Cost of Capital and Market Power: The Effect of Size Dispersion & Entry Barriers on Market Equilibrium

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ABSTRACT. A market power explanation for the observed empirical fact that large firms in a given industry pay less for their capital than small is developed. Larger firms in an industry are shown to pay less for their capital than small because they have more control over the market and the riskiness of their divided stream is correspondingly smaller. More firms in an industry with a given size dispersion raises the cost of capital to the incumbents, but proportionately more to smaller firms. However, the most significant result is that a greater dispersion of sizes will reduce the riskiness of the dividend stream of the larger firm and increase the riskiness of the smaller firm, causing an increase in the dispersion of capital costs. Hence product market power enhances capital cost efficiencies.

1. Introduction

Several papers have recently examined the relation between the firm's cost of capital and its product market power. (Thomadakis (1976), Subrahmanyam and Thomadakis (1980), Conine (1983), and Cheng, Chen and Hite (1986).[1]) The main conclusion to emerge from these studies is that market power lowers the cost of capital to the firm whose market power has increased. This is an important theoretical insight, but the models used to generate it lack economic sophistication. Most analyses assume either a partial equilibrium framework or a general equilibrium approach using the extremes of perfect competition or monopoly. Very little is said about the effects on the cost of capital of differences in firm size within an industry or of market power changes under the empirically dominant market form, viz., *oligopoly*. A clear picture of the interrelationships between a firm's cost of capital and industry structure and dynamics is thus missing.[2]

The present paper addresses these issues by analysing the effects of two specific components of market power on incumbent firms' cost of capital, namely, firm numbers and size dispersion. For industrial policy-makers particular interest centres on whether, as intuition would suggest, larger firms in an industry pay more for their capital than smaller, whether the entry of new firms into an industry of given size dispersion increases the cost of capital to incumbent firms, and whether a greater degree of inequality for given industry size reduces the cost of capital of large firms relative to small. The present paper provides an insight into each of these issues. In the context of the Cournot equal costs model the effects of entry on the firm's cost of capital are examined. The Stackelberg Dominant firm model is employed to look at the effects of increasing size dispersion.

The remainder of the paper is structured as follows. Section 2 develops the Cournot model and its implications for the cost of capital. Section 3 performs the same task using Dominant firm analysis. Section 4 summarises the findings, concludes and indicates directions for future research. An Appendix provides an exposition of the basic CAPM results under monopoly.

2. The Cournot Model

The structure of the firm's optimisation problem is the same for each of the n quantity-choosing oligopolists. Firms operate with a single period horizon. Each firm faces constant returns-to-scale

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in production and a linear demand curve. Each takes its rivals' output as given and chooses its own output to maximise own equity value. The strategy for examining cost of capital effects is to convert the problem of equity maximisation under uncertainty into its certainty-equivalent problem, using the capital market equilibrium conditions of the CAPM, and then to employ standard maximisation techniques. Comparative static results of varying industry numbers on the firm's cost of capital are then easily obtained.

Product market equilibrium

Oligopolist i has operating future cash-flow profits $\tilde{\pi}_i$ given by

$$\tilde{\pi}_i = (\tilde{p} - w\alpha)q_i, \tag{1}$$

where
$\tilde{p} = p(q)(1 + \tilde{e})$
$q = \sum_i^n q_i$ = industry output
q_i = output of firm i
$\tilde{e}$ = white noise
w = constant wage rate
α = constant labour input per unit of firm's output

We assume for simplicity that $p(q)$ takes the linear form

$$p(q) = a - bq, \quad a, b > 0. \tag{2}$$

The CAPM gives the market value of the firm's end-of-period operating cash-flow, V_i, as

$$V_i = [\bar{\pi}_i - \lambda \mathrm{cov}(\tilde{\pi}_i, \tilde{R}_m)]/(1 + r), \tag{3}$$

where
$\bar{\pi}_i = E\tilde{\pi}_i$ = expected operating profits of firm i
λ = market price of covariant risk
r = safe rate of return
$\tilde{R}_m$ = uncertain return on the Market portfolio[3]
$\sigma_{em} = \mathrm{cov}(\tilde{e}, \tilde{R}_m)$ = systematic risk of $\tilde{e}$.

(see Appendix). This yields by substitution from 1:

$$V_i = [\phi p - w\alpha)/(1 + r)]q_i, \ \phi = 1 - \lambda\sigma_{em}. \tag{4}$$

We assume the covariance term is positive in what follows.

Firm's certainty-equivalent problem

At the beginning of the period the Cournot firm uses the market's evaluation ϕ in equation 4 as input to the following certainty-equivalent optimisation problem:

$$\begin{aligned} \max_{q_i} \mathrm{NPV}_i &= V_i - K_i \\ &= [\phi p - (w\alpha + (1 + r)\delta)]q_i/(1 + r) \end{aligned} \tag{5}$$

where $K_i = \delta q_i$, $\delta > 0$ is the firm's current borrowing. The (interior) optimum requires that

$$\frac{\phi[p + p'(q)] - w\alpha}{1 + r} = \delta. \tag{6}$$

Note that equation 6 defines the ith firm's reaction function showing its optimal output given the outputs of its $n - 1$ competitors. It also generates a demand for capital which will be supplied by the market at a risk premium to be determined below.

Product Market equilibrium

Solving these n equations simultaneously we find that the Cournot output per firm is

$$\begin{aligned} q_c &= (a - \xi)/(n + 1)b, \\ \xi &= [w\alpha + (1 + r)\delta]/\phi. \end{aligned} \tag{7}$$

The industry output is therefore n times this:

$$q = nq_c = (a - \xi)n/(n + 1)b. \tag{8}$$

Industry price is obtained by substitution of 8 in the demand function:

$$p_c = (a + n\xi)/(n + 1). \tag{9}$$

Finally the maximised discounted market value of the firm's operating cash-flow is obtained by substituting 7 and 9 into 4:

$$V_c = \frac{\{\phi[a + n\xi] - (n + 1)w\alpha\}(a - \xi)\}}{(n + 1)^2(1 + r)b}. \tag{10}$$

It is routine to show using equations 7–10 that entry reduces Cournot industry price (by increasing industry output), and decreases firm output, borrowing requirements and operating value.

3. Entry and the firm's cost of capital

Considering now effects of entry on the firm's cost of capital, the firm's Beta or standardised measure of risk is given by

$$\beta_c = \mathrm{cov}(\tilde{R}_c, \tilde{R}_m)/\sigma_m^2, \tag{11}$$

where

$\tilde{R}_c = \tilde{\pi}_c/V_c - 1$ = (random) rate of return on firm's equilibrium operating cash-flow given the market valuation of that cash-flow V_c,

$\tilde{\pi}_c$ = (random) equilibrium operating profits of a firm,

using the Cournot equilibrium conditions derived in equations 7–10 above equilibrium Beta for the firm can be written as

$$\beta_c = p_c q_c \sigma_{em}/V_c \sigma_m^2. \tag{12}$$

The effects of changes in n on a firm's Beta are then easily obtained.

We have by definition of V_c

$$V_c = \phi p_c q_c/(1 + r) - w\alpha q_c/(1 + r) \tag{13}$$

Solving 12 for q_c, plugging into 13 and rearranging we get

$$\beta_c = \sigma_{eM}(1 + r)/\sigma_M^2(\phi - w\alpha/p) \tag{14}$$

Differentiating this expression with respect to n yields

$$\partial\beta_c/\partial n = -Aw\alpha[\phi - w\alpha/p_c]^{-2}p_c^{-2}\partial p_c/\partial n,$$
$$A = \sigma_{eM}(1 + r)/\sigma_M^2 \tag{15}$$

Since from 9 p_c is decreasing in n, 15 shows that Beta is increasing in n.

In other words *a smaller(larger) number of firms lowers(raises) the financial risk to individual firms*. This effect operates through changes in the covariance component of cash-flow as output of the firm is changed in response to exit/entry.

However, via the equation of the CAPM the Cournot firm's *equilibrium* cost of capital is given by[4]

$$E\tilde{R}_c = \beta_c[E\tilde{R}_m - r] + r \tag{16}$$

We conclude that: *a larger number of firms will, via the effect on* β, *raise the individual Cournot firm's cost of capital.*

4. The Dominant firm model

The model in this section assumes an industry with one large firm (the Dominant firm) and n small firms (the Fringe). Firms are quantity-setters with the Dominant firm acting as a Stackleberg leader. The former sets its output subject to the reaction function of the Fringe, and the latter, acting as Cournot competitors with respect to the Dominant firm, take its output as given and maximise profits with respect to their own output.

Firms operate with a single period horizon. Production is constant returns to scale. The Dominant firm is assumed to be able to maintain its long run position through possession of superior technology allowing lower inputs per unit of output than the Fringe. As with the Cournot market a firm's end-of-period cash-flow is fixed by its beginning-of-period choice of production technique or quantity of capital (K, and K_i for Dominant and Fringe respectively). Capital is chosen to maximise the present value of its expected net cash flow i.e. the firm's equity value.

To be specific, Fringe firm i and the Dominant firm have operating future cash-flow profits $\tilde{\pi}_i$ and $\tilde{\pi}_d$ given by

$$\begin{aligned}\tilde{\pi}_i &= (\tilde{p} - w\alpha)q_i\\ \tilde{\pi}_d &= (\tilde{p} - w\underline{\alpha})q_d,\end{aligned} \tag{17}$$

respectively, where

$\tilde{p} = p(q)(1 + \tilde{e})$

$q = q_d + \sum_1^n q_i$ = industry output

q_i = output of Fringe firm i

q_d = output of Dominant firm

$\tilde{e}$ = white noise

w = constant wage rate common to both firm types

α, $\underline{\alpha}$ = constant labour input per unit of Fringe and Dominant firms' outputs respectively, $\underline{\alpha} < \alpha$.

Product Market equilibrium

The Fringe firm solves the following certainty-equivalent maximisation problem:

$$\max_{qi} \mathrm{NPV}_i = V_i - K_i$$
$$= [\phi p - \gamma]q_i/(1 + r), \tag{18}$$

where

V_i = the market value of the ith Fringe firm's cash flow

$p = a - b[q_d + \sum q_i]$ = market price

$\gamma = w\alpha + (1 + r)\delta$ = unit costs of the Fringe firm

This maximisation generates the Fringe firm's *reaction function*:

$$q_i = \{a - b[q_d + \sum_{j \neq i} q_j] - \xi\}/2b, \quad \xi = \gamma/\phi. \tag{19}$$

A symmetric solution of the Fringe reaction functions gives Fringe firm optimal output, q_f, as a function of the Dominant firm's output:

$$q_f = [(a - \xi) - bq_d]/(n + 1)b^5. \tag{20}$$

The Dominant firm now solves the following certainty-equivalent maximisation problem:

$$\underset{q_d}{\text{Max}}\ \text{NPV}_d = V_d - K_d = [\phi p - \underline{\gamma}]q_d/(1 + r) \tag{21}$$

subject to 20 holding,

where

$\underline{\gamma} = w\underline{\alpha} + (1 + r)\underline{\delta}$ = Dominant firm's unit production costs.

This maximisation yields equilibrium Dominant firm output

$$q_d = [(a - \underline{\xi}) + n(\xi - \underline{\xi})]/2b, \tag{22}$$

where $\underline{\xi} = \underline{\gamma}/\phi$. Note that q_d^o is independent of n if $\xi = \underline{\xi}$ and increasing in n otherwise. In other words, *if the Dominant firm has a cost advantage, it will expand output under entry.*

Plugging 20 and 22 into the market inverse demand function in 18 we get the equilibrium market price

$$p = [a + n\xi + (n + 1)\underline{\xi}]/2(n + 1)^2 \tag{23}$$

Note that

$$\partial p/\partial n = -(a - \underline{\xi})/2(n + 1)^2, \tag{24}$$

and using from 20 that $a > \xi$, we have

$$\partial p/\partial n < 0. \tag{25}$$

In other words (as in Cournot) *entry reduces the market price by expanding industry output.*

Plugging 22 into 20 we get an expression for market equilibrium Fringe output:

$$q_f = \frac{(a - \underline{\xi}) - (n + 1)(\xi - \underline{\xi})}{2(n + 1)b}. \tag{26}$$

This is a decreasing function of n, as in Cournot. In other words, *entry induces existing Fringe firms to contract output.*

Relative capital costs

Moving now to financing, it is easy to show that the cost of capital is *lower* for the Dominant firm than the Fringe *regardless of the number of firms in the market.*[7]

To prove this proposition, restate equation 14:

$$\beta = \sigma_{eM}(1 + r)/\sigma_M^2(\phi - w\alpha/p) \tag{27}$$

Differentiating with respect to α, holding p constant:

$$\partial\beta/\partial\alpha = \frac{\sigma_{eM}(1 + r)}{\sigma_M^2(\phi - w\alpha/p)^{-2}(w/p)} > 0, \tag{28}$$

we can see that since the Fringe's α is higher than that of the Dominant firm, we have

$$\beta_f > \beta_d \tag{29}$$

Impact of entry

We can show that entry increases the cost of capital to both types of firm but has a larger *marginal* impact on a Fringe firm.

Restate equation 15:

$$\partial\beta/\partial n = -Aw\alpha[\phi - w\alpha/p]^{-2}p^{-2}\partial p/\partial n. \tag{30}$$

This expression is positive using 25, so that *entry raises the cost of capital to all firms in the industry*. Since the expression

$$\alpha[\phi - w\alpha/p]^{-2} \tag{31}$$

is increasing in α (for fixed p), and the α of the Fringe is by assumption greater than that of the Dominant firm, we have from 30

$$\partial\beta_f/\partial n > \partial\beta_d/\partial n \tag{32}$$

Thus *the marginal impact of entry on the cost of capital is greatest for the Fringe.*

Size dispersion effects

Finally we can examine the effect of increasing size dispersion on the firms' cost of capital by varying production cost parameters. Differentiating equation 23 with respect to the Dominant firm's cost we have:

$$\partial p/\partial\underline{\alpha} = w/2\phi > 0 \tag{33}$$

In other words, *lower Dominant firm costs lowers the market price.*

Finally we can examine the effect of increasing size dispersion on the firm's cost of capital by varying production cost parameters.

Using equations 22 and 26 we have

$$\partial q_f/\partial \underline{\alpha} = w/2\phi b > 0 \tag{34}$$

$$\partial q_d/\partial \underline{\alpha} = -(n+1)w/2\phi b < 0 \tag{35}$$

and

$$\partial q_f/\partial \underline{\delta} = (1+r)/2\phi b > 0 \tag{36}$$

$$\partial q_f/\partial \underline{\delta} = -(n+1)(1+r)/2\phi b < 0 \tag{37}$$

Finally, using 27:

$$\partial \beta_f/\partial \underline{\alpha} \propto -(\phi p - w\alpha)^{-2} w^2 \alpha/2\phi < 0 \tag{38}$$

$$\partial \beta_f/\partial \underline{\delta} \propto -(\phi p - w\alpha)^{-2} w\alpha(1+r)/2\phi < 0 \tag{39}$$

$$\partial \beta_d/\partial \underline{\alpha} \propto w(p\phi - w\underline{\alpha}^{-2}(2p\phi - w\underline{\alpha})/2\phi > 0 \tag{40}$$

$$\partial \beta_d/\partial \underline{\alpha} \propto -w\underline{\alpha}(p\phi - w\underline{\alpha})^{-2}(1+r)/2\phi < 0 \tag{41}$$

Thus *a higher market share to the Dominant firm via an increased cost advantage lowers its cost of capital and raises that of the Fringe.* This result is therefore in accord with intuition: a higher market share reduces systematic risk to the firm whose share has risen and raises that of the firm(s) whose share has fallen, respectively reducing and increasing the cost of capital (Table I).

TABLE I
Main comparative statics results

Cournot	n	α	δ	Dominant firm	n	$\underline{\alpha}$	$\underline{\delta}$
q_c	–	–	–	q_f	–	+	+
q	+	–	–	q_d	–	–	–
β_c	+	–	–	β_f	+	–	–
				β_d	+	+	+

5. Summary and conclusions

Using the CAPM the paper demonstrated the effects of entry or entry barriers on the cost of capital to firms in two widely used models of oligopoly, the Cournot quantity-setting model and the Dominant firm model. These effects were shown to operate through firm numbers (with zero size dispersion) and through size dispersion (for fixed numbers). In the Cournot model we showed that as the numbers of (equal-sized) firms in the industry increases the cost of capital to individual firms rises. The model developed here is thus consistent with the established empirical fact (e.g. Prais, 1976) that small firms pay more for their capital than large. Moreover this has been done using the concept of operating risk along without any need to refer to the possibility of bankruptcy, the more common explanation for this phenomenon.

Dominant Firm analysis of oligopoly was then used to examine the effects of firm size dispersion on the cost of capital. Firstly the Dominant firm was shown to have lower cost of capital than the Fringe. Secondly, lower unit costs of production to the Dominant firm (increasing industry size dispersion), will lower its cost of capital and raise that of the Fringe firms. Thus product market power and the systematic risk were shown to operate in the same directions.

The conclusions presented here are, we believe, approximately applicable to markets characterised by relatively undifferentiated products. Markets with product differentiation, where such differentiation confers market power should, however, exhibit similar properties. Whilst these results are the subject of another paper, what emerges clearly from the present paper is the conclusion that effects of product market power are not confined simply to 'excess' operating profits. They also imply that the firm, by virtue of its product market power, can reduce its capital costs. This in turn implies a misallocation of resources in *financial* markets in response to the misallocation in product markets. Policies previously thought to have ramifications in only one of these spheres must now be seen as having ramifications in both.

Appendix: Cost of capital under monopoly

This section provides a simple intuitive account of the model of Chen, Cheng and Hite (1986).

Consider a monopolist facing an uncertain product price $\tilde{p} = p(q)(1 + \tilde{e})$ where $\tilde{e}$ is white noise, so that expected price is $p(q)$. The monopolist has wage costs $W(q)$ at output q and discounts by a factor $1 + r$, where r is the rate of return on the certain asset. Price is realised in the next period. The firm's discounted expected cash-flow operating profit curve $\tilde{\pi}(q)/(1 + r) = [p(q)q - W(q)]/(1 + r)$ is plotted in Figure 1. It has the familiar concave shape.

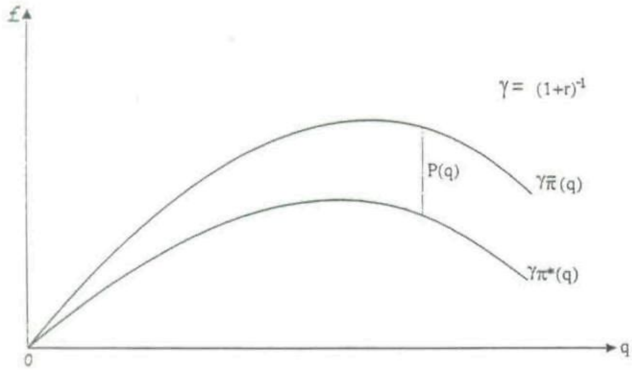

Fig. 1. Firm's expected operating ($\tilde{\pi}$) and certainty-equivalent (π^*) profits and risk premium (P).

Riskiness of the firm's profit is decomposed into two components: one due to the firm itself ('specific' risk) and the other due to the covariation of the firm's profit with the market ('market' risk). Investors in the firm are assumed to have costlessly and completely diversified away the risk attached to individual securities by holding a portfolio of all securities in the market. Thus they place no value on *firm-specific risk*. However they do value *market risk*, the risk attached to the stock market as a whole (the market 'index'), since this kind of risk cannot be eliminated by portfolio adjustments.

Also plotted in the Figure is the discounted *certainty-equivalent profit* curve of the firm, $\pi^*(q)/(1 + r)$. This shows the value the market places on the firm's expected profit given its riskiness and the market's dislike of risk. The curve therefore lies everywhere *below* the expected profit line $\tilde{\pi}(q)/(1 + r)$. The *market risk premium*, P(q), measures the differences between these curves and is the compensation the risk-averse market requires for assuming the risk of that firm's dividend stream.

In financial market equilibrium, demand and (the assumed fixed) supply, of all securities in the market are equated. This determines the equilibrium price of risk. Equilibrium requires that the expected return and risk of the monopolist's profit stream lies on the Market Line. This line in return-risk space shows the extra rate of return required by the market in compensation for extra (covariant) risk of each security. Thus the monopolist's rate of return, ER, must satisfy:

$$E\tilde{R} = r + \lambda \mathrm{cov}(\tilde{R}, \tilde{R}_m), \tag{A1}$$

where
$\tilde{R}$ = uncertain return on monopolist's equity
r = safe rate of return
λ = market price of risk
$\tilde{R}_m$ = uncertain return on the market portfolio.

In words, the monopolist's rate of return on equity must equal the safe rate, r, plus a premium for risk, $\lambda\mathrm{cov}(.)$ (> 0).

But the ex ante rate of return is defined by

$$\tilde{R} = \tilde{\pi}/V, \tag{A2}$$

where
V = the (certain) market value of the monopolist's operating profits
$\tilde{\pi}$ = the uncertain operating profits of the monopolist.

Rearrangements of 1 using 2 yields

$$\begin{aligned} V(q) &\equiv \pi^*(q)/(1 + r) \\ &= [\tilde{\pi}(q) - \lambda \mathrm{cov}(\tilde{\pi}(q), \tilde{R}_m)]/(1 + r) \\ &= p(q)q[1 - \lambda\sigma_{eM}]/(1 + r) - W(q)/(1 + r), \end{aligned} \tag{A3}$$

where

$$\sigma_{eM} = \mathrm{cov}(\tilde{e}, \tilde{R}_M) = \text{quantity of market risk.}$$

Sharpe (1985) provides a derivation of the first equation. We have used the definition of $E\tilde{\pi}$ to derive the second equation from the first.

The firm's opportunity cost of a unit of capital is simply $\lambda\sigma_{eM}/(1 + r)$, and represents the foregone revenue to the monopolist of the market assuming the risk of the firm's revenue stream. As we have seen, risk is measured by σ_{eM}. The *standardised* measure of risk, β, is simply this quantity divided by the variance of the market portfolio, σ_M^2:

$$\beta = \sigma_{eM}/\sigma_M^2. \tag{A4}$$

Using the fact that from the market equilibrium conditions λ is defined by[8]

$$\lambda = [E\tilde{R}_M - r]\sigma_M^2, \tag{A5}$$

substitution of 4 into 1 yields:

$$E\tilde{R} = r + [E\tilde{R}_M - r]\beta. \tag{A6}$$

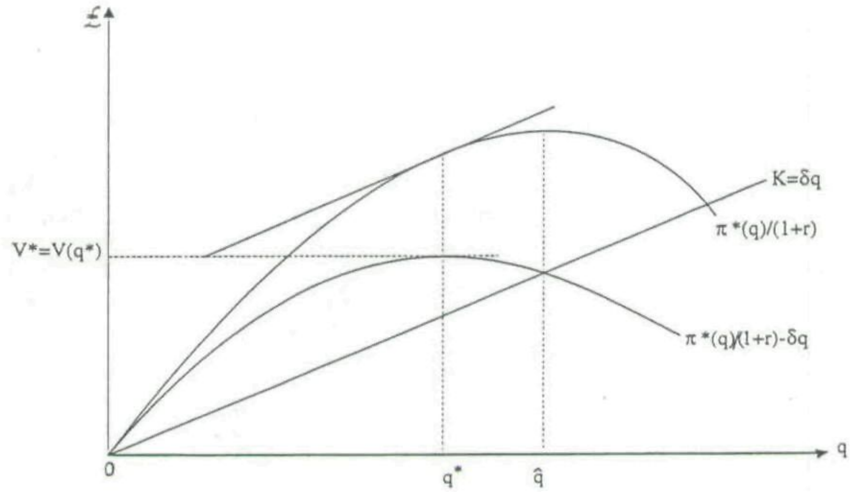

Fig. 2. Determination of optimal (net present value-maximising) monopoly output.

However, the term in brackets is positive, so that we conclude that anything which raises(lowers) β will raise(lower) $E\tilde{R}$, the firm's cost of capital.

Since the market has eliminated uncertainty (transferring it to investors in its shares at a risk premium) the monopolist can now solve the problem of maximising $V(q)$ net of borrowing K as *an optimisation problem under certainty.* Equilibrium q is the solution to

$$\underset{q>0}{\text{Maximise}}\ \text{NPV}(q) = V(q) - K$$

where $K = \delta q$ ($\delta > 0$) shows that debt required is proportional to output (Figure 2). The optimum in Figure 2 is at q^* where the marginal benefit of an extra unit of output measured in terms of operating value equals the marginal borrowing cost of achieving it. Note that this implies $q = q^* < \hat{q}$, where $\hat{q}$ maximises π^*.

Finally, if market price elasticity is treated as a parameter we can see from the above expression that *lower* elasticity is associated with lower monopoly output and hence lower cost of capital.

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Notes

[1] See Conine (1983) for a bibliography of the earlier literature in the area.

[2] For example Subrahmanyam and Thomadakis (1980) examine the effects of increasing market power in a set of perfectly competitive markets. They show that the firm's beta is a function of its labour-capital ratio to that of the economy as a whole and that monopoly power reduces the firm's cost of capital. Whilst being aware of "the usefulness of a more general theory that would take into account various forms of monopoly power" (p. 445) their own analysis of imperfect competition (oligopoly) is conducted in a 'partial-partial' equilibrium framework (a term introduced by Rothschild (1976).

Chen, Cheng and Hite (1986) show that for a product-market monopolist with price uncertainty and constant price-elasticity of demand the systematic risk of the firm is an increasing function of the elasticity of demand for the firm's product. In other words for two otherwise identical monopolists with different price elasticities of demand, the one with the lower elasticity has the lower cost of capital.

Ambiguous conclusions emerge from the analysis by Conine (1983). He demonstrates that if firm liquidation values are taken into account the effect of increasing market power (decreasing price elasticity) on a firm's cost of capital depends on the values of the model's parameters so that market power may decrease or increase a firm's cost of capital.

[3] The Market portfolio is defined as a value-weighted average of all the securities in the market.

[4] See Appendix.

[5] Note that for $q = 0$ this expression is identical with the Cournot output q_c of equation 7.

[6] But not V, see later.

[7] Of course the extent of the differential depends on n.

[8] See Sharpe (1985).

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