
Smithkline Corp.	4.19	Uniroyal, Inc.	.90
Southern California Edison		United Brands	.74
Co.	.81	U.S. Gypsum Co.	1.22
Square D Co.	2.68	U.S. Steel Corp.	.62
Standard Brands, Inc.	1.87	U.S. Tobacco Co.	1.67
Standard Oil Co. (California)	1.18	United Technologies Corp.	.94
Standard Oil Co. (Indiana)	1.24	Wallace-Murray Corp.	.81
Standard Oil Co. (Ohio)	2.09	Warner & Swasey	1.01
Stanley Works	.96	Western Publishing	1.33
Sterling Drug Inc.	3.46	Western Union Corp.	.83
Stewart-Warner Corp.	1.20	Westinghouse Electric Corp.	1.48
Sun Co.	1.26	Weyerhaeuser Co.	1.76
Sunbeam Corp.	1.36	White Motor Corp.	1.12
Sundstrand Corp.	1.17	Wickes Corp.	1.60
Super Value Stores, Inc.	1.35	Wisconsin Public Service	.79
TRW, Inc.	1.32	Woolworth (F. W.) Co.	.84
Texaco, Inc.	1.86	Wrigley (WM.) Jr. Co.	1.74
Textron, Inc.	1.12	Xerox Corp.	5.52
Timken Co.	1.02	Zenith Radio Corp.	2.83

true q_i and, if we assume that $\hat{q}_{it} = a_t q_i$ and define $\hat{q}_t \equiv 1/N \sum_{i=1}^{N} \hat{q}_{it}$, then $\hat{q}_{it}/\bar{\hat{q}}_t$ is a measure of the relative value of rents earned by firm i. However, since our aim is to construct q measures which can be used to compare monopoly and ordinary rents across firms, to the extent to which there are biases which are common across firms—and the use of a common price index means that most of the biases will be common—we should attempt to correct the raw q values. Several approaches are offered below.

The relative variable defined above is one way of dealing with the problems arising from intertemporal changes in q levels. By averaging across firms, we could argue that individual firm errors should wash out in computing $\bar{\hat{q}}_t$. The secular variation in $\bar{\hat{q}}_t$ will measure the impact of the sluggish response of $\hat{RC}_t$ and to assess the impact at the firm level, we must remove the variation in $\hat{q}_{it}$ with the general trend. One approach is to estimate the regression

$$\hat{q}_{it} = a_i + b_i(\bar{\hat{q}}_t - \bar{\bar{\hat{q}}}) + \xi_{it}, \tag{27}$$

where

$$\bar{\bar{q}} = \frac{1}{T} \sum_t \bar{\hat{q}}_t.$$

Now $\hat{a}_i$ will serve as a measure of the long-run value of q_i for the firm.[19]

An allowance should also be made for the presence of dying firms (firms which are not replacing their capital stock). Since such firms will have their true q below unity, we must correct their q to measure the value of rents earned above their return on invested capital. If we assume that investment at time t occurs in response to differences between PV_t and c_t, we can use the normalized difference between investment in plant and equipment, on one hand, and depreciation on the other, as a proxy for this difference. Defining $\hat{g}_{it} \equiv \min [0, (I_{it} - \mathrm{DEP}_{it})/TA_{it}]$, one measure of true q_i can be found from the regression

$$\hat{q}_{it} = a_i + b_i(\bar{\hat{q}}_t - \bar{\bar{q}}) + c_i\hat{g}_{it} + \xi_{it}. \tag{28}$$

(We also tried $(\hat{g}_{it} - \hat{g}_i)$ as an alternative.) Here $\hat{g}_{it}$ measures the extent to which firms are not replacing their capacity. Now $\hat{a}_i$ will be a measure of true q_i that is corrected for the dying-firm phenomenon. Then, to obtain the corrected value of q at each point in time for firm i, denoted by $\tilde{q}_{it}$, we have

$$\tilde{q}_{it} = \hat{a}_i + \hat{\xi}_{it}, \tag{29}$$

where $\hat{\xi}_{it}$ is the calculated residual after performing the regression (28). Alternative formulations to (28), including log-linear forms and the use of weighted averages for $\bar{\bar{q}}$, were also run, but the results described later in this section were not significantly affected.

The residual $\hat{\xi}_{it}$ is probably best interpreted as describing that portion of firm i's q value that is not explained by economy-wide movements in average q. Of course, to the extent to which the movements in the average q are secular movements in the true underlying q for the economy, this procedure will tend to overcorrect. In particular, in a period of declining q it will remove some of the true decline in a firm's q, and the adjusted trend of q for individual firms will be biased upward from the true trend.

Another possible variant of (28) would remove the minimum function in the definition of g_{it} so that (28) will also adjust downward the q values for those firms and industries which are experiencing an increase in demand that increases PV_t above c_t for current investment.

19. We recognize the fact that in performing the regression (27) separately for each firm, the coefficients of the last regression will be functions of the other coefficients due to the definition of $\bar{\hat{q}}_t$. However, with a sufficiently large sample of firms this should not be a significant problem. We also tried variations of (27), e.g., a log form, but the resulting empirical analysis was not very sensitive to the specification, and for simplicity we have not reported these results.

Table 3 Adjustment Coefficients for q

	Definition 1: $\hat{g}_{it} = \frac{I_{it} - \text{DEP}_{it}}{TA_{it}}$		Definition 2: $\hat{g}_{it} = \min\left(0, \frac{I_{it} - \text{DEP}_{it}}{TA_{it}}\right)$	
	$\hat{b}_i$	$\hat{c}_i$	$\hat{b}_i$	$\hat{c}_i$
Positive (N)	236	130	239	201
Significantly > 0 at 5% level (N)	228	15	230	21
Negative (N)	10	116	7	45
Significantly < 0 at 5% level (N)	2	8	2	4

NOTE.—Sample size = 246 firms; N = number of firms in each category.

As we observe above, the capital goods price index does not measure true acquisition cost in this case, since demanders are queuing for investment goods. This may occur even though the firm is not exercising monopoly power. In addition, for firms with heterogeneous mixes of capital goods we cannot conclude that no capital is being replaced simply because depreciation exceeds investment. Of course, the correction is only an approximation in both cases, and it is not clear from the theory alone which form better fits the data. If there is a correlation between growth and true q, we will overcorrect, so that $\hat{a}_i$ will underestimate the true value of q_i for high-growth firms and overestimate it for dying firms.

From the sources listed in table 1, data for an initial sample of over 500 firms, for which SEC 10-K information was at least in part available, was collected. Firms were eliminated when complete 10-K information in 1976–77 was not available. This left 257 firms in the sample. When a further check was made for adequate information for calculation of Lerner indices in the next section, the sample was reduced to 246 firms. Table 2 lists alphabetically the firms in the sample along with their respective unadjusted average q values.

The results of the regressions described above are summarized in table 3. Using definition 1 (in table 3) for $\hat{g}_{it}$, we find that an overwhelming percentage of the $\hat{b}_i$ coefficients had significant positive signs at the 5% level. This confirms our intuition that b_i reflects the responsiveness of measured q_i to economy-wide changes in valuations. We would also expect c_i to be positive, but approximately an equal number had positive and negative signs, although these results were insignificant at the 5% level. The results from definition 2 of $\hat{g}_{it}$ in table 2 were not significantly different, although there was a slight increase in the number of positive $\hat{c}_i$ values. Evidently, the dying-firm effect is more important than the supergrowth effect, although neither of these

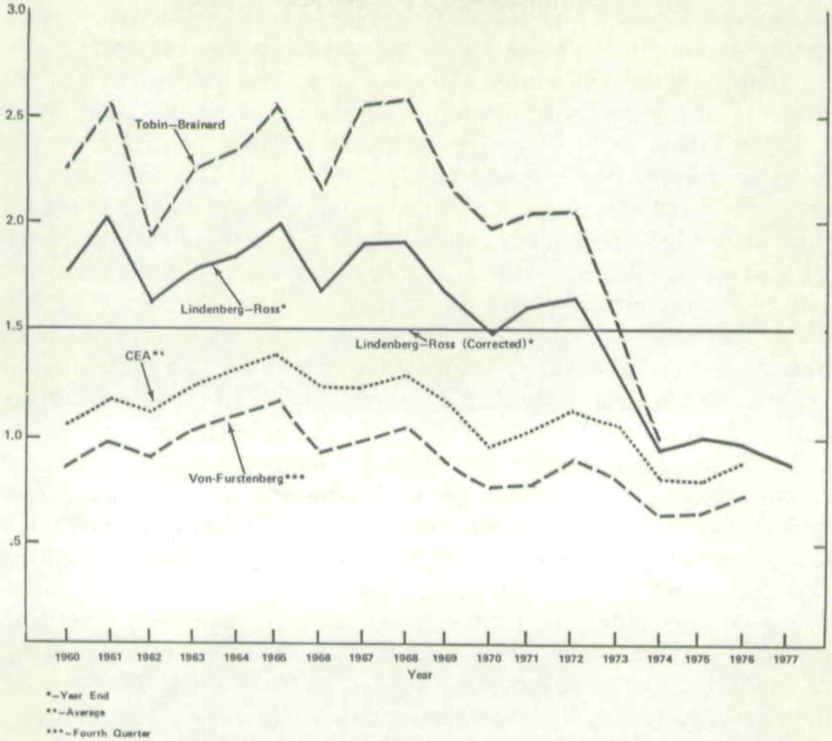

FIG. 2.—Economy-wide q ratios

variables adds much to the adjustment of q. In fact, we have not listed the values of $\hat{a}_i$ for the firms in the sample since the average adjusted value of q differs very little from its unadjusted value. Of course, the actual time series of adjusted $\tilde{q}_{it} = \hat{a}_i + \xi_{it}$ differs from the unadjusted $\hat{q}_{it}$ series and, for some firms in the sample, the difference between $\hat{a}_i$ and $\bar{\tilde{q}}_i$ is significant.

To compare our findings with other studies of q, we plot in figure 2 the average value of q (unadjusted) for the years 1960 through 1977, and the economy-wide values of q reported from three sources: (1) the Economic Report of the President (1978), (2) the year-end numbers in von Furstenberg (1977), and (3) the average q values reported in Tobin and Brainard (1977). We have also plotted the time series of adjusted values of q, averaged over our firms, from our study. The relatively constant value (approximately 1.5) indicating that the capitalized rents, earned by firms in our sample, have been sufficient to keep the average firm's market value approximately 50% above the replacement cost of its assets. Figure 2 also indicates a high degree of correlation between the q as we have measured it and each of the other methods, although there are consistent differences between each of the estimates.[20]

What about the distribution of q across firms and industries? Figure 3 presents histograms for adjusted q across firms for the years 1960, 1965, 1970, and 1977. From these plots we see that the distribution of adjusted q ratios was approximately unchanged. The only apparent change is a reduction of some of the extremely large values of q over time. As we have previously noted, large q values should be associated with either significant monopoly rents or with rent resulting from some special factors employed by the firm, all of which influence market power. In table 4, industry averages are listed in ranked order of overall average adjusted q. Many of the industries with the highest q values contain firms successfully marketing differentiated products (e.g., cereals, drugs, cosmetics) or having strong patent protection (e.g., photo, drugs). Some industries containing firms with large market shares also rank highly, although such firms are scattered throughout table 2,[21] and we will test this explicitly below. We have suggested that low values of q are associated with a relatively competitive market structure, a tightly regulated market structure, or a dying-industry firm, and a casual reading of table 4 appears to confirm this. Steel and primary metal manufacturers rank low, perhaps reflecting the depressed nature of these industries relative to foreign substitutes. Also, the regulated sector, for example, electric utilities, has relatively low q values. Furthermore, many firms in other industries (e.g., petroleum refining) which are regulated in some form are noticeably below the upper ranges of the distribution despite the conventional wisdom concerning the oligopolistic nature of their business.[22]

Finally, as a test of significance, we examined the adjusted average q ratios for individual firms to see whether the monopoly power as measured from the data was significantly above the theoretical competitive level of 1.0. While the individual year-by-year q values can be thought of as independent drawings from a population with unknown

20. These other procedures, used to calculate q for the economy, have employed different techniques to measure either aggregate market value or aggregate replacement cost and are not quite comparable with our results. For example, both the Council of Economic Advisers and von Furstenberg procedures use flow of funds and other data aggregates rather than estimates for a sample of individual firms, and, in fact, their measures of replacement cost appear to be more reflective of reproduction costs, for which much of the effect of technical change is absent. Such an omission would push measured replacement cost up and measured q down.

21. Another reason for ranking high on the list might be a unique sales and marketing organization not easily replicated (Avon, IBM). A reason, not included in the text, for ranking low might be the ability of suppliers (e.g., unions) to appropriate some of the rents earned in output markets.

22. In several cases, the number of sample firms within a given industry is quite small. Some care is needed in making significant statements concerning relative market power in these cases.

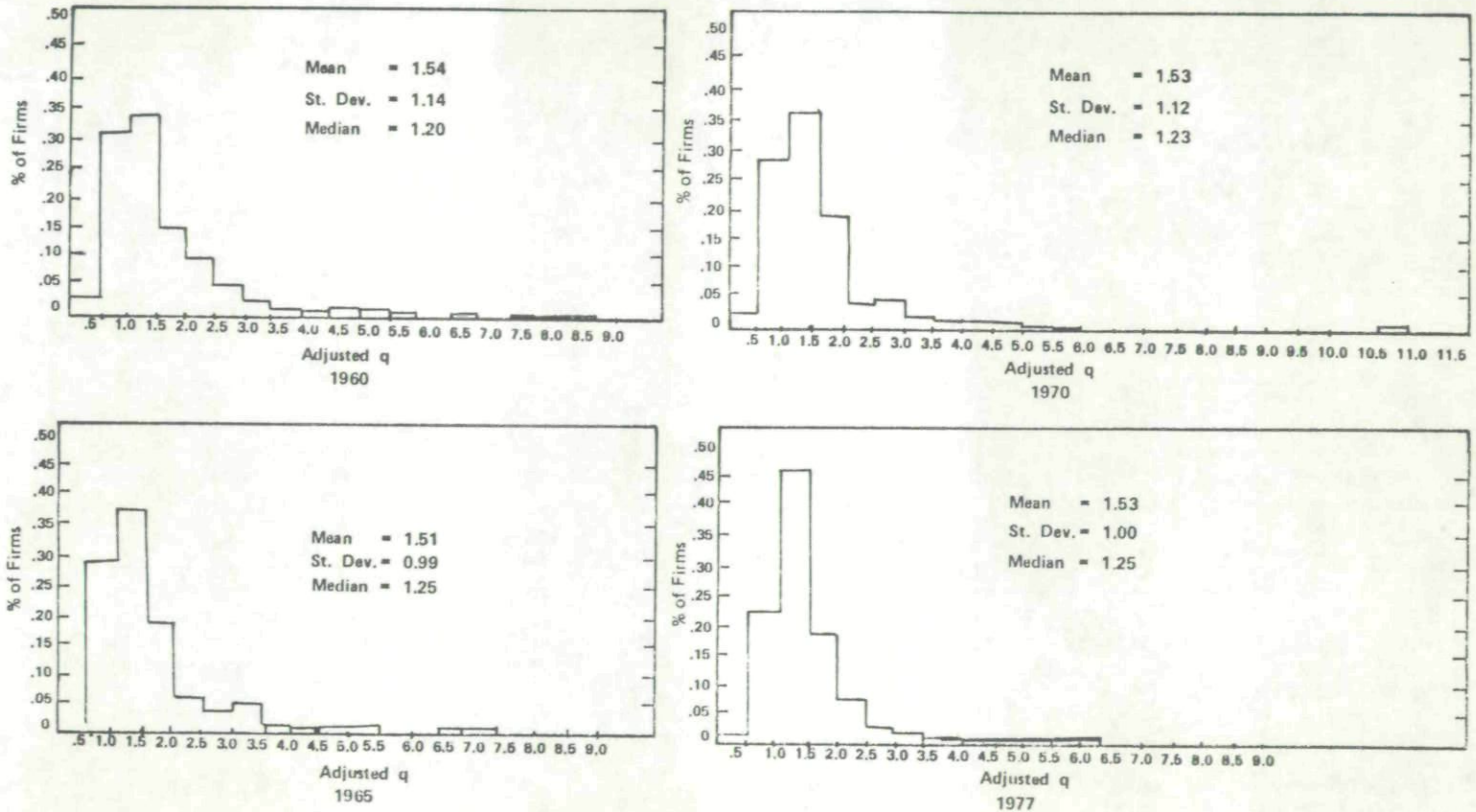

FIG. 3.—Frequency distributions of adjusted q ratios

Table 4 **Industry Adjusted q Ratios, Ranked on Average of 1960–77**

Two-digit SIC Code	Industry	Firms (N)	1960	1962	1964	1966	1968	1970	1972	1974	1976	Average	SD
38	Measure, photo equipment	7	3.76	2.72	1.97	3.49	3.30	2.85	3.19	3.02	2.97	3.08	2.16
13	Oil & gas extracting	1	1.60	1.99	1.69	3.10	5.22	3.24	3.94	2.83	2.47	2.94	1.28
28	Chemicals	31	2.32	2.48	2.61	2.42	2.14	2.42	2.46	2.53	2.35	2.42	1.84
36	Electric Machinery	15	1.58	1.78	1.82	1.90	1.71	1.70	1.78	1.72	1.92	1.79	.70
20	Food products	16	1.59	1.75	1.71	1.67	1.74	1.84	1.84	1.67	1.69	1.72	1.05
35	Machinery (nonelectric)	23	1.77	1.68	1.58	1.62	1.64	1.55	1.49	1.67	1.74	1.67	1.14
27	Printing industries	2	3.06	1.58	1.01	1.26	1.04	1.74	2.45	1.47	1.54	1.66	.88
31	Leather products	2	1.33	1.29	1.65	1.21	2.15	2.24	2.41	1.18	1.76	1.66	.93
52	Building materials	1	1.93	1.82	1.54	1.18	1.94	1.77	.86	1.57	1.70	1.60	.53
24	Lumber & wood products	3	1.36	1.21	1.61	1.46	2.15	2.14	1.56	1.54	1.58	1.59	.43
12	Bituminous coal mining	2	.94	1.40	1.57	1.38	1.96	1.62	1.44	1.57	1.48	1.54	.60
53	General merchandise stores	9	1.20	1.31	1.45	1.22	1.36	1.53	1.80	1.33	1.42	1.42	.61
59	Miscellaneous retail	1	1.31	1.12	1.24	1.58	1.54	1.44	1.39	1.32	1.44	1.41	.41
21	Tobacco manufacture	6	1.44	1.37	1.36	1.19	1.35	1.54	1.45	1.45	1.36	1.39	.44
29	Petroleum refining	22	1.33	1.34	1.52	1.44	1.47	1.43	1.48	1.45	1.27	1.39	.49
51	Nondurable wholesale	1	1.25	1.53	1.61	1.19	1.31	1.20	1.08	1.19	1.58	1.35	.40
39	Miscellaneous manufacture	2	2.31	1.30	.89	.91	1.16	1.39	1.82	1.27	1.34	1.33	.46
32	Stone, clay, glass	16	1.69	1.52	1.31	1.30	1.23	1.24	1.00	1.28	1.38	1.29	.70
10	Metal mining	4	1.10	1.18	1.25	1.26	1.57	1.24	.87	1.32	1.25	1.24	.40
30	Rubber & plastics	4	1.10	1.06	1.15	1.12	1.14	1.37	1.69	1.11	1.17	1.23	.67
54	Food stores	3	1.18	1.18	1.39	1.18	1.29	1.38	1.08	1.12	1.36	1.23	.38
99	Unclassified	3	.97	1.23	1.16	1.30	1.48	1.21	1.21	1.17	1.19	1.20	.37
37	Transport equipment	14	1.09	1.35	1.33	1.14	1.14	1.10	1.13	1.17	1.23	1.17	.28
16	Construction (other)	3	1.03	.91	1.06	.93	1.36	1.02	1.57	1.19	1.06	1.15	.64
23	Apparel Products	1	.90	1.27	1.14	1.06	1.27	1.20	.96	1.12	1.14	1.13	.28
26	Paper & allied products	12	1.29	1.18	1.12	1.02	1.06	1.03	.90	1.06	1.15	1.09	.40
48	Communication	3	1.25	1.21	1.25	1.20	.90	.96	.88	1.10	1.13	1.08	.30
34	Fabricated metals	7	.96	.95	.90	1.08	1.19	1.03	1.14	1.03	1.01	1.04	.38
49	Electric, gas, & sanitation services	8	.96	1.21	1.16	1.05	.77	.84	.70	.94	.96	.94	.24
25	Furniture & fixtures	1	.72	.59	.86	.72	1.24	1.27	1.06	.83	1.05	.93	.29
22	Textile products	7	.67	.81	.91	.84	1.13	1.05	.99	.83	.90	.92	.51
33	Primary metal industries	16	.94	.86	.92	.98	.85	.75	.63	.91	.89	.85	.33

mean, the distribution is not known, and the sample size of 18 years may not be sufficient to use a t-statistic for significance tests. Consequently, we employed a one-sided nonparametric sign test to test the null hypothesis H_0: $q_i = 1$ against the alternative hypothesis H_1: $q_i > 1$. At the 5% level, it was found that 159 of the 246 firms had q ratios significantly above one, while for the others, the estimated values do not permit us to rule out the possibility of no monopoly rents.

V. Comparisons with Other Measures of Monopoly Power

In this section, we examine the empirical relationship between q and two of the most commonly used measures of monopoly power, the Lerner index and the four-firm concentration ratio. The four-firm concentration-ratio data (based on value of shipments) was taken from the 1972 *Census of Manufacturers* (U.S. Department of Commerce 1972) for each of the manufacturing industries by four-digit SIC code. Included on the COMPUSTAT tapes are the four-digit SIC codes, but, in some cases, adjustments were made on the tapes to account for a firm doing significant business in several industries with, say, the same three-digit code. For example, if a firm was significantly involved in industries 2011, 2012, 2013, . . . , the recorded SIC code would read 2010. Consequently, it was necessary to construct averages (weighted by value of shipments) for all three-digit codes, two-digit codes, and so forth. For each firm, there is an associated concentration ratio representing the share of value of shipments in 1972 of the four largest firms in its "industry."

Lerner indices can be constructed using firm-specific data alone. Because we lack adequate marginal cost data, we assume that average *variable* cost equals marginal cost. If the firm produces a homogeneous product, Lerner's index will be given by

$$L \equiv \frac{P - MC}{P} \cong \frac{P - \mathrm{AVC}}{P} \cong \frac{PQ - \mathrm{AVC} \cdot Q}{PQ}$$

$$\cong \frac{\text{Sales-Operating Expenses}}{\text{Sales}}.$$

Letting L_{it} and CR_{it} denote, respectively, Lerner's index and the four-firm concentration ratio for firm i in year t, we regressed $\tilde{q}_{it}$ on L_{it} for the entire 1960–77 period and $\tilde{q}_{i,1972}$ on $L_{i,1972}$ and $CR_{i,1972}$ for the year in which census data was available. The results are reported in table 5.

All of the coefficients have the predicted positive sign. The Lerner index is, from all three regressions, an important contributor toward explaining monopoly and Ricardian rents. The concentration ratio, however, seems to have no significant relationship with q. Evidently, high q's can occur in concentrated or unconcentrated markets and,

Table 5 Regression Results

Regressions	Indices	r^2
$\bar{q}_{it} = 1.03 + 3.10\, L_{it}$ (19.59)	$i = 1, \ldots, 246$ $t = 1960, \ldots, 1977$	.08
$\bar{q}_{i,1972} = 1.46 + .27\, CR_{i,1972}$ (0.63)	i indexes manufacturing-sector firms	.01
$\bar{q}_{i,1972} = .19 + 8.28\, L_{i,1972} + .04\, CR_{i,1972}$ (11.27) (0.11)	i indexes manufacturing-sector firms	.29

NOTE.—Numbers in parentheses are t-values.

conversely, low q's, indicating no significant market power, can occur in markets that have high degrees of concentration.

The values of r^2 in these regressions are not unreasonable for cross-section regressions. But, recalling the basic Proposition of Section II, we see that Lerner's index only provides a lower bound for q which also depends on the ratio of marginal to average cost. The lower bound, then, will be lower for firms with high fixed costs and/or economies of scale. If actual q moves with the bound, we should expect it to be lower for firms with higher degrees of scale economies or higher fixed costs. In these cases, the Lerner index is inadequate in explaining market power because it does not recognize that some of the deviation of P from MC comes from either efficient use of scale or the need to cover fixed costs and does not contribute to market value in excess of replacement cost. An example of this phenomenon occurs for regulated utilities. Their Lerner indices are significantly higher than the average for all firms, and yet they have q ratios among the lowest in the sample. These are firms with large capital investments, high fixed costs, and significant scale economies during the study period.

As a direct test of the Proposition presented in Section II, we construct the statistic $[1/(1 - L)][MC/(\mathrm{AVC} + \mathrm{AFC})]$ for each firm in each year of the study period. According to the Proposition, this should be a lower bound for q. Assuming, again, that marginal cost equals average variable costs, and, in addition, that total fixed cost in a given year equals an interest rate (an annualization factor) times replacement cost, we test the hypothesis

$$H_1\colon q_i > \left(\frac{1}{1 - L_i}\right)\left(\frac{\mathrm{AVC}_i}{\mathrm{AVC}_i + rRC_i}\right)$$

against the null hypothesis

$$H_0\colon q_i = \left(\frac{1}{1 - L_i}\right)\left(\frac{\mathrm{AVC}_i}{\mathrm{AVC}_i + rRC_i}\right).$$

Table 6 reports the results of performing a nonparametric sign test of the hypothesis for the values $r = .05, .10, .15$ and for an interest

Table 6 **Lower Bound Tests for q***

	Interest Rate r (%)			
	5	10	15	5–15
Firms with q above theoretical bound at 5% level (N)	126	150	168	152
Firms with $\hat{a}_i$ above bound (%)	61	67	73	71

*Test of $q \geq (1/1 - L)\ (MC/AC)$, where $L \equiv$ Lerner index, $MC \equiv$ marginal cost, and $AC \equiv$ Average cost $\cong$ average variable cost $+\ r \cdot$ replacement cost.

starting at .05 in 1960 and rising uniformly to .15 in 1970. We list, for each value of r, the number of firms for which H_0 is rejected in favor of H_1 and the percentage of firms whose adjusted q ratio, $\hat{a}_i$, is above the hypothesized bound, evaluated at average values of its components. The majority of firms have average adjusted q ratios that exceed the bound. The test results indicate that H_0 is rejected with a frequency much greater than chance, suggesting that the proposition indeed holds. As is shown in table 6, these results are relatively unaffected by the assumptions on the cost of capital.

VI. Summary and Conclusions

We have developed in this paper a model which enables us to examine the extent, distribution, and history of monopoly and quasi-rents in the industrial sector. This model uses the linkage between financial price data and accounting data to construct empirical measures of super-competitive market power for individual firms. The work grows out of the pioneering work of Tobin, who recognized that the relation between market value and replacement cost is crucial in the investment decision making process.

Our results show a wide dispersion of market power across firms and industries. For the economy as a whole, the raw data is consistent with findings elsewhere that market value as a percentage of replacement cost has declined over the past 2 decades. After adjusting for economy-wide effects and firm effects that do not influence market power, we find that, on average, market values have been approximately 50% above replacement costs over the period 1960–77. We also have shown that the dispersion of monopoly power has not changed significantly over this period. Our results indicate that the sectors of the economy that have q ratios at the high end of the spectrum are often those with relatively unique products, unique factors of production, and so forth, all of which contribute to monopoly and/or quasi-rents. At the low end, we find either relatively competitive, tightly regulated, or dying industries.

We have also examined the relationship between q and two frequently used measures of monopoly power—the Lerner index and the four-firm concentration ratio. We found that while the Lerner index contributed toward explaining q, the concentration ratio seemed to have little significance. We must stress at this point that all these results are subject to the usual caveats concerning data availability and quality, and improvements in these areas would greatly aid future research.

Appendix

It is useful to examine the impact of technical progress and its relationship to market value and replacement cost. Initially, let us define replacement cost as the capital expenditure necessary to produce the identical product line with the most efficient technology.

To be explicit, let K_t be the current, time t, cost of a machine which produces one unit of the product in a perpetual flow. Suppose, also, that C_t is the variable cost stream of the machine and let p_t be the current product price. We consider machines in a putty-clay format; once installed, unit operating costs are fixed. In a competitive market for new capital goods, we must have market value

$$\begin{aligned} M_t &= \int_t^\infty (p_\tau - C_t)e^{-r(\tau-t)}d\tau \\ &= \int_t^\infty p_\tau e^{-r(\tau-t)}d\tau - C_t/r \\ &\equiv P_t - C_t/r \\ &= K_t, \end{aligned} \tag{A1}$$

or $q_t = M_t/K_t = 1$. If the cost streams, $\{C_t\}$ and $\{K_t\}$, are specified, then the product price will adjust through the supply curve to bring about the equilibrium. In particular, with K_t and C_t/r falling over time, discounted prices must fall as well. (Since $K_t + C_t/r > 0$, eventually p_t must fall at a decreasing rate.)

What happens to the q value of vintage equipment? Consider a machine built at time s as viewed at time t. Its market value is given by

$$\begin{aligned} {}_sM_t &= \int_t^\infty (p_\tau - C_s)e^{-r(\tau-t)}d\tau \\ &= P_t - C_s/r. \end{aligned} \tag{A2}$$

By definition, replacement cost is the cost of the most efficient technology, hence ${}_sR_t = K_t$. It follows that

$$\begin{aligned} {}_sq_t &= {}_sM_t/{}_sR_t = (P_t - C_s/r)/K_t \\ &< (P_t - C_t/r)/K_t = M_t/K_t = q_t = 1 \end{aligned} \tag{A3}$$

since operating expenses are falling. In other words, when we are not replacing old equipment, with inefficient operating characteristics, then q, as we would expect, is less than unity.

Notice, though, that if technical progress is capital augmenting and there is no improvement in operating costs, then $C_s = C_t$: ${}_sM_t = M_t$ and ${}_sq_t = {}_sM_t/K_t = M_t/K_t = q_t = 1$. It is tempting to fall into a trap suggested by the following conundrum. Suppose that technical progress occurs as variable cost reductions and new machine costs are actually the same as replacement costs of old machines. It is not now possible for the measured q for old equipment to be lower than its true value? The answer, as we have seen, is clear. As long as the new machine is economically more efficient, it should replace the old machine. Thus the ratio of the old machine's market value to the new replacement cost is the true q. If new machines have a lower operating cost, then resulting product prices bring current q to unity and measured q will be correct.

Technical progress which reduces operating costs, which are not expressible as capital augmenting, will bias q downward. Keep in mind, though, that the division of technical progress in this fashion is somewhat arbitrary and if the production structure permits technical progress to be put in a capital augmenting form, q will be forced to unity for competitive firms.

An alternative definition of replacement cost has the virtue of maintaining the equality of competitive q with unity. Let us define replacement cost as the cost of acquiring the same profit stream with the most efficient, that is, the cost minimizing, technology for producing the same product line. Under this definition, with ${}_s\gamma_t$ units of new capital, we can duplicate the profit stream of vintage capital, where

$$ {}_s\gamma_t M_t = {}_sM_t. \tag{A4} $$

Superscripting the alternative definition by a prime, we have

$$ {}_sq_t' = {}_sM_t/{}_s\gamma_t M_t = M_t/K_t = q_t = 1. \tag{A5} $$

Hence, as long as the product line is produced, $q' = 1$ for competitive firms. Of course, q can exceed unity by monopoly and/or factor rents for noncompetitive firms.

The alternative definition of replacement cost is more suitable for our purposes than the original one, but direct data on it is not readily available. At any rate, our procedures are based on accounting data on dollar investment flows and assume exponential technical progress. Insofar as γ_t declines geometrically, the cross-sectional results should be somewhat immune to these problems. Furthermore, our results on cross-sectional comparisons of q will be robust to the extent that there is not too much cross-firm variation in the relative proportion of capital and variable cost technical progress. Since all firms respond to the same factor price patterns, the endogeneity of technical progress lends some a priori support to this view.

The second definition is also superior to the original one because of a more serious flaw. The choice of an efficient capital stock may not be unique. In particular, there could be a family of efficient choices, those with lower operating costs having higher initial costs. This makes the first definition somewhat arbitrary. The alternative definition, though, gives a unique value to replacement cost. However, in the context of our paper, with technical progress assumed to be capital augmenting, our first definition will suffice. The discussion in this Appendix is intended to clarify alternative approaches to this issue.

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