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Firm's Cost of Capital and Market Power:
The Effect of Size Dispersion and Entry Barriers in Market Equilibrium

by

Robert C. Cressy

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FIRM'S COST OF CAPITAL AND MARKET POWER:
THE EFFECT OF SIZE DISPERSION & ENTRY BARRIERS
IN MARKET EQUILIBRIUM

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ABSTRACT
Two models of industry equilibrium, n-firm Cournot quantity-setting oligopoly and dominant firm quantity-setting oligopoly, are used to explore the effect of firm size dispersion and entry barriers on the individual firm's cost of capital.

It is demonstrated in a homogeneous product Cournot model with market price uncertainty that as the numbers of (equal-sized) firms in the industry increases (entry barriers fall) the cost of capital to individual firms rises.

Dominant Firm analysis of oligopoly is then used to examine the effects of firm size dispersion on the cost of capital. A result of interest here is that lower unit costs of production to the Dominant firm (increasing industry size dispersion) contrary to what naive intuition would suggest raises its cost of capital and lowers that of the Fringe firms. Thus market power and the systematic risk in contradistinction to the literature operate in opposite directions. Our results show that the effect of an increase in market power on the cost of capital to an individual firm will depend on both the source of that increase and on the prevailing market structure within which it occurs.

Finally it is demonstrated that the Dominant firm has a lower cost of capital than Fringe firms and that entry into the industry increases the cost of capital to both large and small firms. However small firms are hit hardest in that the marginal impact of entry on the Fringe firm's costs is greater than that on the Dominant firm's, the differential depending on both cost differentials and the number of Fringe firms.
1. Introduction

Several papers have examined the relation between the firm's cost of capital and its product market power. (See e.g. Thomadakis(1976), Subrahmanyam and Thomadakis(1980), Conine(1983), and Cheng, Chen and Hite(1986)\(^1\).) Whilst conclusions as to the effects of market power, as measured by the elasticity of demand for the firm's product, differ somewhat between studies the general inference is that market power lowers the cost of capital to the firm whose market power has increased. Most analyses however assume either a partial equilibrium framework or a general equilibrium approach using the extremes of perfect competition or monopoly. Very little if anything is said about the effects on the cost of capital as market power increases under oligopoly. Where oligopoly is alluded to it is via an influence on the elasticity of demand for the firm's product with the firm considered in isolation rather than through the components of the more commonly accepted measures of concentration and within the context of a specific model of oligopolistic competition.

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\(^2\).

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.

Whilst the above results are interesting there are genuine problems in using the approach to examine policy issues. Firstly, industrial economists and policy-makers are more interested in the effect of product-market concentration in a given industry on the cost of capital to individual firms in that industry. This rules out partial-partial equilibrium (single firm) approaches and that of Chen, Cheng and Hite where comparison can only be made across industries. Secondly, whilst perfect competition and monopoly are useful as polar cases the typical industry structure met in practice is oligopolistic with a lognormal distribution of firm sizes. (Prais, 1976). Therefore the assumed market structure is at variance with the facts. Thirdly, by concentrating solely on the price elasticity of demand as a measure of market power the models say nothing per se about the effect of firm entry/exit and increasing industry size dispersion on the cost of capital. This requires at least a partial equilibrium model in which firm sizes are allowed to differ.

In short, real-world applications require a specific model of oligopoly to examine the influence of market power on the cost of
capital. For industrial policy-makers particular interest centres on whether, as intuition would suggest, 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. We shall show that once such a model is provided the effect of increased market power on the cost of capital to an individual firm will depend on the source of that increase and on the prevailing market structure within which it occurs.

Two models of industry equilibrium, n-firm Cournot quantity-setting oligopoly and dominant firm quantity-setting oligopoly, are used to explore the effect of firm size dispersion and entry barriers on the individual firm's cost of capital (henceforth "COC").

It is demonstrated in a homogeneous product Cournot model with market price uncertainty that as the numbers of (equal-sized) firms in the industry increases (entry barriers fall) the COC to individual firms rises.

Dominant Firm analysis of oligopoly is then used to examine the effects of firm size dispersion on the COC. The interesting result here is that lower unit costs of production to the Dominant firm (increasing industry size dispersion), contrary to what naive intuition would suggest, raises its COC and lowers that of the Fringe firms. Thus market power and the systematic risk operate here in opposite directions. Whilst this result is entirely consistent with the literature which assumes that market power changes are solely a function of firm price elasticity, it shows how misleading results are that suggest that increasing market power is
associated with a reduction in the COC.

Finally, it is demonstrated that the Dominant firm has a lower COC than Fringe firms and that entry into the industry increases the COC to both large and small firms. However, small firm(s) are hit hardest in that the marginal impact of entry on the Fringe firm's costs is greater than that on the Dominant firm's, the differential depending on both cost differentials and the number of Fringe firms.

We note in passing that our model is consistent with the established empirical fact (e.g., Prais, 1976) that small firms pay more for their capital than large. This is result is achieved moreover without any need to refer to the possibility of bankruptcy, the more common explanation for this phenomenon.

2. The Cournot Model

The basic structure of the firm's problem is the same for each of the n quantity-choosing oligopolists. Each faces constant returns-to-scale in production and a linear demand curve. Each takes the other's output as given and maximises expected profits with respect to its own output over a single period horizon. Its end-of-period cash-flow is fixed by its beginning-of-period choice of production technique or quantity of capital $K_i$. Capital is chosen to maximise the present value of its expected net cash flow i.e. the firm's equity value. The latter is simply the discounted certainty-equivalent value of that cash-flow.

To be specific, oligopolist $i$ has operating future cash-flow $Y_i$ given by
\[ \hat{Y}_i = (\hat{p} - w\alpha)q_i \]  \hspace{1cm} (1)

where \( \hat{p} = p(q)(1 + \hat{e}) \)

\[ q = \sum q_i = \text{industry output} \]

\[ q_i = \text{output of firm } i \]

\[ \hat{e} = \text{white noise} \]

\[ w = \text{constant wage rate} \]

\[ \alpha = \text{constant labour input per unit of firm's output} \]

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

\[ p(q) = a - bq, \quad a, b > 0 \]  \hspace{1cm} (2)

The CAPM (e.g. Sharpe, 1985) gives the market value of the firm's end-of-period operating cash-flow as

\[ V_i = \frac{[E\hat{Y}_i - \lambda \text{cov}(\hat{Y}_i, R_m)]}{(1 + r)} \]  \hspace{1cm} (3)

where \( E = \text{expectations operator} \)

\( \text{cov} = \text{covariance operator} \)
\[ R_m = 1 + \text{market rate of return} \]

\[ r = 1 + \text{riskless rate of return} \]

This can be rearranged to yield

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

where \( \sigma_{em} = \text{cov}(e, R_m) = \text{systematic risk of } e \)

\( \lambda = \text{market price of risk}. \)

The firm at the beginning of the period solves the following optimisation problem:

\[
\text{Max } \text{NPV}_i = V_i - K_i
\]

\[
= [\phi p - (w\alpha + (1 + r)\delta)] q_i / (1 + r) \tag{5}
\]

where \( K_i = \delta q_i, \delta > 0 \) is the firm's current borrowing. The (interior) optimum requires that the firm's marginal net discounted certainty-equivalent revenue from output should equal its current marginal borrowing requirements per unit of output:

\[
\frac{\phi[p + p'(q)] - w\alpha}{1 + r} = \delta \tag{6}
\]
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 (borrowing requirement) which will be supplied by the market at a risk premium to be determined below.

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

\[ q_c = \frac{(a - \xi)}{(n + 1)b}, \quad \xi = \frac{[w\alpha + (1 + r)\delta]}{\phi} \] (7)

The industry output is therefore n times this:

\[ q = nq_c = \frac{(a - \xi)n}{(n + 1)b} \] (8)

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

\[ p_c = \frac{(a + n\xi)}{(n + 1)} \] (9)

Finally the maximised discounted market value of the firm's operating cash-flow is obtained by substituting 6 through 8 into 5:

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

By differentiation of 7 through 10 we get the following results:
\[ \frac{\partial q_c}{\partial n} = -q_c/(n+1) < 0 \]  
(11)

\[ \frac{\partial p_c}{\partial n} = -bq_c/(n+1) < 0 \]  
(12)

\[ \frac{\partial K_c}{\partial n} = \delta \frac{\partial q_c}{\partial n} < 0 \]  
(13)

\[ \frac{\partial q}{\partial n} = q_c/(n+1) > 0 \]  
(14)

\[ \frac{\partial V_c}{\partial n} = -[V_c + \phi b q_c^2/(1+r)]/(n+1) < 0 \]  
(15)

Thus entry reduces Cournot industry price (by increasing industry output), and decreases firm output, borrowing requirements and operating value.

Considering now effects of entry on the firm’s COC, the firm’s Beta (CAPM standardised measure of market risk) is given by

\[ \beta_c = \text{cov}(\bar{R}_c, \bar{R}_m)/\sigma_m^2 \]

where

\[ \bar{R}_c = \bar{\pi}_c/V_c - 1 = \text{(random) rate of return on firm’s equilibrium operating cash-flow given the market valuation of that cash-flow} \]

\[ \bar{\pi}_c = \text{(random) operating profits to the firm} \]

\[ \sigma_m^2 = \text{var}(\bar{R}_m) = \text{variance of market rate of return} \]

Using the definitions of these components Beta can be written as
\[ \beta_c = \frac{p_c q_c \sigma^2}{\sigma^2_{c, m}} \]

The effects of changes in \( n \) on a firm's Beta are then obtained by differentiation of 16:

\[ \frac{\partial \beta_c}{\partial n} = bq_c^2 \left[ \phi p_c q_c - V_c (1 + r) \right] / (n + 1)(1 + r) \]

(17)

\[ > 0 \text{ if } V_c < \phi p_c q_c / (1 + r) \]

But we have by definition of \( V_c \)

\[ V_c = \phi p_c q_c / (1 + r) - w\alpha q_c / (1 + r) \]

\[ < \phi p_c q_c / (1 + r) \]

Hence 17 is indeed positive. In other words a smaller (larger) number of firms lowers (raises) the financial risk to individual firms. It can be shown that this effect operates through 'favourable' changes in the covariance component of cash-flow as output of the firm is reduced in response to exit/entry.

Via the equation of the CAPM we have

\[ \tilde{E}R_c = \beta_c [\tilde{E}R_m - r] + r \]

(18)

Hence a lower \( \beta \) lowers the firm's COC, \( \tilde{E}R_c \).
The limiting values of the above variables as the number of firms tends to infinity are as follows:

\[ \lim_{n \to \infty} q_c = 0 \]  
(19)

\[ \lim q = (a - \xi)/b \]  
(20)

\[ \lim p_c = \xi \]  
(21)

\[ \lim K_c = 0 \]  
(22)

\[ \lim V_c = 0 \]  
(23)

\[ \lim \beta_c = \sigma_{em} \lim \frac{pq_c/V_c}{\sigma_m^2} = \sigma_{em}/\sigma_m^2 \]  
(24)

3. The Dominant Firm Model

This model 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 Stackelberg Leader by setting its output subject to the reaction function of the Fringe and the latter acting as Cournot competitors with respect to the Dominant firm, taking its output as given and maximising profits with respect to their own output.

Firms operate with a single period horizon. Production is constant returns to scale. However 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 ($K_l$, and $K$ for Dominant and Fringe respectively). Capital is chosen to maximise the present value of its expected cash flow i.e. the firm's equity value. The latter is simply the discounted certainty-equivalent value of that cash-flow.

To be specific, Fringe firm $i$ and the Dominant firm have operating future cash-flow $\tilde{Y}_l$ and $\tilde{Y}$ given by

\[ \tilde{Y}_l = (p - w_\alpha)q_\alpha \]

(25)

\[ \tilde{Y} = (p - w_\alpha)q \]

(26)

respectively, where

\[ p = p(Q)(1 + \tilde{e}) \]

\[ q = q_d + \sum q_i = \text{industry output} \]

\[ q_i = \text{output of Fringe firm } i \]

\[ q_d = \text{output of Dominant firm} \]

\[ \tilde{e} = \text{white noise} \]

\[ w = \text{constant wage rate common to both firm types} \]

\[ \alpha, q = \text{constant labour input per unit of Fringe and Dominant firms' outputs respectively.} \]

The Fringe firm solves the following maximisation problem:
Max $NPV_i = V_i - K_i$

$$= [\phi p - \gamma]q_i/(1 + r)$$  \hspace{1cm} (27)

where

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

$$\gamma = \omega\alpha + (1 + r)\delta = \text{unit costs of Fringe firm}$$

This maximisation generates the Fringe firm's Reaction Function:

$$q_i = \frac{(a - b(q + \sum_{j \neq i} q_j) - \xi)/2b, \ \xi = \gamma/\phi}{\text{(28)}}$$

A symmetric solution of the Fringe Reaction Functions gives Fringe firm optimal output as a function of the Dominant firm's output:

$$q_i = [(a - \xi) - bq_d]/(n+1)\delta$$  \hspace{1cm} (29)

The Dominant firm solves the following maximisation problem:
Max $\text{NPV} = V - K$

\[ q \]

\[ = [\phi p - \gamma]q_d/(1 + r) \quad (30) \]

subject to 28 holding,

where

\[ \gamma = w_\alpha + (1 + r)\delta = \text{Dominant firm's unit production costs}. \]

We assume that $\alpha < \alpha$ and $\delta < \delta$ and that the lower cost technique of the Dominant Firm cannot be copied by the Fringe.

This yields equilibrium Dominant firm output

\[ q_d = [(a - \xi) + n(\xi - \xi)]/2b \quad (31) \]

Clearly this exceeds the Cournot output of equation 7 if $\xi \geq \xi$ as we have assumed. Note also that $q_d^2$ is independent of $n$ if $\xi = \xi$ and increasing in $n$ otherwise.

Plugging 29 and 31 into the market inverse demand function we get the equilibrium market price

\[ p = [a + n\xi + (n+1)\xi]/2(n+1) \quad (32) \]

Note that

\[ \partial p/\partial n = (\xi - a)/2(n+1)^2 \quad (33) \]
and 29 imply

$$\frac{\partial p}{\partial n} < 0$$  \hspace{1cm} \text{(34)}$$

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

Plugging 31 into 29 we get an expression for market equilibrium Fringe output:

$$q_f = \frac{[(a - \xi) - (n + 1)(\xi - \xi^*)]/2(n + 1)b}{(n + 1)b}$$  \hspace{1cm} \text{(35)}$$

This is a decreasing function of $n$, as in Cournot. However unlike the Cournot model there exists a finite $n$, $n^*$ say, such that Fringe output is zero. This value satisfies

$$n^* = \frac{(a - \xi)}{(\xi - \xi^*)} - 1$$  \hspace{1cm} \text{(36)}$$

Clearly the bigger the cost differential $\xi - \xi^*$ the smaller $n^*$ will be. In other words, a higher cost differential limits entry more effectively.

Since we have assumed an internal solution to the maximisation problems we assume henceforth that $n < n^*$.

Moving now to the COC calculations we find that the Fringe COC is
\[
\beta_f = \frac{pq_f \sigma_{fem}}{\sigma_{fm}^2} \] 

\[
= pq_f (1 + r) \sigma_{fem} / [\phi pq_d - wq_d] \sigma_m^2 \] (37)

and that of the Dominant firm

\[
\beta = \frac{pq_d \sigma_{dem}}{\sigma_m^2} \] 

\[
= pq_d (1 + r) / \sigma_{dem} [\phi pq_d - wq_d] \sigma_m^2 \] (38)

It is easy to show that the COC is lower for the Dominant firm than the Fringe independently of the number of firms in the market.

To see this note that the discounted cash flow of the two are

\[
V_f = (\phi p - wq) q_f / (1 + r) \] (39)

and

\[
V = (\phi p - wq_d) q_d / (1 + r) \] (40)

Now using expression 37 and 38 for \( \beta \)'s we have

\[
\frac{\beta_f}{\beta} = \frac{q_f/q_d}{V_f/V} \]

\[
= (\phi p - wq_d) / (\phi p - wq) \] (41)

> 1 since \( \alpha < \alpha \) by assumption
Hence the COC is higher for the Fringe for all $n$, as was to be shown.

We are now ready to prove that entry increases the COC to both types of firm but has a larger marginal impact on a Fringe firm. Note that from 37 and 38

$$\frac{\partial \beta_f}{\partial n} \propto -(1 + r) w_\alpha/p^2 (\phi - w_\alpha/p)^2 \partial p/\partial n$$

(42)

and

$$\frac{\partial \beta}{\partial n} \propto -(1 + r) w_\alpha/p^2 (\phi - w_\alpha/p)^2 \partial p/\partial n$$

(43)

Both these expressions are positive since $\partial p/\partial n < 0$ from $34^t$. Thus entry increases the COC to both Fringe and Dominant firms. However it is easy to show also that

$$\frac{(\partial \beta_f/\partial n)/(\partial \beta/\partial n)}{\alpha(\phi - w_\alpha/p)^2/\alpha(\phi - w_\alpha/p)^2}$$

(44)

which is greater than 1 since $\underline{\alpha} < \alpha$. Thus we have shown that the marginal cost of entry measured by its effect on the COC is greater for the Fringe firm than for the Dominant firm.

Finally we can examine the effect of increasing size dispersion on the firms' COC by varying production cost parameters. Using equation 29 we have for the Fringe firm

$$\frac{\partial q_f}{\partial \alpha} = w/2\phi b > 0$$

(45)

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

(46)

and
\[ \frac{\partial q_t}{\partial \bar{\alpha}} = \frac{(1 + r)}{2\phi b} > 0 \] (47)

\[ \frac{\partial q_d}{\partial \bar{\alpha}} = -(n + 1)(1 + r)/2\phi b < 0 \] (48)

Finally

\[ \frac{\partial \beta_t}{\partial \bar{\alpha}} \propto - (\phi p - w\alpha)^2 w^2 \alpha/2\phi < 0 \] (49)

\[ \frac{\partial \beta_f}{\partial \bar{\alpha}} \propto - (\phi p - w\alpha)^2 w\alpha(1 + r)/2\phi < 0 \] (50)

\[ \frac{\partial \beta_d}{\partial \bar{\alpha}} \propto w(p\phi - w\alpha)^2 (2p\phi - w\alpha)/2\phi > 0 \] (49)

\[ \frac{\partial \beta_d}{\partial \bar{\alpha}} \propto -w\alpha(p\phi - w\alpha)^2 (1 + r)/2\phi < 0 \] (50)

Thus a higher market share to the Dominant firm via an increased cost advantage raises its COC and lowers the COC of the Fringe. This result is therefore the opposite of what naive intuition would suggest: a higher market share whilst enhancing monopoly power raises the COC to the firm.

4. Summary and Conclusions
Using the CAPM the paper demonstrated the effects of entry or entry barriers on the COC 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). It was demonstrated in the Cournot model that as the numbers of (equal-sized) firms in the industry increases (entry barriers fall) the cost of capital to individual firms rises. A
model was thus generated that is consistent with the established empirical fact (e.g. Prais, 1976) that small firms pay more for their capital than large. This was done moreover 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. The interesting result here is that lower unit costs of production to the Dominant firm (increasing industry size dispersion), contrary to what naive intuition would suggest, raises its cost of capital and lowers that of the Fringe firms. Thus market power and the systematic risk operate here in opposite directions. Whilst this result is entirely consistent with the literature which assumes that market power changes are solely a function of firm price elasticity, it shows how misleading results are that suggest that increasing market power is associated with a reduction in the cost of capital. Our results show that the effect on the cost of capital to an individual firm of an increase in market power will depend on both the source of that increase and on the prevailing market structure within which it occurs.

Finally it was demonstrated that the Dominant firm has a lower cost of capital than Fringe firms and that entry into the industry increases the cost of capital to both large and small firms. However small firm(s) are hit hardest in that the marginal impact of entry on the Fringe firm's costs is greater than that on the Dominant firm's, the differential depending on both cost differentials and the number of Fringe firms.

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 exhibit similar properties. However these results are the subject of another paper.
### TABLE 1
**MAIN COMPARATIVE STATICS RESULTS**

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<thead>
<tr>
<th>COURNOT</th>
<th>DOMINANT FIRM</th>
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Footnotes

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

2 This terminology is due to Michael Rothschild. It implies that the analysis is less than a partial equilibrium analysis which examines the effects in an industry as a whole.

3 Conine does not consider the consistency of assuming liquidation values in a model which presupposes a zero probability of bankruptcy. The question of bankruptcy and the COC is however addressed in a recent paper by Blaise Allaz and Joel Bessis (1991).

4 Recall that the standard measure of industrial concentration, the Herfindahl index, decomposes into two components, one representing size dispersion (inequality) and the other firm numbers (entry/exit). (See Adelman, 1969)

5 The market rate of return is defined as the return on an equally-weighted portfolio of all assets in the market.

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

7 But not $V$; see later.

8 This is not an essential difference: See Friedman (1983) for a Cournot model with fixed costs.

9 Of course the extent of the differential depends on $n$.

10 We assume $\sigma > 0$. 

25