What Determines Market Structure?

by Lisa Finneran

Traditional market structure theory remained unchanged for many years. This was a static theory which looked only at the technology of production and at market size. Dissatisfaction with a theory which could only explain 20-25% of industry characteristics led to the formulation of a stochastic theory which claimed that random events over time shaped industry. A more constructive dynamic approach developed in the 1980s with the application of game theory to Industrial Organisation(IO) and, although very helpful, this has meant the fragmentation of the discipline since each industry must be studied separately. To remedy this, in the early 1990s John Sutton has attempted to bring together some general results of IOT findings into a new theory of market structure. In this paper we will examine the development of this theory and in particular look at the predictions of how market structure is likely to change as the market size grows. A general model developed by Dasgupta and Stiglitz (1980) within the context of dynamic game theory also includes the effect of the possibilities for innovation on market structure and vice-versa. This is as opposed to the traditional theory where technology was a given and the Dasgupta and Stiglitz model will be considered to finish. To start - what do we mean by "market structure"?

What Is "Market Structure"?

There are two levels to what is meant by "market structure" - the level of concentration and the level of product differentiation. Simply to count the number of FIRMS in the industry would tell us little about concentration as it would ignore size inequalities between firms. An alternative measure is the Hirschman-Herfindahl index $H = Ss_i^2$ where s_i is the share of firm i, although the more common measure is the concentration ratio which simply states the market share of the top four firms in the case of the US and the top five in the case of the UK. However there are obviously problems involved with this aggregate measure as well.

Defining the level of product differentiation can cause problems due to the difficulties involved in defining the boundaries of the industry being studied. Value judgements may often be necessary in deciding on the level at which substitutability means a good belongs to a different industry. Sutton's model illustrates this point.

How Do We Explain "Market Structure"?

Traditional theory

Traditional theory gives the "warranted level" $\frac{D(p^*)}{x^*}$ as determining the number of firms in an industry. This is simply the number of firms operating at the minimum efficient scale (x*) which the market can support.

The problem with this, however, is that engineering and accounting studies have failed to establish whether average cost curves are U-shaped or L-shaped. L-shaped curves would mean that the warranted level would only give the upper boundary for the number of firms the industry could support and would not explain the existence of a smaller number of firms, (fig.1).

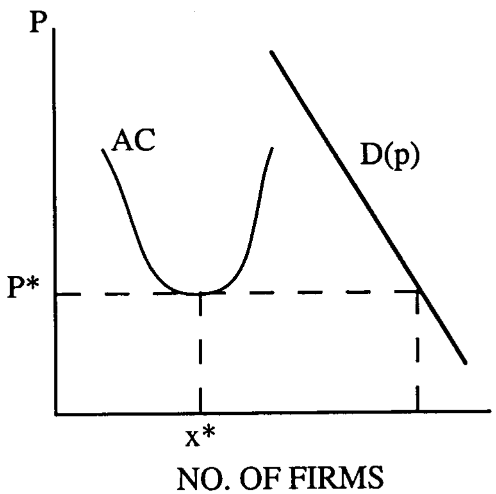

FIGURE 1

Barriers to entry could also mean a lower level of output and a higher price. This could mean higher or lower concentration depending on the rate at which average costs were declining and the magnitude of the price elasticity of demand. Traditional empirical studies of industry structure fail to account for these strategic barriers. Also economies of scope, which are very important in todays world of many multi-product firms are ignored by traditional analysis.

Traditional empirical studies using formulas such as

$$Cj = a0 + a1\frac{(x*)}{X} + \Sigma ai\beta ij$$

(where C_j = concentration index, x^* = Minimum efficient scale, X = Total market size, b_{ij} measures the barriers to entry) to regress concentration against firm specific factors only explained 20-25% of accounting returns by industry characteristics.

We should also note that traditional theory predicted that growth in the market would lead to concentration falling, a prediction which has not been verified despite the collection of a substantial body of empirical evidence over the last fifty years.

Stochastic Models

Stochastic models of concentration found that many industries showed a similar skewed distribution of firms with a few large firms, more medium sized firms and a long tail of small firms. The theory then postulated that the size distribution of firms at a given point in time is the product of a series of random growth patterns in the history of the market. Gibrat was the first to describe the process and "Gibrat's Law of Proportionate Effect" stated that growth would possess three characteristics :

(a) there would be a constant rate of growth of the market which would be common to all firms,

(b) but the tendency for firms to grow would be related to their initial size,

(c) and there would also be a random element affecting different firms in different ways

Although we must allow for a random element in economics, I believe many of the events which Gibrat took as random were not really so. They were simply not explained by traditional theory but can be explained by the application of game theory and of strategic behaviour analysis to different industries. Nevertheless, the stochastic models were a move in the right direction (towards dynamism) and probably still have a small role to play in IOT once random elements are correctly defined and filtered. These theories could then operate in combination with the game theory analysis.

The Sutton Model

Traditional theory took the structure (level of concentration) as given and then considered conduct (degree of collusion) and performance (profitability) to be determined by structure in a unidirectional causal chain. The game theory concept of "sub-game perfect equilibria" points out that decisions to enter a market will be based on what will happen once entry has occurred. This analysis usually focuses on one industry and tailor-makes a specific oligopoly model for it. John Sutton

(1991) has tried to bridge the gap between this "ultra-micro" work and the traditional cross-industry analysis. His market structure theory represents one of the relatively few robust theoretical results to have emerged from the game theory literature. Put very simply, the level of concentration depends upon the relative importance of "exogenous" and "endogenous" sunk costs in an industry (exogenous sunk costs are the physical capital requirements while endogenous sunk costs are variables such as advertising and R&D) and on whether goods are homogeneous or heterogeneous.

For homogeneous goods he finds that as the ratio of market size to set-up costs rises, concentration drops as in traditional theory. But also as the "toughness of price competition" in the market increases, concentration levels increase.The extreme case is Bertrand competition where with exogeneous sunk costs the industry is a monopoly. These two effects simultaneously determine the effect of exogenous sunk costs on the number of firms in the industry. This two stage game involves working out what prices will be in the second stage (given the toughness of price competition) for a certain number of firms n. Then using this we find how many firms will enter in equilibrium in the first stage.

e.g. If demand is given by $X = \frac{S}{P}$ where s is a constant and P represents price

$X = 0$ for $P > P^*$,

Competition is of the Cournot form,

Marginal costs are constant = c

and firms are symmetric $x = \frac{X}{n}$

then to find prices given n:

Max $px - cx$

$$= \frac{dP}{dX}x + P - c$$

But $\frac{dP}{dx} = \frac{-S}{X^2} = \frac{-S}{(nx^2)}$

$$\therefore \frac{-Sx}{(nx)^2} + P - c = 0 \qquad \text{But } S = PX = Pnx$$

$$\therefore \frac{-Pnx^2}{n^2x^2} + P - c = 0$$

$$\therefore P(1 - \frac{1}{n}) - c = 0$$

$$\therefore \quad P = \frac{cn}{(n-1)}$$

Then how many firms will enter in equilibrium in Stage 1?

In equilibrium $\pi = (P-c)\,x = K$ where K is the sunk cost.

where π = profit

We know $\quad x = \frac{S}{nP} = \frac{S(n-1)}{cn^2}$

Thus $\pi = \left(\frac{cn}{(n-1)} - c\right)\frac{S(n-1)}{cn^2} = \frac{S}{n^2}$

Therefore, in equilibrium, $\frac{S}{n^2} = K$

i.e. $\quad n^* = \sqrt{\frac{S}{K}}$

However if products are heterogeneous and firms are multi-product producers then such a simple result cannot be derived. Multiple equilibria result and it is not possible to say which equilibrium will occur. Assuming no demand interdependencies or economies of scope, the two polar cases are

(i) each product is produced by a different firm,

(ii) each product is produced by the same firm.

Then if sunk costs rise in case (i), prices must be higher in the second stage to cover the extra costs. This means demand will drop and less products will be produced. This means that the number of firms, n, will drop. However, in case (ii) there will be no effect on n if sunk costs rise. For each of the cases between these two polar cases we cannot say whether a rise in sunk costs will lead to a fall in the equilibrium number of firms.

The existence of endogenous costs makes the results on concentration even more ambiguous. Here, Sutton finds that

(i) increases in market size need not cause a fall in concentration and (ii) the relationship between concentration and market size need not even be monotonic. This is because, for example, in the case of advertising, an industry will need a critical level of output for advertising to be viable so exogenous costs will matter more in this range of output and so as market size rises, concentration will fall. But once this critical level of output is reached, market growth may cause increased expenditure on advertising and this may cause concentration to increase rather than decrease.

In Sutton's model a change in market structure with respect to a change in market size thus depends on whether the industry produces homogeneous or heterogeneous goods and whether exogenous or endogenous costs are relatively more important.Sutton also points out the importance of first-mover advantages, giving the examples of industries which have different structures in different countries due to these advantages.

Dasgupta and Stiglitz (1980)

Finally we look at the Dasgupta-Stiglitz model which shows how opportunities for innovation, demand characteristics and toughness of price competition operate simultaneously to determine market structure, conduct and performance.

The model :

Cournot competition

$P(Q) = SQ^{\varepsilon}$ where ε = the inverse of the elasticity of demand.

$C(x) = Bx^{-\alpha}$ where α= the elasticity of the arrival date of an innovation with respect to x which is a firm's expenditure on R&D.

Marginal costs of production are constant at C(x).

Then profit is given by $Pq - C(x)q - x$

q is the quantity produced by the indivdual firm

1.Firms maximise profit with respect to their quantity q

ie $$\frac{dP}{dQ}\frac{dQ}{dq}q + P - C = 0$$

2. Firms maximise profit with respect to their expenditure on R&D

ie $$\frac{-dC}{dx}q - 1 = 0$$

ie $$\frac{-dC}{dx} = 1$$

3. Because entry is free profits = (P-C)q - x = 0.

From 1. $\frac{P-C}{P} = \frac{-dP}{dQ}\frac{q}{P}$ but P = SQ and so $\frac{dP}{dQ} = -\varepsilon S(nq)$

so $$\frac{P-C}{P} = \frac{\varepsilon S(nq)^{-\varepsilon-1}q}{s(nq)^{-\varepsilon}}) = \frac{e}{n}$$

From 3. $P\text{-}C = \frac{x}{q} = \frac{-dC}{dx}x$

and so $$P = C - \frac{\delta C}{\delta x}x$$

$$\text{and } \frac{P\text{-}C}{P} = \frac{\frac{-\delta C}{\delta x}x}{C - \frac{\delta C}{\delta x}(x)}$$

But $\quad C = \beta x^{-\alpha}$

so $\quad \frac{\delta C}{\delta x} = -\alpha\beta x^{-\alpha-1}$

and $\quad \frac{\delta C}{\delta x}x = -\beta x^{-\alpha-1} = \alpha C$

thus $\quad \frac{P\text{-}C}{p} = \frac{\alpha C}{C+\ \alpha C} = \frac{\alpha}{\alpha+1}.$

But from 1 $\quad \frac{P\text{-}C}{P} = \frac{\varepsilon}{n}$

Thus $\quad \frac{\varepsilon}{n} = \frac{\alpha}{\alpha+1}$

Thus $\quad n = \frac{\varepsilon(1+\alpha)}{\alpha}.$

Thus we have a very neat formula for the number of firms in the industry. This tells us that as a, the elasticity of arrival date of an innovation with respect to expenditure on R&D, rises, then (P-C)/P, the mark-up also rises and the number of firms in the industry falls.

We note that the structure of an industry in this model has nothing to do with the size of the market which fits in with Sutton's view of R&D as an endogenous sunk cost.

Conclusion

We can see that market structure theory has developed a great deal from the traditional approach and it turns out to be a far more complex subject than the original theories indicated it to be. We have been able to analyse the effects of individual characteristics such as the levels of fixed costs, R&D, advertising, the degree of product differentiation, and the magnitude of the price elasticity of demand upon the level of concentration. However these can work in different directions and in any one industry it may be difficult to disentangle their effects. Nevertheless Sutton's work, which is probably one of the most important break throughs in the new IO school, providing it with cohesion in one area at least, which means that far better predictions can be made as regards the future of different industries and that cross-industry analyses are now possible, despite some limitations, within this framework.

Bibliography

Dasgupta P. and Stiglitz J. (1980), "Industrial Structure and the Nature of Innovative Activity", Economic Journal 90:266.

Sutton J. (1991), "Sunk Costs and Market structure", MIT Press.