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Market Structure, Market Performance, and Capacity: An Excess Capacity Model

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Abstract. The objective of this paper is to discover whether the relationship between market structure and excess capacity is nonmonotonic. Excess capacity rises as market power rises; but after some point, according to the hypothesis, excess capacity falls as market power continues to rise. In order to examine the hypothesis, a theoretical model of excess capacity is developed. The model is based on the assumption that each firm in the industry maximizes its profit; from the profit maximization we can generate predictions about the relationship between market structure and excess capacity.

The findings of the study confirm and hypothesis stated above and prove that the market structure-excess capacity relationship is nonmonotonic.

Introduction

The study of the relationship between market structure and performance is a major activity within the field of industrial organization. Market structure refers to the organizational characteristics of a market, such as seller concentration, barriers to entry, product differentiation and number of firms. This study will focus primarily on three broad market structure categories: tight oligopoly, partial oligopoly and atomistic markets. Tight oligopoly markets are defined to have high seller concentration, high barriers to entry, high product differentiation and a low number of firms. Partial oligopoly markets are characterized by moderate barriers to entry, moderate product differentiation and an intermediate number of firms. Atomistic markets have low seller concentration, low barriers to entry, low product differentiation and a large number of firms.

There are many studies on the relationship between market structure and market performance. Most of them focus on allocative efficiency [1]. The basic approach of such studies is to observe whether price-cost margins vary positively with market power as measured by concentration and barriers to entry. Serious research began with Bain [2]. He found a direct association between market power, measured by concentration and barriers to entry, and rate of return [1,2]. At least 50 other studies have found the same results(1).

The importance of empirical investigations of the profit-market power relationship should be viewed in relationship to the existing welfare theory. This theory states that resources are allocated efficiently, in terms of the Pareto optimum, when price equals marginal cost. Thus, the best economy is one in which all industries are perfectly competitive. As theory predicts and profit-market power literature suggests, tight oligopolistic industries tend to misallocate resources more than partial oligopolistic industries and atomistic industries [4; p. 300, 5; pp. 1-2].

Although there is an abundance of literature dealing with the relationship between market structure and performance, few studies have dealt with market structure and excess capacity(2) as a unique phenomena of market performance [6]. Moreover, none of these studies has paid much attention to theoretical perspective of that subject.

Of the few empirical studies on the relationship between market structure and excess capacity (Bain, [7]; Meehan, [5]; Scherer, [8]; Esposito and Esposito, [1,6]; Mann, Meehan, and Ramsay, [9]; Caves, Jarret, and Louck, [10]) only Bain [7] and the Espositos [1,6] directly relate excess capacity to market structure. Bain employed a sample of nine industries and found that chronic excess capacity did not appear in six "moderate" or "high" barrier sample industries but appeared in three "low" barriers industries [7]. On the other hand, the Espositos investigated this relationship using concentration as a measure of market structure. The results of their investigations suggest that partial oligopolies experience more excess capacity than do tight oligopolistic or atomistic industries [1,6].

Industries with high barriers to entry and high concentration will exhibit the highest degree of resource misallocation as a result of setting price above marginal cost. This amounts to an argument that tight oligopolies should not be permitted

(1) For a good review see [3; pp. 184-233]

(2) Excess capacity is the difference between the output where the firm's long-run average total cost is a minimum and the firm's actual output in the long-run equilibrium [1; p. 190, 11; p. 295, 12; p. 427].

[4, p. 300]. Given the weight of empirical studies, however, tight oligopolies seem to carry less excess capacity than partial oligopolies. If this is true, then the difference betweeen price and marginal cost should not be the sole consideration in forming public policy. Any proposal to break up right oligopolies, or to prevent their formation should be evaluated in the light of this apparent trade off between excess capacity[3] and allocative efficiency [1; pp. 192-193, 5; p. 2].

The purpose of this research is to investigate the relationship between market and excess capacity. In particular, the research hypothesizes a nonmonotonic relationship between market power and excess capacity. Excess capacity rises as market power (measured by sellers concentration, barriers to entry, product differentiation, and the number of firms) rises; but after some point excess capacity falls as market power continues to rise. It is expected that excess capacity will equal zero in perfect competition, will be greater than zero in both atomistic and partial oligopolies, and will approach zero in tight oligopoly. The hypothesis is justified as follows:

(1) According to conventional economic theory, excess capacity is zero in perfectly competitive industries because it is eliminated through free entry and exit [10; p. 487]. If the firms in atomistic industries behave as perfect competitors, there will be no excess capacity. However, atomistic firms might maintain some excess capacity to respond to changes in their own sales.

(2) In partial oligopolistic industries (or imperfectly collusive industries), firms colluding successfully on pricing could rationally maintain excess capacity to retain buyers to serve the needs of their rivals' customers if an unexpected increase in demand occurs [13]. Oligopolists also create excess capacity to maintain a credible threat against rivals [10; p. 487].

(3) Tight oligopolistic industries are characterized by the ability of firms to agree on price and non-price aspects of the market. Under this type of oligopoly model, excess capacity may not develop because the firms can agree to avoid excess capacity so as to reduce cost. On the other hand, firms may maintain some excess capacity as an entry barrier [17].

(4) The assumed goal of monopolies is to maximize their profits. To achieve that goal, monopolists try to minimize costs. As a result excess capacity is not likely

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(3) It may be argued that some excess capacity is not necessarily undesirable from the standpoint of overall efficiency, because it serves to reduce waiting time and planning costs for consumers and enhance the ability of the producers to meet peak demands [14; pp. 210-211, 15; p. 468, 16; p. 419].

to exist in monopolistic industries, where it would conflict with profit maximization(4) [10: p. 487].

In the subsequent section, a model will be developed to demonstrate this expected nonmonotonic relationship between market structure and excess capacity.

The Theoretical Model

The model developed in this section attempts to show how firm behavior can generate predictions about excess capacity in an industry. In the standard neoclassical model, it is usually assumed that the ultimate objective of each firm in the industry is to maximize profit. Using the implicit function theorem, the first order conditions for profit maximizations can be used to derive an excess capacity equation that is a function of market structure. The model will then be used to make "a priori" predictions about the effect of market structure on excess capacity.

The model is based on the assumption that these profit maximizing firms are identical throughout each particular industry. Industry output (Q) is equal to the number of firms (N) times each firm's output (q), and industry (K) is equal to the number of firms (N) times each firm's capacity (k):

$$Q = Nq \tag{1}$$
$$K = Nk \tag{2}$$

The profit (π) of the representative firm is assumed to be a function of market structure (Z), industry output (Q), and industry capacity (K):

$$\pi(Z,Q,K) = P(Z,Q,K)\,q - C(q,k) \tag{3}$$

where C(q,k) is the cost function which is assumed to be an increasing function of the firm's capacity (k) and output (q). Also, it is assumed that q and k are complementary in term of the marginal cost of each with respect to firms' output and capacity. Market demand is represented by P(Z,Q,K). The product of market price and the firm's output is the firm's total revenue (R).

The market structure variable (Z) is included in the profit equation to show the effect of market power on the profit of the firm. According to conventional price

(4) Monopolists are more likely to have X-inefficiency

theory, market power gives firms in the market the ability to restrict output and raise prices. Greater market power will result in higher profits for the firm.

Two additional variables are included in the profit equation, the first being industry output (Q). The higher is the industry output, the lower the price. The second is industry capacity (K). In this model, capacity is used to measure barriers to entry. The higher the industry capacity (given output), the less likely is the entry of other firms, and the higher the price [18].

In this model the representative firm controls its output (q) and its capacity (k). So, the firms maximizes its profits with respect to q and k.

The maximization leads to the usual first-order conditions:

$$\pi_q = R_q - C_q = 0 \quad (4)$$

$$\pi_k = R_k - C_k = 0 \quad (5)$$

where

$$R_q = P_Q \cdot Q_q \cdot q + P \quad (6)$$

$$R_k = P_K \cdot K_k \cdot q \quad (7)$$

Function subscripts indicate derivatives with respect to the subscripting variable.

The second-order conditions require that the principle minors of the relevant Hessian determinant alternate in sign:

$$\frac{d^2\pi}{dq^2} = \pi_{qq} < 0 \ , \ \frac{d^2\pi}{dk^2} = \pi_{kk} < 0 \quad (8)$$

$$\begin{vmatrix} \frac{d^2\pi}{dq^2} & \frac{d^2\pi}{dq\,dk} \\ \frac{d^2\pi}{dk\,dq} & \frac{d^2\pi}{dk^2} \end{vmatrix} = \begin{vmatrix} \pi_{qq} & \pi_{qk} \\ \pi_{kq} & \pi_{kk} \end{vmatrix} > 0 \quad (9)$$

Expanding D we have:

$$\pi_{qq}\,\pi_{kk} - (\pi_{qk})^2 > 0 \quad (10)$$

for a maximum.

The second order condition (8) implies that profit must be decreasing with respect to further increases in either q or k. Condition (9) ensures that profit is decreasing with respect to further increases in both q and k. Conditions (8) and (9) require that the profit function be strictly concave.

Since $q = q^{-1}(Q)$ and $k = k^{-1}(K)$, equations (4) and (5) form a system of two equations with three variables (q, k, and Z). The system is written implicitly as follows:

$$g^1(k,q,Z) = 0 \tag{11}$$

$$g^2(k,q,Z) = 0 \tag{12}$$

The implicit function theorem could be used to solve the system for q and k in terms of Z:

$$q = J^1(Z) \tag{13}$$

$$k = J^2(Z) \tag{14}$$

The derivatives of q and k with respect to Z will be found. These derivatives will imply a relation between Z and excess capacity.

Totally differentiating the first-order conditions for profit maximization (equations (4) and (5)) and rearranging terms, we find:

$$\pi_{qq}\,dq + \pi_{qk}\,dk = -R_{qZ}\,dZ \tag{15}$$

$$\pi_{kq}\,dq + \pi_{kk}\,dk = -R_{kZ}\,dZ \tag{16}$$

where:

$$\begin{aligned}\pi_{qq} &= R_{qq} - C_{qq} \\ &= q\,(P_{QQ}\,Q^2 q + P_Q\,Q_{qq}) + 2(P_Q\,Q_q) - C_{qq} \qquad (17)\end{aligned}$$

$$\begin{aligned}\pi_{kk} &= R_{kk} - C_{kk} \\ &= q\,(P_{KK}\,K^2 k + P_K\,K_{kk}) - C_{kk} \qquad (18)\end{aligned}$$

$$\begin{aligned}\pi_{qk} &= \pi_{kq} = R_{qk} - C_{kq} \\ &= K_k\,(P_{KQ}\,Q_q\,q + P_K) - C_{qk} \qquad (19)\end{aligned}$$

$$R_{qZ} = P_Z + q\,P_{QZ}\,Q_q \tag{20}$$

and

$$R_{kZ} = P_{KZ} K_k q \tag{21}$$

Since the Hessian determinant D is not equal to zero, the derivatives of equation (13), the firm's output, and equation (14), the firm's capacity, can be found from (15) and (16) by Cramer's rule. The following expressions are the derivatives of q and k with respect to Z:

$$\frac{dq}{dZ} = \frac{\begin{vmatrix} -R_{qZ} & \pi_{qk} \\ -R_{kZ} & \pi_{kk} \end{vmatrix}}{D} \tag{22}$$

$$\frac{dq}{dZ} = \frac{\begin{vmatrix} \pi_{qq} & R_{qZ} \\ \pi_{qk} & R_{kZ} \end{vmatrix}}{D} \tag{23}$$

Equations (22) and (23) can be used to find the effect of Z on excess capacity.

Excess capacity (XC) is the difference between industry capacity (K) and industry output (Q) [17; p. 535]:

$$XC = K(Z) - Q(Z) \tag{24}$$

Using the identical-firm assumption, substitute K = N k and Q = N q into (24) and factor out N:

$$XC = N\,[\,k(Z) - q(Z)\,] \tag{25}$$

Equation (25) shows a relationship between the market structure variable (Z) and excess capacity (XC).

Differentiate (24) with respect to Z;

$$\frac{dXC}{dZ} = N \left| \frac{dk}{dZ} - \frac{dq}{dZ} \right| \tag{26}$$

Finally, substitute (22) and (23) into equation (26) to get:

$$\frac{dXC}{dZ} = N \left[\frac{\begin{vmatrix} \pi_{qq} & -R_{qZ} \\ \pi_{qk} & -R_{kZ} \end{vmatrix} - \begin{vmatrix} -R_{qZ} & \pi_{qk} \\ -R_{kZ} & \pi_{kk} \end{vmatrix}}{D} \right] \tag{27}$$

This research, as mentioned earlier hypothesized that excess capacity rises as market power rises, but after some point excess capacity falls as market power continues to rise. Given that Z is positively related to market power, the sign of equation (27) is positive in the region of low market power (or in competition), and negative in the region of high market power (oligopoly).

Because N and D are positive, $\frac{dXC}{dZ} \lesseqgtr 0$ when:

$$R_{qZ}\,\pi_{qk} - R_{kZ}\,\pi_{qq} \gtrless R_{kZ}\,\pi_{qk} - R_{qZ}\,\pi_{kk} \tag{28}$$

Rewrite equation (28) so that π_{kk} is a function of π_{qq}:

$$\pi_{kk} \gtrless \frac{R_{kZ}\,R_{qZ}}{R_{qZ}}(\pi_{qk}) + \frac{R_{kZ}}{R_{qZ}}(\pi_{qq}) \tag{29}$$

To evaluate the derivative in equation (27) for a profit maximizing firm, let us begin by drawing the second-order conditions in (π_{qq}, π_{kk}) space to determine the set of all points for which the second-order conditions are satisfied (Fig. 1).

The area below and to the left of the hyperpola is the set of all points that satisfy the second-order conditions.

The restrictions on the second-order conditions for profit maximization are necessary in both oligopoly and competition. However, the values of $\pi_{qk} = \pi_{kq}$, R_{qZ} and R_{kZ} depend on the type of market structure.

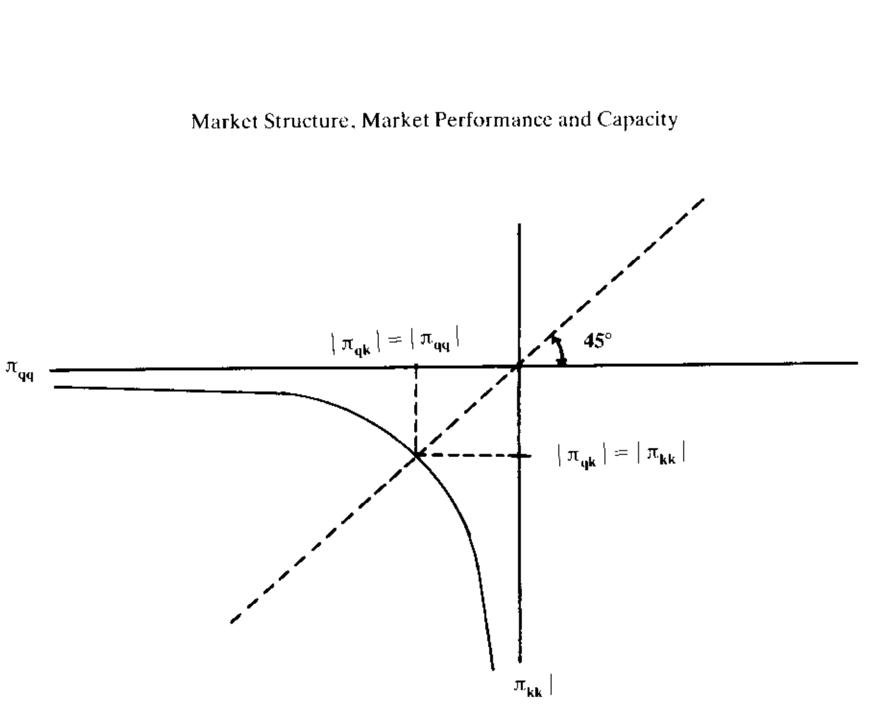

Fig. 1. Illustrate the points that satisfy the second order conditions which lies to the left of the hyperpola.

Oligopolistic firms are responsive to each other behavior, and without loss of generality the response is assumed linear, making the conjectural variations Q_q and K_k equal to one. The derivatives Q_{qq} and K_{kk} are then zero. This simplifies the expression for $\pi_{qk} = \pi_{kq}$, R_{qZ} and R_{kZ} to the following:

$$\pi_{kq} = \pi_{qk} = P_K + q\, P_{QK} - C_{qk} > 0 \tag{30}$$

$$R_{qZ} = P_Z + q\, P_{QZ} > 0 \tag{31}$$

$$R_{kZ} = q\, P_{KZ} > 0 \tag{32}$$

The following information can be used to verify the signs of the above expressions. From the first-order conditions, $P_K > 0$. The higher the market power, the higher is the price charged by the firm, making $P_Z > 0$. Because K is used to measure barriers to entry, and Z is positively related to market power, then the higher is K or Z the steeper is the demand curve. This makes P_{QZ}, P_{KZ}, and P_{QK} positive. Finally, because q and k are complementary, $C_{qk} < 0$.

Equation (29) can be added to the second-order conditions as shown in Fig. 2. The slope of equation (29) is R_{kZ}/R_{qZ} and the intercept is $(R_{kZ} - R_{qZ})\, \pi_{qZ}/R_{qZ}$. Given that the signs of R_{kZ}, R_{qZ}, and $\pi_{kq} = \pi_{qk}$ are positive, the value and the sign of the intercept depend on the value of R_{kZ}. The value of the slope also depends on the value of R_{kZ}. Therefore, we can classify the possibilities as follows:

Case-1: $R_{kZ} > R_{qZ}$; in this case the slope is greater than 1, and the intercept is positive.

Case-2: $R_{kZ} < R_{qZ}$; in this case the slope is less than 1, and the intercept is negative.

The two cases are shown on a diagram (Fig. 2) which is similar to Fig. 1 to determine the intersection of the sets. The intersection of the sets is the set of (π_{qq} , π_{kk}) where the derivative is negative and the second-order conditions are satisfied.

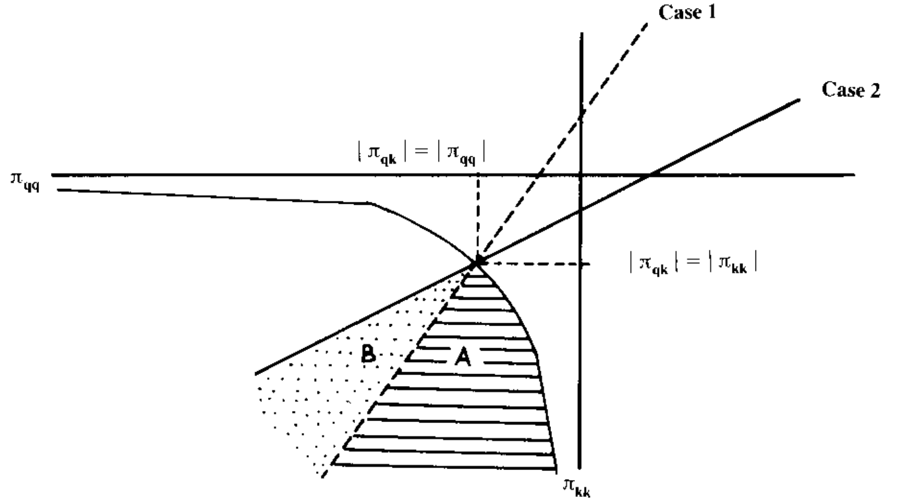

Fig. 2. Depicts the intersection of the sets, where (A) satisfies case-1, and (A+B) satisfies case-2.

In case-1, the intersection of the sets is area (A). In case-2, the intersection of the sets is area (A+B). Assume that each point in A has the same probability under case-2 as it does under case-1. Then it is more likely that the negative derivative will occur under case-2. This indicates that the closer is R_{kZ} to zero, the more likely it is that the derivative will be negative.

In competition, firms are not responsive to each other's behavior, making the conjectural variations, Q_q and K_k, equal to zero. The expressions for π_{qk}, R_{qZ}, and R_{kZ} are simplified to the following:

$$\pi_{qk} = C_{qk} \tag{33}$$

$$R_{qZ} = P_Z \tag{34}$$

$$R_{kZ} = 0 \tag{35}$$

Because $C_{qk} < 0$, πqk is positive. Because Z is positively related to market power, P_Z is positive.

For the derivative of excess capacity to be positive with respect to market structure, the relation (29) must hold true in the form:

$$\pi_{kk} > \frac{R_{kZ} - R_{qZ}}{R_{qZ}} \pi_{qk} + \frac{R_{kZ}}{R_{qZ}} \pi_{qq} \tag{36}$$

Because $R_{kZ} = 0$, equation (36) can be simplified to the following:

$$\pi_{kk} > - \pi_{qk} \tag{37}$$

Equation (37) shows that the slope is zero, and the intercept is $-\pi_{qk}$. This equation may be graphed on a diagram similar to Fig. 1 in order to determine the intersection of the sets. The intersection is the set of (π_{qq}, π_{kk}) where the derivative is positive and the Second-order conditions are satisfied (Fig. 3).

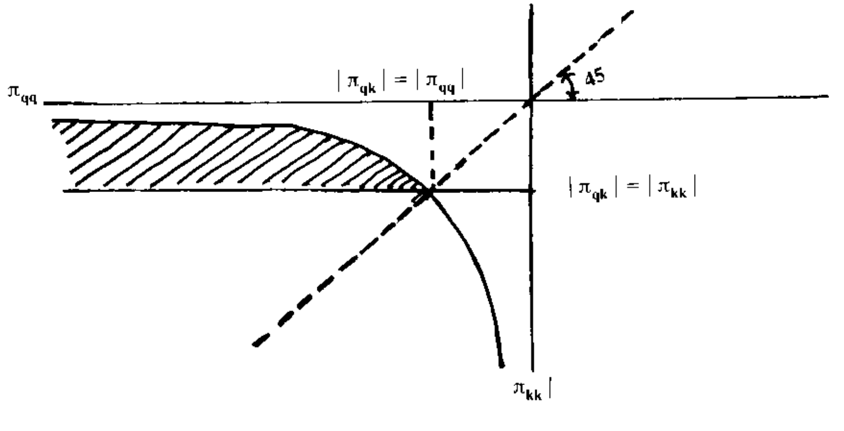

Fig. 3. The Shaded area depicts the intersection of the sets.

The intersection of the sets is the shaded area. This area is small, which indicates that positive derivative may not take place.

Conclusion

The model presented is consistent with the "ad-hoc" theory but does not give definite results. The model presented in this paper established the possibility of a nonmonotonic relationship between market structure and excess capacity. This relationship is arrived at by utilizing the implict function theorem which allowed the researcher to establish the link between market structure and excess capacity via the well established theory of profit maximization.

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هيكل السوق وأدائه وطاقته : نموذج طاقة زائدة

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ملخص البحث. تهدف هذه الدراسة إلى تحديد ما إذا كانت العلاقة بين هيكل السوق (market structure) وفائض الطاقة الإنتاجية (excess capacity) لدى المؤسسة (معرفاً بالفرق بين حجم الإنتاج المتحقق عند أدنى متوسط نقطة إنتاج في المدى الطويل وبين حجم الإنتاج الحقيقي في المدى الطويل) هي علاقة غير أحادية (nonmonotonic) حيث يزداد فائض الطاقة الإنتاجية مع زيادة القوة الاحتكارية، ولكن بعد الوصول إلى حجم معين من الإنتاج، فإن فائض الطاقة الإنتاجية سيبدأ بالانخفاض إذا استمرت القوة الاحتكارية بالزيادة.

ولاختبار هذه الفرضية، تم تطوير نموذج نظري لفائض الطاقة الإنتاجية، ويستند بناء هذا النموذج على افتراض أساسي هو أن كل منشأة في الصناعة تهدف إلى تعظيم الأرباح، ومن هدف تعظيم الأرباح يمكننا بناء توقعاتنا حول العلاقة بين هيكل السوق وفائض الطاقة الإنتاجية.

وتؤكد نتائج الدراسة الفرضية الأساسية، وتثبت أن العلاقة بين هيكل السوق وفائض الطاقة الإنتاجية هي غير أحادية (Nonmonotonic) .