THE MEASUREMENT OF PROFITABILITY AND THE DIAGNOSIS
OF MARKET POWER

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This paper develops a model which yields the specification of an empirical test for the difference
between price and marginal revenue, which will be significantly positive if a firm exercises
market power. The test can be carried out with any of a number of commonly used measures of
accounting profitability, and embodies a specific functional form for the consideration of non-
constant returns to scale. The model is estimated for four firms in the medical–surgical supply
industry and four firms in the motor vehicle industry. The results are consistent with the
hypothesis that product differentiation is an important basis for firm-specific market power;
import quotas are shown to increase market power in the motor vehicle industry. Claims that
accounting data cannot be used to analyze market power are rejected.

1. Introduction

Students of industrial economics are often confronted with the task of
analyzing market power. This is true not only in policy applications, where
the focus is typically on the presence or absence of market power, but also in
research, where the focus is usually on structural and behavioral factors
which generate and sustain market power.

It has recently been suggested [by Fisher and McGowan (1983)] that the
only measure of profitability which is suitable for economic analysis is what
is usually called the internal rate of return, and that because received
empirical studies of structure–performance relationships commonly employ
accounting measures of profitability, such studies are of dubious value. If this
argument is correct, it raises the possibility that economists will be unable to
conduct any empirical tests of structure–performance relationships, since
calculating the internal rate of return requires, in principle, estimates of
returns to investment over all future time. In addition, the assertion that the
internal rate of return is the appropriate measure of profitability is unaccom-
panied by any model which suggests a test for the presence or absence of

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Responsibility for errors is my own.
market power based on the internal rate of return, even if it could be measured.

I therefore take a different approach, and ask how the accounting rates of return which are usually available are affected by market power. I do so in the context of a model which considers both input and financial markets, and so distinguishes between rates of return on sales, on assets, and on the stock market value of the firm. The model does not assume constant returns to scale. The model yields a test for market power, and further indicates specific functional forms by which the test can be carried out, using alternative accounting rates of return.

I set up the model in section 2. In section 3 I report estimates of the model for eight firms: four in the medical–surgical supply industry and four in the motor vehicle industry. Section 4 contains a few final remarks.

2. Market power in oligopoly with financial markets

I wish to pursue the implications of market power for a firm which operates in an oligopolistic industry. The model dichotomizes into submodels of demand and cost, which I treat separately. As will be seen, the test for market power involves both the demand and cost sides of the firm's environment.

2.1. Demand

I begin with a model of an oligopoly of firms producing a standardized product, due to Clarke and Davies (1982) [and directly descended from Cowling and Waterson (1976)]. Somewhat later, with specific reference to the motor vehicle industry, I outline a demand model which allows for product differentiation.

For simplicity, let the (inverse) demand curve take a constant-elasticity form,

\[ P_i = a(Q_{-i} + Q_i)^{-1/\epsilon_{P}}, \tag{1} \]

where \( Q_{-i} \) is the combined output of all other firms in the industry.

The model must parameterize, in some way, the reactions which the firm expects from its rivals in response to its own actions. The easiest way to do this is to introduce as a parameter the elasticity which the firm assigns to rivals' output with respect to its own:¹

¹For theoretical work on conjectural variations, see Frisch (1933) and Hicks (1935); and more recently Bresnahan (1981); for empirical applications, see Cowling and Waterson (1976); Iwata (1974) (Japanese flat glass industry); Gollop and Roberts (1979) (U.S. coffee roasting industry); Rogers (1983) (U.S. steel industry); Geroski (1983) (U.S. cigarette industry). Here and in what follows, I will omit the subscript \( i \) unless clarity requires otherwise.
\[ \frac{Q_i}{Q_{-i}} \frac{dQ_{-i}}{dQ_i} = \alpha. \] \hfill (2)

Positive values of \( \alpha \) indicate that the firm expects its rivals to restrict output when it restricts output.

In this case, it is easy to show that the firm’s marginal revenue is

\[ MR = P \left\{ 1 - \frac{\alpha + (1 - \alpha)MS_i}{\varepsilon_{QP}} \right\}, \] \hfill (3)

where \( MS_i \) is the firm’s market share. On the usual definition, there is no exercise of power if the firm has no control over price, so there is no exercise of market power if

\[ \frac{\alpha + (1 - \alpha)MS_i}{\varepsilon_{QP}} = 0. \] \hfill (4)

This will be the basis for the test of market power which is implemented below. The test which is proposed here is a test of the difference between price and marginal revenue. If the difference between price and marginal revenue – the left-hand-side of (4) – is insignificantly different from zero, then a firm does not exercise market power. This test amounts to an estimation of the Lerner (1934) index of monopoly power, and is related to work of Appelbaum (1979, 1982), Bresnahan (1982), Lau (1982), and Ilmakunnas (1985).

2.2 Cost

A model which excludes financial markets cannot guide the specification of tests for market power based on rates of return to financial variables (such as the stock market value of the firm). For this reason, I develop here a model of firm operations which takes into account the firm’s costs in factor markets and the firm’s costs in financial markets. For ease of exposition, I proceed in two stages. First, I model the costs of a firm which raises funds for investment by selling bonds. Second, I expand this model to include the financing of investment by the sale of stock.

2.2.1. Bonds

Consider a firm which is a limited liability corporation, and finances investment by the sale of bonds. At the start of each period, the firm inherits a certain number of physical units of equity capital (\( K_E \)) from the past. This
is the initial capital risked by the owners of the firm. The firm purchases additional capital \( I \) at cost \( p_0^K \) per unit. The result is total capital \( K = K_e + I \) with an initial value of \( p_0^K \).

The investment is financed by the sale of bonds. The firm sells \( B \) one-period bonds for \$1 each, so \( B = p_0^K I \). If bankruptcy (to be defined presently) does not occur, all bonds are redeemed at the end of the period, and the firm pays each bondholder \$\( (1 + r) \) per bond.\(^3\) The firm then passes on a fraction \( 1 - \delta \) of its capital for use in the following period. \( \delta \) is the rate of true or economic depreciation of capital. If bankruptcy occurs, bond-holders divide up the end-of-period value of the firm, which includes the value of remaining assets and any funds remaining after the firm pays \( W \) per unit for \( L \) units of labor services.

If \( r^* \) is the rate of return on a safe asset, the present discounted value of the returns to the equity capital (equivalently, the value of the firm net of initial equity) is

\[
PDV = B - p_0^K + \frac{PQ_i - WL - (1 + r)B + (1 - \delta)p_1^K + \psi}{1 + r^*},
\]

where \( \psi \) is a random variable capturing beginning-of-period uncertainty about the end-of-period situation of the firm.\(^4\)

Combining terms in (5), one obtains

\[
PDV = \frac{PQ_i - WL - \lambda p_0^K - (r - r^*)B + \psi}{1 + r^*} = \frac{X + \psi - (r - r^*)B}{1 + r^*},
\]

where

\[
\lambda = r^* + \delta - (1 - \delta) \frac{p_1^K - p_0^K}{p_0^K}
\]

is the familiar rental cost of the services of a dollar’s worth of capital and

\[
X = PQ_i - WL - \lambda p_0^K
\]

\(^2\)Assuming capital assets are not sunk, the owners of the firm could always sell off capital inherited from the past and realize its value. For an extension of the model developed here to include sunk cost, see Martin (1988).

\(^3\)If the firm is not bankrupt, it will be able to ‘roll over’ bonds by selling just as many bonds at the start of the period as it redeemed at the end of the previous period. Thus the use of one-period bonds is not a restrictive specification.

\(^4\)PDV is the return to equity capital, but not the return to equity investors in the event of bankruptcy. Similar results, and in particular identical estimating equations, hold if uncertainty is made proportional to the size of the firm (for example, modeling uncertainty as a random return multiplied by the firm’s capital stock or the number of bonds sold).
is gross economic profit, before allowing for bond redemption or the uncertain portion of the firm’s return.

The opportunity cost per bond to the firm of bond financing is

\[(r - r^*)\]  \hspace{1cm} (9)

This is the difference between the rate of return which could have been earned on a safe asset and the interest rate the firm must pay to raise funds on the bond market.

The present-discounted sell-off value of the firm,

\[PDS = \frac{PQ_i - WL - (1 + r)B + (1 - \delta)p_1^i K + \psi}{1 + r^*},\]  \hspace{1cm} (10)

is the present value of the amount the firm could realize at the end of the period if it sold all assets. With a little manipulation, (10) becomes

\[PDS = p_0^k K_E + PDV = p_0^k K_E + \frac{X + \psi - (r - r^*)B}{1 + r^*}.\]  \hspace{1cm} (11)

Sell-off value differs from end-of-period value by the value of equity capital contributed by the firm’s owners, which is pledged to satisfy the firm’s obligations. The firm is bankrupt if its sell-off value at the end of the period, which depends on the realized value of \(\psi\), is negative. If the realized end-of-period value of the firm is negative, it is unable to redeem its bonds. There is a breakeven value of \(\psi\),

\[\psi^* = (r - r^*)B - X - (1 + r^*)p_0^k K_E,\]  \hspace{1cm} (12)

and for \(\psi \geq \psi^*\) the firm avoids bankruptcy; otherwise it does not. \(\psi^*\) is a function of \(K_E, L,\) and \(B\).

Let \(f(\psi)\) be the density function owners of the firm assign to the random variable \(\psi\). To describe the expectations of the owners of the firm, let

\[\pi_\psi = \int_{-\infty}^{\psi^*} f(\psi) \text{d}\psi, \quad \pi_\psi = \int_{\psi^*}^{\infty} f(\psi) \text{d}\psi, \quad E_\psi = \int_{-\infty}^{\psi^*} \psi f(\psi) \text{d}\psi.\]  \hspace{1cm} (13)

\(\pi_{\psi}\) is the probability owners of the firm assign to bankruptcy. \(\pi_{\psi}\) is the probability owners assign to the avoidance of bankruptcy. \(E_{\psi}\) is owners’ conditional expected value of \(\psi\), given that bankruptcy does not occur. The
functional dependence of \( \pi_-, \pi_+ \) and \( E_+ \) on \( K, L, \) and \( B \) follows from the functional dependence of \( \psi^* \) on these three choice variables of the firm.\(^5\)

Now assume that the owners of the firm maximize their expected present discounted return, which is

\[
B = p_0^k K + \frac{[PQ_i - WL - (1+r)B + (1-\delta) p_1^k K] \pi_+ + E_+}{1 + r^*}. \tag{14}
\]

The first term in (14) is funds raised through the sale of bonds at the start of the period. The second term in (14) is the value of capital – new investment and inherited from the past – committed to production.\(^6\) At the end of the period, the owners of the firm receive nothing if bankruptcy occurs. If bankruptcy is avoided, then the owners of the firm share in the net end-of-period cash flows. These cash flows must be discounted back to the beginning of the period. This is the third term in (14).

(14) is maximized subject to the constraint that investment be financed by the sale of bonds:

\[
B = p_0^k I = p_0^k K - p_0^k K_E. \tag{15}
\]

With some manipulation, (14) can be rewritten

\[
- p_0^k K_E \pi_- + \frac{[X - (r - r^*) B] \pi_+ + E_+}{1 + r^*}. \tag{16}
\]

If bankruptcy occurs, the owners of the firm lose the capital \( (K_E) \) which they committed to the firm at the start of the period. Otherwise, the return to owners of the firm is the expected present discounted value of the firm, after redeeming bonds, conditional on the fact that bankruptcy does not occur.

Write the owners’ constrained optimization problem as\(^7\)

\[
\max_{B, K, L} - p_0^k K_E \pi_- + \frac{[X - (r - r^*) B] \pi_+ + E_+}{1 + r^*} + \gamma(B + p_0^k K_E - p_0^k K). \tag{17}
\]

Derivation of the test for market power involves the first-order conditions

\(^5\)\( \psi^* \) appears in the limits of the integrals which define \( \pi_-, \pi_+ \), and \( E_+ \). Derivatives of \( \pi_-, \pi_+ \), and \( E_+ \) with respect to \( K, L, \) and \( B \) are assumed to exist.

\(^6\)Income is received from the sale of bonds, investment purchases are made, and capital \( K_E \) is committed at the start of the period whether or not bankruptcy occurs at the end of the period. The first two terms in (14) are not, therefore, multiplied by a probability term.

\(^7\)It is a consequence of Arrow’s (1964) myopia principle that even though the firm operates over many periods, its decisions may be analyzed one period at a time [see Martin (1984) for further discussion].
from (17). Take the derivative of (17) with respect to $B$, and solve the resulting first-order condition for $\gamma$, the Lagrangian multiplier associated with the finance constraint. Take the derivative of (17) with respect to $L$, which after some manipulation can be written

$$(MR)MPL = \left(\varepsilon_{rQ_i} \frac{rB}{Q_i}\right) MPL + w.$$  

(18)

$\varepsilon_{rQ_i}$ is the elasticity of the firm's interest rate with respect to output. This elasticity should be negative. The more output the firm produces, the more capital it will employ. The more capital the firm employs, the greater the value of assets which bondholders will be able to redeem in the unhappy event that bankruptcy occurs. The greater the value of assets which secure the firm's debt, the lower will be the interest rate which lenders require of the firm.

The optimal employment of labor equates the marginal revenue product of labor to the marginal cost of labor. The marginal cost of labor includes not only the wage cost of labor, but also the effect ($\varepsilon_{Q_i}(rB/Q_i)$) of increased output ($MPL$) on the interest rate on the firm's bonds.

Take the derivative of (17) with respect to $K$, and simplify using the previously obtained value for $\gamma$. The result is

$$(MR)MPK = \left(\varepsilon_{rQ_i} \frac{rB}{Q_i}\right) MPK + \lambda_B p^k,$$

(19)

where

$$\lambda_B = r_B + \delta - (1 - \delta) \frac{p^k - p_0^k}{p_0^k}$$

(20)

is the marginal rental cost of capital services to the firm and

$$r_B = (1 + \varepsilon_{rB})r$$

(21)

is the marginal cost of borrowed capital to the firm – the direct interest cost $r$ of the marginal bond sold plus the increase in interest on inframarginal bonds, $r\varepsilon_{rB}$ ($\varepsilon_{rB}$ is the elasticity of the firm's interest rate, $r$, with respect to the number of bonds issued, $B$).

When a firm finances investment by sale of bonds, the rental cost of capital which is relevant to the firm's output decision depends on the

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8 The same steps are followed, for a standard neoclassical model (i.e., no financing constraint) in Martin (1984). Derivation of the results described below is considerably simplified if one substitutes (12) into (17), to reformulate the constrained optimization problem in terms of $\psi^*$. 
marginal cost of capital to the firm, not the rate of return on a safe asset. In models which admit the possibility of bankruptcy, there is no dichotomy between ‘real’ and ‘financial’ decisions of the firm. The more the firm wishes to produce (e.g., in response to greater demand), the more capital it will wish to employ, all else equal. Expansion of the capital stock will mean the sale of bonds (and, as modeled below, shares of stock). Sale of bonds raises the interest rate the firm must pay and therefore the rental cost of capital services to the firm. Real and financial desisions of the firm cannot be separated [see Stiglitz (1972)].

To proceed from the first-order conditions for labor and capital to a test for market power, multiply the first-order condition for \( L \) by \( L \), the first-order condition for \( K \) by \( K \), and add. Using (3) to evaluate marginal revenue and the fact that the function coefficient, which is the conventional neoclassical index of returns to scale, can be written

\[
FC = \frac{K(MP_K) + L(MP_L)}{Q},
\]  

(22)

the weighted sum of the first-order conditions can be written

\[
\frac{PQ_i - WL}{PQ_i} = \left( 1 - FC + FC \frac{\alpha}{\varepsilon_{QP}} \right) + FC \frac{1 - \alpha}{\varepsilon_{QP}} MS_i + \lambda_B \frac{p^k K}{PQ_i} + FC e_{rQ_i} \frac{rB}{PQ_i}.
\]  

(23)

Taking \( WL \) as the cost of all variable factors, the left-hand side of (23) is the gross rate of return on sales revenue. This is comparable, analytically, to the familiar ‘price–cost margin’ computed from Census of Manufactures data. Variables on the right in (23) include several constant parameters, the ratio of the value of capital to sales, and the ratio of interest payments to sales. Treating the coefficients in (23) as parameters to be estimated yields a linear equation

\[
\frac{PQ_i - WL}{PQ_i} = a_0 + a_1 MS_i + a_2 \frac{p^k K}{PQ_i} + a_3 \frac{rB}{PQ_i}.
\]  

(24)

As we will see below, an estimate of (24) could be made to yield a statistic which is a test for the exercise of market power. But the model of cost which produces (24) is incomplete, because it does not allow for the possibility of raising funds through the sale of stock.

\(^9\)Values of the function coefficient greater than one indicate increasing returns to scale, values of the function coefficient less than one indicate decreasing returns to scale.
2.2.2. Stocks and bonds

Suppose now that the original owners of the firm own \( S_E \) shares of stock at the beginning of the period.\(^{10}\) They raise funds for investment by sale of bonds, as above, but also by sale of \( S_N \) new shares of stock, each sold at price \( m \). The present discounted value of the firm is then

\[
PDV = B + mS_N - p_0^k K + \frac{PQ_i - W - (1 + r)B + (1 - \delta)p_1^k K + \psi}{1 + r^*}
\]

\[
= mS_N + \frac{X + \psi - (r - r^*)B}{1 + r^*},
\]

(25)

[which may be compared with (6)]. \( X \) continues to be given by (8). Again, the firm is bankrupt if its present-discounted sell-off value is negative. The breakeven value of \( \psi \) is now

\[
\psi^* = (r - r^*)B - X - (1 + r^*)(p_0^k K_E + mS_N).
\]

(26)

All else equal, this is larger in magnitude than in the previous model. Funds raised on the stock market help the firm avoid bankruptcy.

The original owners of the firm are assumed to select \( L, K, B, \) and \( S_N \) to maximize the expected value of their return, which is

\[
B + mS_N - p_0^k K + \frac{S_E}{S_E + S_N} \frac{[PQ_i - W - (1 + r)B + (1 - \delta)p_1^k K] \pi_\ge + E_\ge}{1 + r^*}.
\]

(27)

If bankruptcy is avoided, the original owners of the firm are entitled to only a fraction of the end-of-period worth of the firm. The remainder is claimed by the new shareholders. The cost to the original shareholders of raising funds through the sale of stock is the dilution of their ownership of the firm.

After some manipulation, the optimization problem of the original owners can be written

\[
\max - \frac{S_N}{S_E + S_N} p_0^k K_E
\]

\(^{10}\)The choice of units in which stock is measured is arbitrary. Setting \( S_E = K_E \) would mean the original owners of the firm received one share of stock for each unit of capital contributed. Setting \( S_E = p_0^k K_E \) would mean that the original owners of the firm received one share of stock for each dollar's worth of capital contributed. Choice of normalization does not affect the results of the analysis which follows.
\[
\begin{aligned}
  & + \frac{S_E}{S_E + S_N} \left\{-p_0^k K_E \pi_\gamma + \frac{[X + (1 + r^*) m S_N - (r - r^*) B] \pi_\gamma + E_\gamma}{1 + r^*} \right\} \\
  & + \gamma [B + m S_N + p_0^k K_E - p_0^k K]. \\
\end{aligned}
\] (28)

The first term in (28) is the portion of the value of capital contributed by the original owners of the firm (\(K_E\)) which is given over to new shareholders. Whether bankruptcy occurs or not, this is lost to the original owners of the firm. The second term, which includes as a factor the share original owners retain in the firm, is similar to (16), but allows for receipts from the sale of stock. The second term in (28) includes the loss of original capital if bankruptcy occurs, and the returns received if bankruptcy is avoided. The financing constraint

\[
B + m S_N + p_0^k K_E = p_0^k K
\] (29)

is that investment must be financed by the sale of stock or bonds.

When a firm can raise funds by the sale of stock as well as bonds, the marginal cost of capital to the firm is

\[
r_{SB} = \frac{(1 + \varepsilon_{rB}) r - \varepsilon_{mB} (m S_N / B)}{1 + \varepsilon_{mB} (m S_N / B)}. \\
\] (30)

This includes the marginal bond rate, \((1 + \varepsilon_{rB}) r\), which appeared in the previous model. But there is now an additional cost to selling bonds. All else equal, the more bonds are sold, the more likely is bankruptcy. The more likely is bankruptcy, the lower the price (.m) at which the firm will be able to sell shares of stock. Thus in (30), \(\varepsilon_{mB}\) is the elasticity of the price of stock with respect to the number of bonds sold, and \(\varepsilon_{mB} (m S_N / B)\) is the marginal loss on the sale of stock as the number of bonds sold increases.

Using \(r_{SB}\) as the marginal cost of capital to the firm, the marginal rental rate of capital services is

\[
\lambda = r_{SB} + \delta - (1 - \delta) \frac{p_1^k - p_0^k}{p_0^k}. \\
\] (31)

Proceeding as in the previous model, one obtains a price–cost margin equation

\[
\frac{P Q_i - W L}{P Q_i} = \left(1 - FC + FC \frac{\alpha}{\varepsilon_{QP}}\right) + FC \frac{1 - \alpha}{\varepsilon_{QP}} MS_i + \lambda_{SB} \frac{p_0^k K}{P Q_i} + FC r_{ SB}, \frac{r B}{P Q_i}
\]
\[ -FC(1 + r_{SB})\varepsilon_{mQ_i} \frac{mS_N}{PQ_i}. \] 

(32)

\( \varepsilon_{mQ} \) is the elasticity of the price of stock with respect to the firm's output. An increase in output will make bankruptcy less likely (as noted above, an increase in output should reduce the firm's interest rate), and therefore increase the price of the firm's stock. In this event \( \varepsilon_{mQ} \) will be positive. Eq. (32) leads to a linear equation,

\[ \frac{PQ_i - WL}{PQ_i} = a_0 + a_1 MS_i + a_2 p_i^h K \frac{rB}{PQ_i} + a_3 \frac{mS_N}{PQ_i}, \] 

(33)

which, like (24), can be made to yield a test for the exercise of market power.\(^{11}\)

2.3. A test for market power

Assuming an error term with the usual properties, (33) can be estimated with time series data for a firm if the coefficients of the right-hand side variables are treated as parameters to be estimated. Sometimes this will be a plausible assumption and sometimes it will not. I show below that it is possible to allow for changes in the coefficients within a sample period.

I have written (33) in terms of the 'price–cost margin' to emphasize the relation of the test for market power yielded by this model to the received literature. In this formulation, the price–cost margin emerges as appropriate for the diagnosis of market power because the model predicts how market power will affect the price–cost margin, not because the price–cost margin is a proxy for the internal rate of return or any other 'ideal' rate of return.

One can easily obtain expressions for other common notions of the rate of return – such as a gross rate of return on capital – by simple algebraic transformations of (33).\(^{12}\) This model, which includes real and financial activities of the firm, does not yield any particular rate of return as 'correct'

\(^{11}\)Using a standard model of taxes [for example, Musgrave and Musgrave (1984, pp. 664–665)], one can reach the estimating equation in a model which allows for arbitrary tax treatments of depreciation and investment tax credits. The main effect of the more elaborate model is to alter the marginal conditions for employment of capital. The important point here is that accounting conventions and tax rules do not prevent the analysis of rates of return for the presence or absence of market power. Details of the extended model are available from the author on request.

\(^{12}\)For example, multiply (33) through by the ratio of sales revenue to value of capital stock to obtain the specification appropriate for analysis of the gross rate of return on capital. Note that this specification will include the ratio of sales revenue to value of capital – a sort of turnover rate – as an explanatory variable. This variable has been omitted in studies which use the rate of return on capital as a measure of profitability.
for the analysis of market power. It does show that the choice of a measure of market power implies an appropriate specification of explanatory variables.

From (4), if a firm exercises market power we will find

$$\frac{\alpha + (1-\alpha)MS_i}{\varepsilon_{QP}} > 0$$ \hspace{1cm} (34)

in a statistical sense. But the expression on the left in (34) cannot be estimated, since the parameters estimated in (33) are defined in terms of the function coefficient ($FC$) as well as $\alpha$ and $\varepsilon$. Since

$$a_0 + a_1MS_i = 1 - FC + FC \frac{\alpha}{\varepsilon_{QP}} + FC \frac{1-\alpha}{\varepsilon_{QP}} MS_i,$$ \hspace{1cm} (35)

it follows that

$$\frac{\alpha + (1-\alpha)MS_i}{\varepsilon_{QP}} = 1 - \frac{1-(a_0 + a_1MS_i)}{FC},$$ \hspace{1cm} (36)

and (34) is satisfied if and only if

$$a_0 + a_1MS_i > 1 - FC,$$ \hspace{1cm} (37)

in a statistically significant sense.

From (37), it appears that in order to judge the presence or absence of market power, it is necessary to make a specific assumption about the nature of returns to scale. This is always the case: usually it is dealt with by assuming, implicitly or otherwise, constant returns to scale. One advantage of the approach developed here is that it shows explicitly how returns to scale affect a test for market power when they are not constant.

The greater are returns to scale – the greater is the function coefficient – the more likely is it that a firm possesses market power, all else equal. There is an intuitively plausible reason for this. The greater are returns to scale, all else equal, the more is it in the interest of the firm to increase output, which will reduce average cost. To increase output, the firm must sell more, and in a model such as this, the firm must lower price to sell more. The greater are
returns to scale, the lower the price-cost margin which a profit-maximizing firm will accept.

2.4. Other aspects of the model

For simplicity, I have omitted advertising and research and development from the model. By extending the model along Dorfman–Steiner lines, one can show that profitability should be measured gross of advertising expense.\textsuperscript{13} A similar argument applies to product-differentiating R & D.

3. Empirical results

3.1. Samples

I have estimated the model outlined above, using data for 4 U.S. firms which operate in the medical–surgical supplies industry and 4 U.S. firms which operate in the motor vehicle industry. The estimation uses quarterly data for the period 1973.1 through 1982.4. In some cases, fewer observations were available, but never less than 36. All firm-specific variables except capital stock were taken from Compustat data tapes, and are described, firm by firm, in an appendix which is available on request. Market share data combines information on firm sales with industry sales figures taken from trade sources or U.S. Bureau of the Census publications. The nature of the publicly available data compels me to test the model for firms as a whole, and with market share estimates defined on a national basis. The model developed here can be extended to deal with a firm which is diversified over products or regions. Carefully tailored document requests will be able to generate such data in antitrust proceedings.

I have noted elsewhere [Martin (1984)] my agreement with the argument of Fisher and McGowan (1983) that accounting measures of the value of capital stock are likely to be inaccurate. The capital stock values used for this study were derived by taking the Valueline accounting figure for 1969 capital stock, assuming depreciation according to the depreciation rates of Hulten and Wycoff (1981),\textsuperscript{14} adjusting for inflation according to the GNP deflator, and using Valueline figures for investment.\textsuperscript{15,16}

\textsuperscript{13}Sawyer (1982) makes this observation.

\textsuperscript{14}Assuming also that capital goods were purchased in the proportion indicated in the 1972 Capital Flows Table produced in connection with the 1972 Input–Output Tables for the United States.

\textsuperscript{15}In contrast to Compustat data [Thies and Revsine (1977)], Valueline reports assets acquired through merger or acquisition.

\textsuperscript{16}Verma (1986) examines the robustness of the results of tests of structure–performance relationships to the use of alternative measures of capital stock; results appear not to be particularly sensitive to the use of alternative accounting conventions.
3.2. Estimates

Table 1 reports estimates of eq. (33) for the firms studied here, and various related statistics.\(^{17}\)

In 7 of 8 cases, the intercept term is highly significant. The coefficient of market share is significantly negative in 2 cases. For these firms there is generally little variation in market share over the sample period, which makes the estimate of the coefficient of market share imprecise. As will be seen below, the test for market power depends on a combination of the first two coefficients, which can be estimated precisely even if its components are not.

The coefficient of the capital-sales ratio is an estimate of the marginal rental cost of capital to the firm. This coefficient is negative and significant for 4 of the 8. These results are counter-intuitive but not entirely without precedent. Structure–performance studies using the Federal Trade Commission’s disaggregated Line of Business data base have generally found negative coefficients for the capital-sales ratio in studies of the price–cost margin and other measures of profitability.\(^{18}\)

The coefficient of the interest payment-sales ratio should have the same sign as the elasticity of the firm’s interest rate with respect to its own output. As indicated above, this elasticity should be negative. The estimates of this coefficient are negative but insignificant for 3 firms, positive and significant for 2 firms.

The coefficient of the value of new shares-sales ratio should have a sign opposite that of the elasticity of the price of stock with respect to the firm’s output. \(e_{mQ}\) should be positive, and the estimates of \(a_4\) should be negative. The estimates reported are negative but insignificant for four firms and positive and significant for one firm.\(^{19}\)

Using the usual \(F\)-test, the coefficients of the two financial-market variables are jointly significant at the 5 percent level for three of the firms tested here: American Hospital Supply Corporation, C.R. Bard, and General Motors. For the remaining firms, the results of a test for market power seem

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\(^{17}\)The estimates of table 1 are obtained by ordinary least squares. The model developed here could be embedded in a more general model in which the right-hand variables would be treated as endogenous.

\(^{18}\)See Martin (1983) and Ravenscraft (1983) for examples. These results are not due to the inclusion of the financial cost variables as explanatory variables. If \(rB/PQ\) and \(mS_n/PQ\) are omitted as right-hand side variables, the estimated coefficient of the capital-sales ratio is significantly negative for all firms except American Hospital Supply Corporation. It is also possible that the result should be taken at face value. The rental cost of capital services may be negative if there is an investment tax credit. In such a case, the rising interest cost of borrowing as the firm increased investment would limit the optimal use of capital.

\(^{19}\)It is tempting to appeal to a lack of variability in \(mS_n/PQ\) as a source of these results, but this is plausible only for the automobile companies. The hospital supply companies engaged in an active pattern of acquisitions over the same period, often financed by the issuance of stock. They also engaged in occasional stock buybacks, producing negative values of \(mS_n/PO\).
<table>
<thead>
<tr>
<th>Firm</th>
<th>Intercept</th>
<th>$MS$</th>
<th>$p^K/PQ$</th>
<th>$rB/PQ$</th>
<th>$mS\alpha/PQ$</th>
<th>$R^2$</th>
<th>$MS$</th>
<th>$a_0 + a_1 MS$</th>
<th>min FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical–surgical supplies</td>
<td>0.1815</td>
<td>-0.2377</td>
<td>-0.0321</td>
<td>1.8495</td>
<td>-0.0246</td>
<td>0.2597</td>
<td>0.2824</td>
<td>0.1144</td>
<td>0.94</td>
</tr>
<tr>
<td>American Hospital Supply</td>
<td>(4.509)</td>
<td>(2.2306)</td>
<td>(1.2553)</td>
<td>(1.9315)</td>
<td>(1.2866)</td>
<td></td>
<td></td>
<td>(4.4566)</td>
<td></td>
</tr>
<tr>
<td>Baxter–Travenol</td>
<td>0.4929</td>
<td>-0.6502</td>
<td>-0.1207</td>
<td>-0.6421</td>
<td>-0.0096</td>
<td>0.4647</td>
<td>0.1511</td>
<td>0.3947</td>
<td>0.74</td>
</tr>
<tr>
<td>(4.7882)</td>
<td>(2.1294)</td>
<td>(3.6588)</td>
<td>(1.8460)</td>
<td>(0.3857)</td>
<td></td>
<td></td>
<td></td>
<td>(6.7277)</td>
<td></td>
</tr>
<tr>
<td>Becton–Dickinson</td>
<td>0.2632</td>
<td>-0.3193</td>
<td>-0.0427</td>
<td>-0.7607</td>
<td>0.0408</td>
<td>0.5447</td>
<td>0.1161</td>
<td>0.2261</td>
<td>0.82</td>
</tr>
<tr>
<td>(6.0125)</td>
<td>(1.2488)</td>
<td>(1.3995)</td>
<td>(0.7587)</td>
<td>(1.9642)</td>
<td></td>
<td></td>
<td></td>
<td>(9.8900)</td>
<td></td>
</tr>
<tr>
<td>C.R. Bard</td>
<td>0.0797</td>
<td>0.6921</td>
<td>0.0499</td>
<td>2.1190</td>
<td>0.0509</td>
<td>0.4344</td>
<td>0.0320</td>
<td>0.1019</td>
<td>0.99</td>
</tr>
<tr>
<td>(1.1030)</td>
<td>(0.4893)</td>
<td>(1.0030)</td>
<td>(3.6812)</td>
<td>(0.8968)</td>
<td></td>
<td></td>
<td></td>
<td>(2.5667)</td>
<td></td>
</tr>
<tr>
<td>Motor vehicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Motors</td>
<td>0.2130</td>
<td>-2.4777</td>
<td>-0.2086</td>
<td>2.8948</td>
<td>-0.2604</td>
<td>0.5831</td>
<td>0.0193</td>
<td>0.1653</td>
<td>0.90</td>
</tr>
<tr>
<td>(3.9117)</td>
<td>(1.3784)</td>
<td>(4.4259)</td>
<td>(1.1831)</td>
<td>(0.9866)</td>
<td></td>
<td></td>
<td></td>
<td>(5.9006)</td>
<td></td>
</tr>
<tr>
<td>Chrysler</td>
<td>0.2104</td>
<td>-0.6277</td>
<td>-0.0850</td>
<td>-1.9492</td>
<td>0.0245</td>
<td>0.5455</td>
<td>0.0974</td>
<td>0.1492</td>
<td>0.98</td>
</tr>
<tr>
<td>(2.0245)</td>
<td>(1.2391)</td>
<td>(1.3426)</td>
<td>(1.1551)</td>
<td>(0.0170)</td>
<td></td>
<td></td>
<td></td>
<td>(2.6077)</td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>0.2809</td>
<td>-0.1111</td>
<td>-0.1758</td>
<td>1.1966</td>
<td>-0.6812</td>
<td>0.5909</td>
<td>0.2592</td>
<td>0.2521</td>
<td>0.83</td>
</tr>
<tr>
<td>(4.4691)</td>
<td>(0.5113)</td>
<td>(4.2467)</td>
<td>(0.6652)</td>
<td>(1.1575)</td>
<td></td>
<td></td>
<td></td>
<td>(7.2067)</td>
<td></td>
</tr>
<tr>
<td>General Motors</td>
<td>0.3596</td>
<td>-0.0785</td>
<td>-0.2654</td>
<td>7.8220</td>
<td>1.0226</td>
<td>0.8007</td>
<td>0.3946</td>
<td>0.3286</td>
<td>0.72</td>
</tr>
<tr>
<td>(6.5910)</td>
<td>(0.7142)</td>
<td>(9.5480)</td>
<td>(6.9200)</td>
<td>(0.5487)</td>
<td></td>
<td></td>
<td></td>
<td>(15.2722)</td>
<td></td>
</tr>
</tbody>
</table>

* $MS$ is mean market share; $t$-statistics in parentheses.
unlikely to be affected by a failure to control for the impact of financial markets on cost. An alternative interpretation (pursued below for the motor vehicle firms) is that values of the coefficients shifted within the sample period.

3.3. Testing for market power

The final two columns of table 1 contain the statistics which are of interest from the point of view of tests of market power. The next-to-last column contains an estimate of the left-hand side of (37), evaluated at the sample-mean value for market share. The $t$-statistic is computed on the null hypothesis that the true value of the statistic is zero, which is the test for a marginal revenue above price if the value of the function coefficient is one.

Assuming constant returns to scale, none of the firms studied here fails to exercise some degree of market power. Given the levels of concentration and product differentiation in these industries, a finding of power to control price among the largest firms is not implausible.

For sufficiently small values of the function coefficient, the observed returns may reflect diseconomies of large-scale operation, not market power. The final column of table 1 gives the smallest value of the function coefficient for which the estimates imply market power with at least a 1 percent degree of significance. The conclusion one would draw about two firms is sensitive to what one thinks about the nature of returns to scale. If either C.R. Bard or Chrysler operate with only slightly decreasing returns to scale ($\text{FC} < 0.99$), then the results reported here would not support a finding of market power.

3.4. Extensions: Motor vehicles

3.4.1. Quotas

It may be objected that the estimates for the automobile industry mix time periods over which there was a structural change: import quotas were imposed on automobiles in the first quarter of 1981, within the sample period. I have re-estimated (33) with an intercept dummy taking the value one during the quota period, and zero otherwise, and also with a right-hand side variable defined as the product of this quota dummy and market share. This allows estimates of the market power statistic before and after the imposition of quotas. The resulting market power statistics are given in table 1. 

---

20 The familiar 'numbers equivalent' from approximate Herfindahl indices computed from the market share estimates used here suggest a level of concentration consistent with about 8.5 'equal sized' firms in medical–surgical supplies and about 4.3 'equal sized' firms in motor vehicles (market share estimates for motor vehicles include foreign suppliers).

21 The extent of product differentiation in the motor vehicle industry is too well known to require discussion. Service by salesmen and detail men is an important product differentiating activity in the medical–surgical supply industry; see Martin and Goddes (1985).
Table 2
Pre- and post-quota market power statistics, motor vehicles.*

<table>
<thead>
<tr>
<th></th>
<th>Pre-quota</th>
<th>Post-quota</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Motors</td>
<td>0.1673</td>
<td>0.2701</td>
</tr>
<tr>
<td></td>
<td>(5.3378)</td>
<td>(4.0517)</td>
</tr>
<tr>
<td>Chrysler</td>
<td>0.2278</td>
<td>0.3855</td>
</tr>
<tr>
<td></td>
<td>(5.7013)</td>
<td>(4.6064)</td>
</tr>
<tr>
<td>Ford</td>
<td>0.2524</td>
<td>0.2586</td>
</tr>
<tr>
<td></td>
<td>(6.9887)</td>
<td>(6.5904)</td>
</tr>
<tr>
<td>General Motors</td>
<td>0.3422</td>
<td>0.4242</td>
</tr>
<tr>
<td></td>
<td>(18.3723)</td>
<td>(12.8177)</td>
</tr>
</tbody>
</table>

*Estimates of $a_0 + a_1 \bar{M}S$, allowing for changes in intercept and slope after imposition of import quotas.

2. In every case, the estimate of the difference between price and marginal revenue (assuming constant returns to scale) increases after the imposition of quotas, although the change for Ford is minimal.

3.4.2. Product differentiation

The cost model developed in section 2.2 may be paired with any model of demand to derive a test for power to control price. I present one such model here, and test it for the motor vehicle industry.

This model is based on the product-differentiation model of Spence (1972). Suppose General Motors faces a demand curve of the form\(^{22}\)

$$P_{GM} = a - b(\theta_A q_A + \theta_C q_C + \theta_F q_F + \theta_M q_M) - bq_{GM},$$

(38)

where \(q\) indicates number of motor vehicles sold and subscripts \(A, C, F, M,\) and \(GM\) denote American Motors, Chrysler, Ford, importers, and General Motors, respectively. The \(\theta\) parameters measure the degree of product differentiation between the motor vehicles of the indicated producer and those of General Motors. If \(\theta_F = 1\), sale of an additional car by Ford reduces the price General Motors receives for its cars by just as much \((b)\) as sale of an additional car by General Motors. In this case, Ford cars and General Motors cars are perfect substitutes. If \(\theta_F = 0\), sale of an additional car by Ford does not affect the price General Motors receives for its cars. General Motors cars are then completely differentiated from Ford cars. The remaining product-differentiation parameters are subject to a similar interpretation.

The marginal differentiation parameter is then

\(^{22}\)There is no need to assume a linear demand curve to reach the estimating equation which
\[ MR = P \left\{ 1 - \frac{1}{\varepsilon} \left[ 1 + \theta_A \alpha_A \frac{q_A}{q_{GM}} + \theta_C \alpha_C \frac{q_C}{q_{GM}} + \theta_F \alpha_F \frac{q_F}{q_{GM}} + \theta_M \alpha_M \frac{q_M}{q_{GM}} \right] \right\}, \]  

(39)

where \( \alpha_A \) is the conjectural variation ascribed by General Motors to American Motors, and so on. Using the expression for marginal revenue with the cost model developed in section 2.2 one obtains a gross price–cost margin equation

\[
\frac{PQ - WL}{PQ} = 1 - FC + \frac{FC}{\varepsilon} + \Xi \left[ \theta_A \alpha_A \frac{q_A}{q_{GM}} + \theta_C \alpha_C \frac{q_C}{q_{GM}} + \theta_F \alpha_F \frac{q_F}{q_{GM}} + \theta_M \alpha_M \frac{q_M}{q_{GM}} \right] + \cdots,
\]

(40)

and remaining terms which are identical to the final terms in (32). From (40), one obtains an estimating equation

\[
\frac{PQ - WL}{PQ} = a_0 + a_A(q_A/q_{GM}) + a_C(q_C/q_{GM}) + a_F(q_F/q_{GM}) + a_M(q_M/q_{GM}) + \cdots,
\]

(41)

with additional explanatory variables identical to those in (33). In the context of this model, General Motors exercises market power if and only if

\[ a_0 + a_A(q_A/q_{GM}) + a_C(q_C/q_{GM}) + a_F(q_F/q_{GM}) + a_M(q_M/q_{GM}) > 1 - FC, \]  

(42)

in a statistically significant sense. I have estimated this model for the four automobile firms, using vehicle sales data from Ward’s Automotive Yearbook, and lumping all foreign suppliers together as ‘imports’. The implied market power statistics are reported in table 3, and they are very much the same as those contained in table 1. For the automobile industry, results seem robust to an explicit treatment of product differentiation.

4. Conclusion

Economists are often called upon to offer opinions about the presence or

\[ ^{23} \] Foreign suppliers which opened U.S. plants during the sample period were combined with
Table 3
Market power statistics, product-differentiation model.*

<table>
<thead>
<tr>
<th></th>
<th>Market power statistic</th>
<th>min FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Motors</td>
<td>0.1242 (4.1764)</td>
<td>0.9479</td>
</tr>
<tr>
<td>Chrysler</td>
<td>0.1906 (3.3980)</td>
<td>0.9453</td>
</tr>
<tr>
<td>Ford</td>
<td>0.2312 (6.4542)</td>
<td>0.8556</td>
</tr>
<tr>
<td>General Motors</td>
<td>0.2414 (10.4971)</td>
<td>0.7374</td>
</tr>
</tbody>
</table>

*min FC is the smallest value of the function coefficient for which the estimated difference between marginal revenue and price is significant at the 1 percent level.

absence of market power. Sometimes these opinions are offered to public officials who must decide whether or not to challenge a merger or some sort of strategic behavior. Sometimes they are offered as expert testimony in antitrust cases. For better or worse, such opinion has been a matter of judgement, involving subjective evaluation of the degrees of market power based on market share, entry conditions, product differentiation, and so on.²⁴

Fisher (1984, p. 516) interprets his joint work with John McGowan as 'making it harder for economists to give loose but pontificating testimony for which there is no solid analytic foundation'. This it does, and that is a worthwhile contribution. But the force of Fisher and McGowan's work is entirely negative, criticizing received approaches without offering any alternative.

The model presented above suggests that it is incorrect to argue that market power cannot be analyzed using accounting rates of return because accounting rates of return are a poor proxy for the internal rate of return.²⁵ Using a relatively straightforward, although detailed, model of firm behavior, we can predict the impact of market power on accounting rates of return. Since we can predict the impact of market power on accounting rates of return, we can analyze accounting rates of return for the presence or absence of market power. In the analysis of market power, the relationship – or lack

²⁴See Areeda and Turner (1978, Ch. 5) and Landes and Posner (1981).
²⁵Kay and Mayer (1986) suggest that Fisher and McGowan have seriously overstated even this part of their case.
of relationship – between accounting rates of return and the internal rate of return is simply a red herring.

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