TECHNOLOGY AND MARKET STRUCTURE: GAME THEORETIC VIEW VERSUS THE SCHUMPETERIAN PERSPECTIVE

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Abstract

This study investigates how the relationship between technology and market structure is treated in Schumpeterian and game-theoretic approaches. While Schumpeterian view mainly postulates that (i) large firm captures more benefits from an innovation and (ii) technology is determined in a concentrated market; game-theoretic view, on the other hand, (i) treats technology endogenous as the outcome of firms' strategy, (ii) technology can lead to concentrated market and (iii) empirical models are more robust.

JEL classification: L1, L11, L13

Key Words: Technology, Market Structure, Non-price Competition

Özet

Bu çalışma, teknoloji ve piyasa yapısı ilişkisinin Schumpeterci görüş ile Oyun-Teorik yaklaşımı savunanlar arasında nasıl ele alındığını ortaya koymayı amaçlamaktadır. Bu bağlamda, Shumpeterci görüş temel olarak (i) büyük ölçekli firmaların yenilik faaliyetlerinden daha fazla getiri elde ettiklerini ve (ii) teknolojinin yoğunlaşmış bir piyasa konfigürasyonunda belirlendiğini ileri sürerken; diğer taraftan Oyun-Teorik görüş ise (i) teknolojinin piyasa yapısından bağımsız olarak firmaların stratejik kararlarının sonucu olarak içsel olarak belirlendiğini ve (ii) ampirik modellerin teoriyi açıklamada daha başarılı olduklarını öne sürmektedir.

AnahtarKelimeler: Teknoloji, Piyasa yapısı, Fiyat Dışı Rekabet

Introduction

An important issue in economics is how market structure affects technological progress. In this respect, demand growth, cost structure, market size and firm rivalry are key variables in the explanation and evolution of market structure and technological change. Increases in demand generally induce the adoption of new and usually more specialized technology in order to increase the willingness to pay for a new or existing product which typically characterized by higher sunk costs. The high level of these costs generates a barrier to entry for potential firms which relatively operate above a minimum efficient scale, thus leading to some firms to be out of the market. On the other hand, the rivalry among incumbent firms alters the structure of market from a competitive framework to a collusive one.

However, the implications of introduction of a new technology which generally associated with research and development, innovation and advertising activities are ambiguous for evolution of market structure. On the one hand, non-switching rival firms may lose market share and then exit leading to a decrease in the number of firms. On the other hand, a growing market can be expected to accommodate a larger number of firms if free entry prevails. Therefore, a priori, it is not clear that how and to what extent a new technology would changes the market structure.

But once, now that a direct relationship, which links an industry's technological intensity to its level of concentration, holds a clue to the evolution of market structure, we also need to draw the pattern of "technological trajectories and tastes" in these industries that drives them toward such a highly concentrated structure.

In the present article, it is aimed to explain the theoretical phenomenon of the relationship between technological progress and market structure. For this purpose, the issue is brought into two mainstream views: (i) Schumpeterian view according to which it is argued that the large firm operating in a concentrated market is the main engine of technological progress where technology is treated as exogenous, and, (ii) game-theoretical view which argues that technological investments such as innovation and product differentiation are strategic choice for firms' competition stages and lead to a fragmented and concentrated market where technology is treated endogenous.

1. Technology and market structure: Schumpeterian view

The classical economist were aware that technological progress was closely related to market structure and competition. Adam Smith and Karl Marx, in particular, were very interested in the origins of new technology or sources of innovation as well as in the effects of technological change whereas Ricardo changed his mind about machines in a famous revision of his principles.

Smith linked division of labour (hence, productivity advances) to the size of the market, introducing some endogenous character to technological progress. Karl Marx went further and argued that technological advance generates new specialized skills at the interface between science and production—notably the various types of engineering. The new specialists are able to interpret the needs of the entrepreneur to the scientists, and economic demands begin to affect the orientation of science. Schumpeter developed further these ideas in his study of innovation and gave a formal account of how competition in the free-enterprise economy leads to a sustained demand for innovations (Cooper, 1972). Therefore, new technologies are essentially a source of monopolistic advantage to the entrepreneur who commands them (Schumpeter, 1912).

The debate on technological regimes and market structure can be tracked back to the writings of Schumpeter, where the author described rather different constellations of competition and the role of innovations. In Schumpeter (1912) the author emphasized the role of small entrants who challenge the incumbents with their innovations. In the literature this scenario was named as Schumpeter Mark I. But later on, Schumpeter (1942) almost radically changed his view to the effect that now for him large firms had better capabilities to accumulate knowledge and gain economic profits from innovations, which results in better technological development of an industry. This view was labelled as Schumpeter Mark II. Schumpeter Mark I is characterised by *creative destruction* with technological ease of entry and a fundamental role played by entrepreneurs and new firms in innovative activities. New entrepreneurs come in an industry with new ideas and innovations, launch new enterprises which challenge established firms and continuously disrupt the current ways of production, organisation and distribution, thus wiping out the quasi-rents associated with previous innovations. Schumpeter Mark II is instead characterised by *creative accumulation* with the prevalence of large established firms and the presence of relevant barriers to entry to new innovators. With their accumulated stock of knowledge in specific technological areas, their competencies in R&D, production and distribution and their relevant financial resources, large established firms create relevant barriers to entry to new entrepreneurs and small firms. The Schumpeterian Mark I and Mark II patterns of innovation have been labelled also, respectively, widening and deepening. A widening pattern of innovative activities is related to an innovative base which is continuously enlarging through the entry of new innovators and to the erosion of the competitive and technological advantages of the established firms. A deepening pattern of innovation, on the contrary, is related to the dominance of a few firms, which are continuously innovative through the accumulation over time of technological and innovative capabilities (Malerba and Orsenigo, 1994 and 1996).

Schumpeter (1934) describes a competitive mechanism that spurs innovation during a creative destruction process among firms. Innovative effort is motivated by the resulting source of profit that exceeds the normal level. He also described how competitors' imitation erodes the profit and forces the profit-maximizing firm to advance further if the innovative quasi-rent (IR) is not to dry up. The unmatched production and growth performances of free enterprise economies are mainly due to the competition forthe IR that constantly reduces cost or increases production.

Schumpeter (1942) claimed that society must be willing to put up with imperfectly competitive markets in order to achieve rapid technical progress. He argued that large firms in imperfectly competitive markets are the most conducive conditions for technical progress. To the extent that firms in more concentrated industries operate in a way that more closely approximates imperfectly competitive markets in which firms possess market power, this led to the long-standing and much debated hypothesis that more concentrated industries are more conducive for innovation.

Then the questions of how technology (innovation) affect market structure (or vice versa) and what type of firm innovates under which circumstances have theoretically been analysed under two basic Schumpeterian hypothesis:

(i) Technology increases with firm size
(ii) Technology increases with market concentration.

According to the former, large firms in concentrated markets are more likely to support innovation. Since firms exploit innovations through their own output and current firm size limits firm growth, large firms are more prone to incur large fixed costs of research and development (hereafter R&D). Namely, based on durability and viability conditions of a market, economies of scale and of scope matter to incurring large level of technological investments. On the other hand, large diversified firms are in better position than small sized firms to exploit unforeseen innovations. Because, their capability of spreading involved in R&D by undertaken many projects at the same time and better access to financial sources enable them to escalate the level of technological investments.

In the context of the latter hypothesis, firms with greater market power (a concentrated market) are rather able to finance R&D expenditures through own profits. It is obviously clear that this ability is a result of better accessibility to finance large-scale R&D efforts. Therefore, firms remarkably enjoying a credible market power can more easily appropriate the returns from innovation and thus have better incentives to innovate. This leads large firms to have scale advantages in the R&D process. Actually in the models of Schumpeterian competition, there are two qualitatively different types of R&D strategic behaviour (Nelson and Winter, 1982a, b): pioneering and imitative R&D. Pioneering R&D involves the development of a new family of products with the possibility of very significant therapeutic advances and commercial success to the innovating firm. Pioneering R&D thus offers the firm the opportunity for a big winner, but the technical probabilities of success for such R&D activities are very low. Imitative R&D, on the other hand, involves the investigation of a known family of products with the hope of developing marginal advances in therapeutic quality. Imitative R&D has more modest commercial success possibilities, but also involves less risk because it has shorter development times and higher probabilities of technical success. Imitators can also key their R&D expenditures to the observed successes of pioneering firms, while pioneering firms are subject to much more fundamental technical uncertainties in their R&D allocations

Following these main hypotheses explained above, it can be concluded that large (monopoly) firms are more likely to innovate than small competitive ones, and the long-run gains from innovation under monopolistic rivalry are likely to outweigh the short-run gains of better resource allocation under competition. That being the case, it is also understood that technological improvements are basically formed under monopolistic market conditions, so the structure of market determines the level and type of technology.

So, what type of competition is played among firmsin the framework of *creative destruction*? Competition is presented by Schumpeter as more than setting quantities and prices. Schumpeterian competition is also not covered by the structure-conduct-performance model of Industrial Organisation or Chamberlin's monopolistic competition (Barney, 1986). The first step towards an analysis of Schumpeterian competition is to conceptualise the firm as made up of a multitude of routines (Nelson and Winter, 1982a): firms have routines for price setting, routines for investment behaviour and routines for marketing and so on. Competition is the process in which firms introduce new routines, copy the routines of other firms leading to new combinations of routines, while markets act as a selection mechanisms on the population of firms. This selection leads to firms based on superior combinations of routines to flourish while those based on inferior combinations contract. Schumpeterian competition may thus be characterised by three mechanisms: the disequilibrating mechanism of novelty creation, the equilibrating mechanism of market selection, and continuity through the retention of successful routines. Continuity can be considered a prerequisite for selection, as some degree of inertia in routines at the firm level is necessary for the routines to be selected upon in the market (Nelson and Winter (2002), Knudsen (2004)).

Innovations are being introduced continuously into the competition for transitory market power but that is not to say that the stream of innovations owes at a constant pace. The exposition by Schumpeter presented evolution as taking place in waves. Once an innovation has been introduced, a large number of more or less imitative innovations will follow and erode the rents to the original innovator. Following this period of increasing diversity of routines comes a period of decreasing diversity in which resources are allocated towards the superior routines and firms based on inferior routines contract or even exit the market. As the market sorts the routines in the population of firms the population settles down (i.e. approaches equilibrium) and the low uncertainty associated with this stable and predictable situation means that the time is just right for the introduction of new innovations. Schumpeter puts implicit emphasis on inertia by arguing that firms based on inferior routines may change only slightly, and will be forced to close down in the long run (Holm, 2009). That means that firms facing an*imitative* competition reduce the product diversity and select a superior technological trajectory in which they might be less imitated, thus counteracting the profits to be eroded by incumbents or potential firms. Therefore, if technological progress is superior, then the structure of market can be thought as being concentrated since in the long run some firms will be forced to exit. This result is essentially the outcome of incumbents responding to creative destruction.

On the other hand, Katz and Shelanski (2005) point out that when firms face competition, they seek to attract costumer by offering lower prices and/or higher quality products and services than their rivals, thus benefiting consumers. When firms invest in R&D, they bring beneficial new products to the marketplace and reduce the costs of producing existing products.

When it comes to the debate of market structure and innovation, the ease of innovative entry in an industry is the first relevant aspect. Technological entry barriers define the competitive advantages of the incumbents over potential competitors related to knowledge and innovations (see Pavitt, Robson and Townsend (1989), Marsili (2001)). A highly cumulative character of knowledge, low knowledge spillover between firms and no learning from public sources may result in high technological entry barriers and prevent firms from entering a market. The question whether competition increases or decreases firms' incentive to innovate, is the second aspect of market structure and innovation. After Schumpeter (1942) it was assumed that innovation would decline with competition as more competition reduces the monopoly rents that reward successful innovators. Taking this assumption being true it could be argued that there is a trade-off between static and dynamic efficiency, because more innovations would occur in more concentrated industries (Wersching, 2008: 5).

There is a variety of empirical literature on the Schumpeterian relationships between innovation and firm size on the one hand, and innovation and market structure, on the other hand. The most frequently used measures of inputs into the innovation process are R&D expenditure and personnel involved in R&D. Scherer (1965a, 1965b) used a sample of 448 firms from the 500 largest US industrial firms. He ran regressions of R&D employment intensity (i.e. R&D employment relative to total employment) on sales and number of patents on sales both for the whole sample, without including industry effects, and for various sub-samples for particular sectors. He found evidence of an inverted-U relationship between R&D employment intensity and sales for the pooled sample and for most sub-samples (the chemical sector was an exception, the relationship being clearly positive). He also found that the number of patents increased less than proportionately with sales, except for a few very large firms. These results were interpreted by Scherer as a clear refutation of the Schumpeterian hypothesis of a positive effect of firm size on innovation

In Cohen and Levin (1989), since firm size is likely to be correlated with industry-level variables such as technological opportunity, which are, in turn, likely to have a positive effect on innovation, it is important to control for industry effects to avoid obtaining biased estimates of the size coefficient when using a sample covering many industries. It is, however, difficult to control properly for industry effects, because most large firms are diversified and operate in more than one industry. To avoid this difficulty, industry assignments could be made at a high level of aggregation such as the 2-digit level, but this then introduces measurement error to the extent that relevant industry characteristics vary across industries within a sector.

Scherer (1992) takes the firm size exogenously in his analysis. According to him, innovation affects firm growth and hence firm size, so that size in a year t is influenced by innovative activity in the year t_{-1}.

Most other studies in the 1960s and 70s also found little support for the Schumpeterian view. Most of the evidence was based on US data, although there was also some evidence for Canada and European countries. Some authors found a positive relationship between R&D intensity and firm size up to a certain size, and no significant effect for larger firms. Others obtained results similar to those of Scherer or even a negative relationship between R&D intensity and size. However, none of the authors who used cross-industry samples of firms managed to control for industry effects in a satisfactory way. On the other hand, the industry-level studies revealed considerable differences in the tested relationships across industries, although for some industries the evidence was conflicting and the small size of the samples generally resulted in low levels of statistical significance. Despite these limitations, Kamien and Schwartz were able to conclude in their 1982 survey that, with the exception of the chemical sector, there was little support for the hypothesis of a positive effect of firm size either on R&D effort or on innovative output (Symeonidis, 1996).

With regard to the empirical preliminary surveys on exploring the relationship between innovation and market structure, many studies in this area used single equation models to relate some measure of innovative inputs or output to some concentration index. Since these models focus on one-way causal relationship from structure to conduct (i.e. firms' innovative activity), endogeneity problem exists for concentration. The fact that while the Schumpeterian hypothesis is that innovation is higher in the presence of market power, most of the literature has actually tested a different proposition, namely that innovation is higher in concentrated markets. The implicit assumption is that market power, i.e. the profit margin or mark-up, is greater in concentrated markets. This is not obvious in a framework where market structure is seen as endogenous. For example, there is evidence which supports the view that more intensive competition can result in higher concentration levels, as margins are squeezed and firms cannot cover their fixed costs unless their number falls through merger or exit (Sutton, 1991;Symeonidis, 1995). These recent results and the inconclusiveness of the vast empirical literature on the relationship between profitability and market structure suggest that concentration is at best an imperfect proxy for market power in cross-industry studies (Schmalensee, 1989).

2. Technology and market structure: Game-theoretic view

Following Schumpeter, the search for unravelling the relationship between technology and market structure has basically focused on R&D intensity (the ratio of R&D to sales) and some measure of sales concentration (such as CR4 and Herfindahl Index) in the literature over the past fifty years, but no clear consensus has emerged. Theoretical and empirical literature has at length debated on this relationship without reaching a common view. On the theoretical ground, it was initially the direction of causation (from concentration to R&D intensity, or vice versa) to be disputed. However, starting from the 70's the view that concentration and R&D intensity were both endogenous variables became widely accepted, and therefore they should be simultaneously determined within an equilibrium system. On the empirical ground, no clear consensus appears to emerge in empirical cross-industry analyses about the sign and the form of the relationship between R&D intensity and concentration: beside papers that report a positive correlation, others emphasize a negative relationship or no correlation at all.

Much of the recent Industrial Organization (IO) literature on market structure has been formulated within the framework of multi-stage games. Over a series of stages, firms make choices that involve the expenditure of fixed and sunk costs, whether by entering a market by constructing a plant, by introducing new products or building additional plan capacity, or by carrying out advertising or R&D spending. In a final stage subgame, all the results of such prior actions are summarized in terms of some space of outcomes, i.e. the final configuration of plants and / or products that emerges at the final stage of the game. A description of this outcome enters as a set of parameters in the payoff function of the final stage (price competition) subgame and so the outcome of the entry process, together with a specification of the nature of price competition, determines the vector of final stage profits and market shares.

Within the recent game-theoretic literature, numerous authors have sought to examine the determination of industrial structure (for example, Dasgupta and Stiglitz 1980; Bresnahan and Reiss 1987, 1990; Shaked and Sutton 1982, 1987, 1990; Sutton 1991, 1997, 1998; Vickers 1986; Symeonidis, 2000; Giorgetti 2001).

The starting point of the theory, developed by Sutton (Shaked and Sutton 1982, 1987; Sutton 1989, 1991, 1998) lies in the observation that R&D (and advertising) outlays can both be considered as sunk costs incurred by the firm with a view to enhance consumers' willingness-to-pay for the firm's product: R&D (and advertising) outlays are choice variables to the firms and so their levels must be determined endogenously as part of the specification of industry equilibrium (endogenous sunk costs).

Interest in these questions has in part been driven by the observation that some, but not all, high-technology industries have come to be dominated at the global level by a handful of leading firms. Is there anything special about the pattern of "technology and tastes" in these industries that drives them toward such a highly concentrated structure? Despite the development of a very extensive literature on such questions, no settled view has emerged. The relationship between R&D intensity and concentration remains controversial (Cohen and Levin 1989). Moreover, the Schumpeterian link between industry concentration and research effort has remained fuzzy (Scherer and Rose, 1990)

One question raised in the early literature on this relationship was whether, if such a correlation did exist, the direction of causation should be seen as running from concentration to R&D intensity, or vice versa. Do highly concentrated industries generate more R&D, or do industries in which firms do a great deal of R&D tend to become concentrated? This dispute about causation faded out in the late 1970s, with the widespread acceptance of the view that concentration and R&D intensity were both endogenous variables and so should be seen as being simultaneously determined within an equilibrium system (Phillips 1971, Dasgupta and Stiglitz 1980). This left open the question of what empirically identifiable characteristics of the technology might be used as exogenous explanatory variables.

Different industries clearly had quite different R&D technologies, but these technologies varied in many different ways, and no usefully simple classification of technologies could command general acceptance.

On this issue, Cohen and Levin (1989) note that most paper on the question report a positive relation, though some find a negative relation, while others argue for a non-monotonic relation. Since results change substantially many authors favour including some index of technological opportunity.

Potentially, Sutton (1998) provides a unifying framework between these two traditions in empirical IO. On the one hand, his modelling approach makes extensive use of the game theoretic tools that form the basis of theoretical developments in IO. On the other hand, his results are, under a set of reasonable assumptions, very general, as they encompass entire classes of models. This implies that the equilibrium concept is not limited to a single outcome, but extends to a variety of outcomes defined within a set of bounds (Marin and Siotis, 2007).

In what follows, Sutton (1998:5) argues that the mixed empirical results regarding the nature of the relationship between R&D intensity and concentration are unsurprising for two reasons. First, it is claimed that measured R&D intensity alone does not serve as an adequate summary description of an industry's relevant technological characteristics. Second, it is claimed that the link between R&D intensity and concentration involves a "bounds" constraint, which is poorly captured by any regression specification.

3.1. The Stage-Game Approach

In the stage-game approach, firms first make various decisions involving the expenditure of sunk costs, whether in setting up plants, spending R&D on product development, or otherwise. Once these decisions have been made, the results can be summarized as a configuration in some space of outcomes. Depending on the context, the outcome might be described as a list of plant locations in geographic space, or a list of plant capacities, or a set of products in some space of product characteristics. When the entry process is complete, firms compete in a "final-stage subgame" (whether à la Cournot, Bertrand, or otherwise). In this final-stage subgame, their plant locations and capacities and their products' attributes are taken as given. Formally, the outcome of the earlier process enters as a set of parameters into each firm's payoff function in this final-stage subgame. The series of decisions made in the earlier stages of the game may be modelled in various ways. Sometimes, firms are modelled as making all these decisions simultaneously. Sometimes, different firms are modelled as making various decisions at different stages. The range of possibilities open to modellers is wide, and the results obtained in these models often depend delicately on how these decisions are modelled. Justifying one representation over another on empirical grounds is often difficult. This is one of the most troublesome of the problems to lump together under the heading of *unobservables*(Sutton, 1998: 7).

In his theory, Sutton essentially presents robust proofs to two main claims: (i) measured intensity does not serve as an adequate summary description of the relevant technological characteristic of an industry, and, (ii) the link between R&D intensity and concentration is poorly captured by any regression analysis.

Sutton (1998) begins with an example that shows how an industry can have a high R&D / Sales ratio, together with an arbitrarily low level of concentration. In the standard linear demand model, a population of ***S***identical consumers have a utility function defined over ***n*** substitute goods. Then, he considers a 3-stage game as follows: At stage 1, firms decide whether or not to enter. At stage 2, each of the N firms that have entered offers a single product of some quality u_i and finally incurs a fixed cost (*F)*.

$$F(u_i) = u_i^{\beta}, \quad u_i \geq 1 , \quad \beta \succ 2 \quad (1)$$

whereparameter β stands for the expenditure in order to rise the perceived quality of firm's product. To rise the level of β, firms have to incur their level of sunk expenditure.The restriction onβ ensures *F(u)* rises with *u* at least as rapidly as profit. In the final stage, firms compute a la Cournot and earn some profits whose level is mainly determined by the number of rival firms and the average quality of all goods that have positive output at equilibrium$\left\langle \pi(\mathrm{u} \,\middle|\, N, \bar{u}) \right\rangle$. The two necessary conditions for a symmetric equilibrium in which N firms offer quality $v > 1$ are as follows:

(Free entry)

$$\pi(v|N, v) = F(v)(2)$$

(Choice of quality)

$$\left.\frac{\partial \pi}{\partial u_i}\right|_{u_i=v} = \left.\frac{dF}{du_i}\right|_{u_i=v} (3)$$

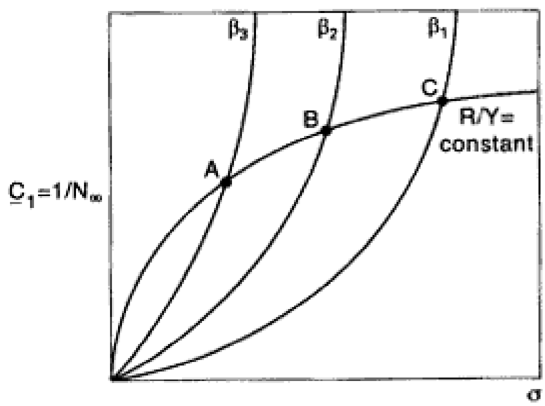
Now combining Eqs.(1), (2) and (3) we obtain

$$\left.\frac{u_i}{\pi}\frac{\partial \pi}{\partial u_i}\right|_{u_i=v} = \left.\frac{u_i}{F}\frac{dF}{du_i}\right|_{u_i=v} = \beta(4)$$

If market size is sufficiently small, firms find it optimal to enter with the lowest possible quality level *v=1*, thereby incurring a fixed outlay of unity. Once market size reaches a critical level, however, further increases in market size are associated, not with further entry, but with an escalation of fixed outlays. Given the functional form chosen for $F(u)$ here, as S increases the number of firms N remains constant. In this case, corresponding concentration level (C_1) remains high and bounded away from zero.

So, what determines the limiting level of concentration C_1? For a given value of β, C_1 is lower according as substitution parameter (σ) is lower. A fall in the substitution parameter shifts the balance of incentives away from an escalation of spending aimed at raising$u$, and towards the introduction of new varieties. Conversely, for any fixed value of a lower value of β implies a higher level of concentration. The intuition here is that lowering βmakes it cheaper to improve technical performance. Rather than attracting entry, this encourages escalation, leading to a rise in fixed outlays and a fall in the number of firms.

Figure 1.Concentration and R&D intensity in the linear demand example.



Source:Sutton,1998:p.72

In the figure, $\beta(\beta_1 > \beta_2 > \beta_3)$ reflects different values of the cost parameter. The sequence of points labelled A, B, C corresponds to different (β, σ) pairs for which R&D/Sales ratio (R/Y) is constant while market concentration varies. The point of the fig. 2 is to show how R&D intensity can coincide with low concentration. By combining a low value of $\beta$with a low value of σ**,** C_1 can be make arbitrarily small, for a given level of R/Y. The intuition behind the result is this: A low value of σ makes it relatively profitable to introduce new products rather than to escalate spending on existing products. If the new products are poor substitutes for existing products, this tendency becomes stronger. The result is a greater degree of proliferation of products (categories) as opposed to an escalation of spending.

To put in a nutshell, Sutton's game-theoretic market configuration points out that the relationship between R&D intensity and concentration will depend, not only on the effectiveness of R&D expenditure (as measured by β and assumed to be endogenous) but also on the extent to which a high-spending firm can draw consumers away from rival firms (as measured by σ).

2.2. The Lower Bound to Concentration in Low and High Alpha Industries

A central theorem within the Bound approach to market structure (Sutton, 1991) specifies conditions under which concentration cannot converge to zero, no matter how large the market becomes. This theorem holds good over a wide range of models; it is couched in terms of a single abstract property which describes the returns earned by a firm that derives by out-spending its rivals in its outlays of fixed costs (whether on R&D or advertising or otherwise). This is basic non-convergence theorem (Shaked and Sutton, 1987) that makes no reference to the behaviour of R&D intensity which later on has been extended by Sutton making statements about the joint behaviour of concentration and R&D intensity.

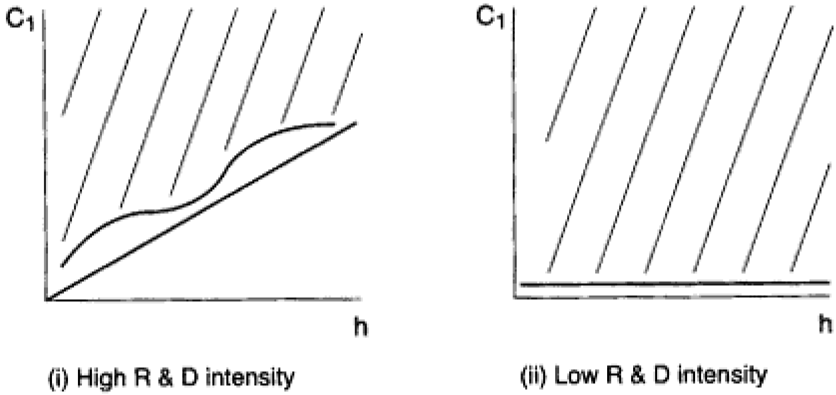
The Bound approach is basically based on the distinction between endogenous and exogenous sunk cost industries. In an exogenous sunk cost industry, potential firms first incur the setup cost which is exogenously given by industry conditions, and then determine the quantity of their products to be supplied and, secondly, firms observe rivals' prices. The most discouraging entry barrier for a new firm deciding to enter to market is the setup cost of minimum efficient scale (MES) below which firm has to exit from the industry or market. Therefore, in case of the presence of low barriers, as a market becomes larger and profitable, then we should expect that the number of potential firms would go to infinity with decreasing concentration rate, thus leading to a competitive structure. But in an endogenous sunk cost industry, toughness of price competition leads to incumbent firms to involve in a non-price competition over which firms have to invest more in rising product quality. Since the quality is subject to product differentiation (especially vertically), in order to raise its level, firms need to incur additional sunk advertising and

R&D expenditures independent of industry's conditions. So, ever-growing level of these sunk entry barriers both prevents potential entries and leads to some suboptimal incumbent firms to exit from industry. Thus, as firms exit from the market, then the number of rival firms shrinks and concentration rate rises. In such an industry configuration, we should expect that the level of advertising and R&D expenditures to rise (Arvas and Bozkır, 2013).

Then, Sutton dichotomizes between *low-alpha* and *high-alpha* industries. High-alpha industries are those in which a firm can achieve large sales and profit gains by trumping rival firms' R&D expenditures. On the other hand, low-alpha industries are those in which the ratio of sales gains to degree of R&D escalation runs from negligible to modest. The value of alpha depends in turn in part upon the extent to which technological innovation can yield decisive product differentiation of production cost advantages and partly upon the extent to which a technological advance confers sales gains across the full array of consumers buying an industry's products, and not merely in some subset of the industry's products (Scherer, 2000: 216)

It is clear that alpha will be affected both by the pattern of technology and tastes in the industry, and by the nature of price competition. According to Sutton, since alpha in not directly measurable it is better in practice to work with the observables *R/Y* (R&D / Sales ratio of the industry) and *h* (homogeneity) index as proxies. The homogeneity index measures the extent to which the market is fragmented into submarkets associated with different technological trajectories. This is treated as an observable. Its value is determined endogenously as the outcome of a competitive process. The theory implies that a high-alpha industry must have a high value of h; equivalently, it implies that an industry with a low value of h cannot be a high-alpha industry. In other words, if *h* is low, in the sense that industry sales revenue is divided among many product categories, then alpha must be low. If *h* is low, R&D spending must be spread over many trajectories, whence the spending per category is small relative to industry sales. This being the case, some firms enter the market and spend along some one trajectory, thereby capture sales from the many rivals.

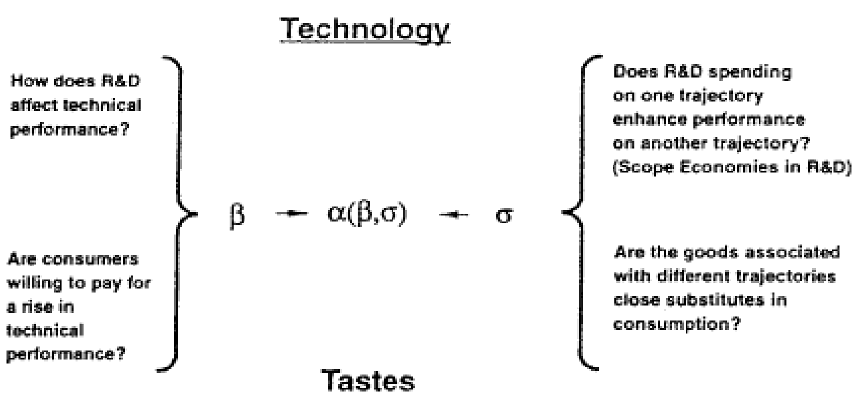
Figure 2: The empirical prediction for concentration in High and Low R&D industries



Source: Sutton, 1998: p. 87

In figure 2, it is shown the relationship between market concentration and technological intensity which is captured by R&D intensity in industries with high and low R&D intensity, respectively. If R&D is high (i), then the market is fragmented into submarkets for new differentiated products. In that case, high R&D spending creates barrier to entry for the potential firms. On the other hand, for the incumbents, the toughness of competition is carried over technological trajectories. If competition is though, then the market structure is concentrated. But, in case of low R&D (section ii), the level of concentration converges to zero, implying a non-blockaded entry for firms.

Figure 3. Interpreting α as a function of β and σ .



Source: Sutton, 1998: p. 90

It is worth commenting on the analytical relationship between alpha and the parameters β and σ as shown in figure 3. For a given profit function (or value of σ), a rise in β implies a fall in alpha. But no such monotonic relationship holds between sigma and alpha. This link is complicated, and the only claims we can make at the present level of generality relate to the way in which certain properties, which hold good once we fix σ at any strictly positive value may break down in the limiting case where $\sigma \rightarrow 0$.

Sutton (1991) presents evidence for twenty food and drink industries across six countries, splitting the sample into a low advertising group and high advertising group. Robinson (1993), using the PIMS dataset for the U.S., examined 1,880 observations on businesses, classifying the industries in which the businesses operated into advertising-intensive, R&D-intensive and others. Matraves (1992) and Lyons and Matraves (1995) have assembled a large dataset for 3-digit industries across four European countries and have looked at both advertising intensive and R&D intensive industries. All these studies indicate that the non-convergence property (the case where concentration rate is bounded away from zero in endogenous sunk cost industries) appears to hold good for advertising intensive and R&D intensive industries. Some recent empirical studies has also shown that the game-theoretic predictions are more robust to reflect the relationship between technology and market structurein manufacturing industries of different countries ranging from developed to developing ones (i.e. Robinson and Chiang, 1996; Symeonidis, 2000; Giorgetti, 2003; Marin and Siotis, 2007; Yang and Kuo, 2007; Resende, 2009; Arvas and Mıhçı, 2013).

Conclusion

A central issue in industrial economics is how different market structures affect economic performance and social welfare. The exercise of monopoly power is known to result in static allocative inefficiency, although empirical estimates of the associated welfare loss vary widely. On the other hand, the static analysis of the social costs of monopoly (or oligopoly) fails to take into account the implications of alternative market structures for dynamic efficiency. A common argument in this context is that concentrated market structures may be favourable to technological progress, and hence economic growth and higher welfare. This implies that there may be a trade-off between short run allocative gains from increased price competition and long run welfare improvements from a higher rate of innovation under a more concentrated structure.

The advent of game-theoretic methods in industrial organization has led to an emphasis in recent years on strategic interactions as the subject's central theme. Yet in the older tradition of the subject, such interactions formed one strand of a less tightly structured but more eclectic approach. In this older tradition, stories about how industry characteristics shaped cross-industry differences in structure sat side by side with a separate literature that emphasized the role of purely stochastic factors in shaping the pattern of industry evolution (Sutton, 1998: 495).

In explaining how industry characteristics shaped industry structure, Schumpeter, in 1942, argued that the large firm operating in a concentrated market is the main engine of technological progress. A number of specific hypotheses as to why this may be the case have been advanced, most of which were already present in Schumpeter's own work.

One of the crucial assumptions of Schumpeterian view to explain the relationship between technology and market structure asserts that large firms in concentrated markets are more likely to support innovation. According this view, this condition must be hold since large firms are able to easily reach to financial resources with regard to relatively small-sized firms. Yet, another intuition in that view which evolves out of Bain (1956)'s structure-conduct-performance paradigm points out that the form of technology is basically determined in a concentrated market structure. That is, the causal relationship which runs from structure to conduct constitutes a one-way causality. Some early studies for the United States and other leading nations found a positive correlation between concentration/firm size and a measure of innovation. Some studies found non-linear relationships that suggest that innovative activity increases with firm size/concentration to some point, then levels off or declines. However, these early studies employed simple models, used aggregated data, and did not always control for industry effects. Surprisingly, some case studies show that a significant number of major inventions came from smaller firms. Even though large firms fund most R&D, small firms' R&D activity has been increasing faster.

In contrast to the traditional analysis, game-theoretic approach uses complex mathematical and statistical methods in order to explain to how competition mechanism is emerged among firms in an industry. The preliminary studies in this field were dominantly done by Sutton. In his analysis, Sutton first divided industries as endogenous where R&D is not a topic of competition and exogenous where technology matters for viability and stability condition in an industry. His analysis suggests that R&D intensity does not constitute an adequate proxy for the technological factors relevant to the determinants of market structure; on the other hand, it suggests that the pair (*h* and *R/Y*) does form an adequate if crude proxy. This provides a very simple classification procedure that avoids many potential problems that arise in classifying technologies. Another contribution is that the causal relationship is not a one-way, rather there is reverse causality which runs from conduct to structure, from performance to conduct, and then to structure. Namely, in the context of this study, technology can lead to a concentrated market configuration.

The central theme in game-theoretic approach concerns with the idea that cross-industry links between concentration and industry characteristics and between concentration and endogenous outcomes such as the degree of R&D intensity are best approached, not by way of the traditional regressions, which presuppose the existence of some identifiable true model, but rather by reference to the operation of a few strong mechanism whose operation imposes certain bounds in the space of observed outcomes.

The pendulum [on technology and market structure] has swung widely since Schumpeter's day. The dominant paradigm, over the past half-century, represents a triumph of 'equilibrium' over 'history'. This paradigm rests on the notion that observed outcomes should be modelled as the uniquely determined equilibrium outcomes of some 'true model', plus random noise. One (overly extreme) version of this paradigm claims that the constraints imposed on current outcomes by the working of the market mechanism are so tight that today's influences uniquely determine today's outcomes. But much less need be claimed: even if 'history matters', in the sense that past influences affect current outcomes, this paradigm may still be retained. What is needed is that all relevant factors, historical or otherwise, that impinge on outcomes are specified in the model (Sutton, 1996: 529). But, game theoretic literature, instead of taking these influences as random noise, permits us systematically to observe their role, their effects.

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