COMBINING SMALL AND LARGE FIRM ADVANTAGES IN INNOVATION: THEORY AND EXAMPLES

Robert W. Vossen

SOM theme B: Marketing and Networks

COMBINING SMALL AND LARGE FIRM ADVANTAGES IN INNOVATION: THEORY AND EXAMPLES

Robert W. Vossen

Abstract

This paper gives an overview of possible sources of relative advantage of small and large firms with respect to innovation, that have been put forward in the economic and management literature. The relative strengths of large firms lie mostly in resources, while those of small firms are generally argued in terms of behavioral characteristics. It is however not either small firms or large firms which are the better innovators. Small and large firms are likely to play complementary roles in the process of technical advance, in the sense that they are better at different types of innovation. A challenge for management would be to find ways to combine large firm resources with some of the advantages of small-scale organization, or for small firms to compensate some of their scale disadvantages by R&D cooperation and the development of networks. As an example of how large and small firm advantages may be combined, I discuss the case of 3M. Maintaining mutually complementary relationships appears to be an increasingly important factor determining innovative success, especially for smaller firms. Two examples of successful networks of SME's are discussed in the final section of the paper.

Introduction

In contrast to his earlier work (Schumpeter, 1912; 1939), in which the independent, small scale, entrepreneurial type of firm was portrayed as the driving force of innovation, Schumpeters hypothesis in Capitalism, Socialism and Democracy (1942) that triggered such an enormous amount of research in the following decades, was that it was "the large scale establishment or unit of control that does not work under conditions of comparatively free competition" which was the most effective innovator. He did not clearly distinguish between effects of firm size and effects of market power on innovative activity, but his primary focus was on the effects of market power on innovation and of (successful) innovation on market structure in a dynamic process of creative destruction. Scherer (1992, p1418) summarized the process of creative destruction as follows.

"*Innovation led not only to superior new goods and services; it simultaneously undermined the market positions of firms committed to old ways of doing business. It destroyed old monopolies while creating new economic value. And to the extent that monopoly power accompanied the value-creating innovations, its possessors had to exercise their power cautiously both in pricing and product policy lest they stimulate another wave of monopoly-eroding changes.*"

Galbraith (1952) more explicitly stated that innovation had become so costly that it could only be done by firms that had the resources associated with considerable size. In this paper I will discuss the possible sources of advantage of small and large firms with respect to innovation.

Large Firm Advantages

It is not always easy to separate the effects of market power and firm size, as these two are obviously correlated. It has been argued that firms possessing monopoly power would be more inclined to innovate because they are better able to realize the rewards from innovation. Also, firms realizing monopoly profits should be better able to finance R&D from internal sources. Internal financing can be

important in two ways. First, in order to obtain external financing at least some information about the project must be disclosed, and secondly, a failed R&D project leaves little in the way of tangible collateral for the external financiers.

It has been suggested that there may be scale economies in R&D. These could be financial, in that it may take a firm of a certain size to be able to finance a particular R&D project, or because returns from R&D are higher if the innovator has a large volume of sales over which to spread the fixed cost of an innovation. Also, larger firms have a larger output over which to realize the benefits of process innovations. Next, larger firms can diversify the risks of performing R&D by maintaining a diversified portfolio of R&D projects and, also due to capital market imperfections, large firms can more easily obtain finance for risky R&D projects. Finally, large firms may be in a better position to exploit the results of its research efforts. Either because a large firm with an established name and reputation can more easily enter a new market than a firm without these attributes as suggested by Nelson (1959), or because complementarities between R&D and other activities are better developed in larger firms. For instance, the value of innovative output may be greater for a large firm with well-developed marketing channels.

There may also be scale economies in the R&D process itself. These can be purely technological, or stemming from a higher productivity of researchers who have more colleagues with whom to interact. Kamien and Schwartz (1982) suggest that this may be the case because a large research group permits the division of labor, increases the chance of serendipitous discoveries being recognized as important, and the effort to come up with a solution can be reduced if there are other colleagues around with new insights or a special familiarity with the problem at hand.

Nooteboom (1994) and Rothwell and Dodgson (1994) find that the relative strengths of large firms are predominantly material. For instance economies of scale and scope, more and cheaper financial resources, possibilities for risk spreading, and greater capacity for specialization, in people as well as equipment.

Small Firm Advantages

A number of counterarguments to those in favor of large firms being the most efficient innovators have also been offered in the literature. A firm already in possession of monopoly power may be less motivated to innovate because it feels less threatened by rivals (Scherer, 1980), or because sales of new products may be at the expense of the sales from existing products. Mansfield (1968) and Mansfield et al. (1971) suggested that in large firms, where there are more people involved in decisions and there is a longer chain of command, there might be a managerial coordination inefficiency and loss of flexibility. The most frequently heard argument is that firms may become bureaucratic as they grow large. Also, researchers may be less motivated in larger firms because they do not have as much personal benefit from their efforts as do researchers in smaller firms, and unexpected research findings may be more likely to get lost in the shuffle in a large than in a small firm.

In general, the relative strengths of small firms lie in behavioral characteristics. For instance greater motivation in management and labor, due to intertwined ownership and management, and more variation and improvisation in the tasks of workers, tacit knowledge in unique skills, more efficient communication, and flexibility (Nooteboom, 1994; Rothwell and Dodgson, 1994).

As the advantages of large firms are generally the disadvantages of small firms and vice versa, they can be summarized as the relative advantages of small and large firms as in table 1.

Other Characteristics

There are also other characteristics of small and large firms, which may represent an advantage as well as a disadvantage. For instance while the presence of fewer hierarchical layers in smaller firms may on the one hand reduce bureaucracy, increase flexibility and result in less filtering of proposals, it also limits career opportunities for their employees. Less filtering of proposals can result in very

Table 1 Relative advantages of small and large firms

Small Firms	**Large Firms**
Little bureaucracy	Formal management skills
Rapid decision making	Able to control complex organizations
Risk taking	Can spread risk over a portfolio of products
Motivated and committed management	Functional expertise in staff functionaries
Motivated labour	More specialized labour
Rapid and effective internal communication, shorter decision chains	Time and resources to establish comprehensive external Science & Technology networks
Fast reaction to changing market requirements	Comprehensive distribution and servicing facilities
Can dominate narrow market niches	High market power with existing products
R&D efficiency	Economies of scale and scope in R&D
	Can support the establishment of a large R&D laboratory
	Access to external capital
Capacity for customization	Better able to fund diversification, synergy
Capable of fast learning and adapting routines and strategy	Able to obtain learning curve economies through investment in production
	Capacity for absorption of new knowledge / technology
Appropriation of rewards from innovation through tacitness of knowledge	Able to erect entry barriers

original ventures, or a fatal lack of opposition to misapprehensions. Or while craftsmanship may yield unique or scarce competencies, it can also result in a lack of attention for marketing and financial planning.

There is some disagreement on still other features. Rothwell and Dodgson (1994) suggest that technical manpower can become isolated from other corporate functions in large firms, while the technical personnel is well plugged into other departments in small firms. Others (Cf. Cohen and Levin, 1989) have argued that complementarities between R&D and other (non-manufacturing) activities are better developed in larger firms. Also, it has been suggested that large firms would be better able to attract highly skilled specialists (e.g. by Rothwell and Dodgson, 1994), while Zenger (1994) finds that small firms more efficiently offer contracts that reward performance than large firms, and consequently, small firms attract and retain engineers with higher ability and skill, and that small firms, through these more performance-contingent contracts, induce higher levels of effort than large firms. Another point is that in small firms management is more often ad hoc due to lack of managerial time which can yield a short term perspective (Nooteboom, 1994). At the same time, in large firms shareholder pressures can force a focus on short-term profits (Rothwell and Dodgson, 1994).

Complementary Roles

Most empirical findings suggest that small and medium-sized firms, rather than large firms, conduct R&D more efficiently. Also small firms and independent inventors are disproportionately responsible for significant innovations (e.g. Acs and Audretsch, 1990; 1991). This is in close agreement with the conclusion by Vossen (1996) that smaller firms are more profit/cost efficient in innovation. There are however other, complementary explanations for the empirical finding that small firms have much more innovative output than one would expect on the basis of their innovative input. First, small firm R&D tends to be underestimated in many standard surveys, because mainly formal R&D, conducted in separate R&D-departments is measured (Kleinknecht and Reijnen, 1991). Moreover, studies of the different components of innovation costs indicate that larger firms have higher

shares of R&D in total innovation costs than smaller firms (Archibugi, Evangelista and Simonetti, 1995; Felder, Licht, Nerlinger and Stahl, 1996), so that independently from the way it is measured, R&D would underestimate the innovative input of smaller firms. Second, the results of Acs, Audretsch and Feldman (1994) indicate that small firms more effectively take advantage of knowledge spillovers from corporate R&D laboratories and universities. And third, the economic value of innovations may differ between smaller and larger firms, as suggested by Cohen and Klepper (1992), who find theoretically that under certain stochastic conditions, larger firms will produce fewer innovations per dollar spent on R&D, but their innovations will be on average of a higher quality.

From the stylized fact that smaller firms produce more innovations than one would expect on the basis of their input, Zenger (1994) concludes that apparently organizational diseconomies of scale outweigh the technological economies of scale in R&D. The aforementioned explanations and the organizational characteristics related to size mentioned in the last paragraph suggest however, that it is not either small firms or large firms which are the better innovators per se[1]. Instead, small and large firms are probably good at different types of innovation, or their roles vary over the industry cycle in a "dynamic complementary" (Cf. Nooteboom, 1994). Large firms are probably better at the kind of innovations that make use of economies of scale and scope, or require large teams of specialists, such as fundamental, science based innovations and large scale applications, which are probably also the innovations with higher average economic value (Cf. Cohen & Klepper, 1992). Small firms are likely to be relatively strong in innovations where effects of scale are not (yet) important and where they can make use of their flexibility and proximity to market demand, such as new products or product-market combinations, modifications to existing products for niche markets, and small-scale applications. Moreover, the small firms' efficiency in producing these kinds of innovations is enhanced by their ability to take advantage of knowledge spillovers from large firms' corporate R&D departments (Cf. Acs, Audretsch and Feldman, 1994).

Organization of Innovation: the Case of 3M

As an example of a large firm that has been successful in combining some of the typical small and large firm advantages in innovation described above, I take the case of 3M where R&D is organized on three levels (Uhl, 1993).

Basic, science based research into new materials or basic chemicals is performed on the upper research level. Here, there is cooperation with universities and research institutes. On this level research has little to do with product development. On the second level there are three sector laboratories, organized around technology areas. Here, research is directed towards picking up technologies and processes, resulting for instance from the basic research on the upper level, and integrating them into processes and technology areas. On the third level, a large number of divisional laboratories work on concrete product development, taking the last step to make new products ready to bring to the market.

The three levels in the R&D organization are to a large degree independent, but cooperation between them is important and necessary. There are two rules. The product belongs to the division, but the technology belongs to the company. And every R&D employee may spend about 15% of his or her time on projects that lay outside their normal area of research.

This type of research organization is a perfect example of combining the resources of a large firm for fundamental, science based innovations and large scale applications on the first and second level, and the flexibility and proximity to market demand of small firms (divisions) for new products or product-market combinations on the third level. Of course an organizational structure is not sufficient to be successful in bringing about innovation. Strategic awareness and company culture are equally important. At 3M, a lot of attention is paid to the motivation of personnel. In 1992, they produced about 60,000 different products

---

[1] It was first suggested by Jewkes, Sawers and Stillerman (1958) that there may be no optimum size of firm, but merely an optimal pattern for any industry ensuring the most effective search for, and commercialization of, innovations.

based on over 100 main technologies. More than 30% of the company's turnover was achieved with products that did not exist four years earlier.

Inter-Firm Relationships

The ability of firms of all sizes to maintain mutually complementary relationships seems likely to be an increasingly important factor determining innovative success. This holds especially for smaller firms, which often lack scale as well as scope in technological and related resources, limiting their potential in finding synergies across technologies (Rothwell and Dodgson, 1994).

In an empirical analysis of German high-tech industries, Gemünden, Ritter and Heydebreck (1996) have shown that efficient network management requires the management of synergies and coordination of all relationships, rather than optimization of single relationships independently from each other. Customer orientation, mentioned earlier as a typical strength of small firms, is critical for product innovation success, but isolated cooperation with customers is not enough. They show that for product innovation as well as process innovation, simultaneous cooperation with different types of actors (for instance suppliers and customers) enhances success.

An example of a successful network is the industrial district of Stavanger, Norway (Asheim, 1994). Here, an organization called TESA was established by local industry in 1957, in collaboration with the local technical schools and later with regional and national R&D institutions, with the aim of supporting technological development among the (medium sized) member firms, producing mainly farm machinery. This close, horizontal inter-firm cooperation, in a production system characterized by horizontal specialization or complementarity in products, has resulted in the district being the center for industrial robot technology in Norway today.

Government policy can play a role in stimulating such networks of inter-firm relations, as is illustrated by the example of the industrial district of Modena, in

Emilia-Romagna, Italy. Modena is the center of the Italian metalworking and mechanical engineering industry. It has long benefited from a pool of trained entrepreneurs and workers in mechanics. In addition, Modena offers a considerable number of public technical consulting services to SME's of the district. The public services provided include a center for real services (rather than just financial support) for technological upgrading of the metalworking and mechanical engineering industry, as well as a center for technology transfer in industrial automation. According to Zeitlin (1992), this local and regional public intervention has contributed significantly to the competitive position of the industrial district today.

References

Acs, Z.J. and Audretsch, D.B. (1990) *Innovation and Small Firms*, Cambridge: The MIT Press.

Acs, Z.J. and Audretsch, D.B. (1991) 'R&D, Firm Size and Innovative Activity', in *Innovation and Technological Change*, Editors Z.J. Acs and D.B. Audretsch, London: Harvester Wheatsheaf, pp39-59.

Acs, Z.J., Audretsch, D.B. and Feldman, M.P. (1994) 'R&D Spillovers and Recipient Firm Size', *Review of Economics and Statistics*, Vol. 76, No.2, pp336-339.

Archibugi, D., Evangelista, R. and Simonetti, R. (1995) 'Concentration, Firm Size and Innovation: Evidence from Innovation Costs', *Technovation*, Vol. 15, No. 3, pp153-163.

Asheim, B.T. (1994) 'Industrial Districts, Inter-Firm Cooperation and Endogenous Technological Development: The Experience of Developed Countries', in *Technological Dynamism in Industrial Districts: An Alternative Approach to Industrialization in Developing Countries?*, UNCTAD/ITD/TEC/11.

Cohen, W.M. and Klepper, S. (1992) 'The Anatomy of R&D Intensity Distributions', *American Economic Review*, Vol. 82, No. 4, pp773-799.

Cohen, W.M. and Levin, R.C. (1989) 'Empirical Studies of Innovation and Market Structure', in *Handbook of Industrial Organization, Volume II*, Editors R.

Schmalensee and R.D. Willig, Amsterdam: Elsevier Science Publishers, pp1059-1107.

Felder, J., Licht, G., Nerlinger, E. and Stahl, H. (1996) 'Factors Determining R&D and Innovation Expenditures in German Manufacturing Industries', in *Determinants of Innovation: The Message from New Indicators*, Editor A.H. Kleinknecht, London: Macmillan Press, pp125-154.

Galbraith, J.K. (1952) *American Capitalism*, Boston: Houghton Mifflin.

Gemünden, H.G., Ritter, T and Heydebreck, P (1996) 'Network Configuration and Innovation Success: An Empirical Analysis in German High-Tech Industries', *International Journal of Research in Marketing*, Vol.13, pp449-462.

Jewkes, J., Sawers, D. and Stillerman, R. (1958) *The Sources of Invention*, London: Macmillan.

Kamien, M.I. and Schwarz, N.L. (1982) *Market Structure and Innovation*, Cambridge: Cambridge University Press.

Kleinknecht, A.H. and J.O.N. Reijnen (1991) 'More Evidence on the Undercounting of Small Firm R&D', *Research Policy*, Vol. 20, pp579-587.

Mansfield, E. (1968) *Industrial Research and Technological Innovation: An Econometric Analysis*, New York: Norton.

Mansfield, E., Rapoport, J., Schnee, J., Wagner, S. and Hamburger, M. (1971) *Research and Innovation in the Modern Corporation*, New York: Norton.

Nelson, R.R. (1959) 'The Simple Economics of Basic Scientific Research', *Journal of Political Economy*, Vol. 67, pp297-306.

Nooteboom, B. (1994) 'Innovation and Diffusion in Small Firms: Theory and Evidence', *Small Business Economics*, Vol. 6, pp327-347.

Rothwell, R. (1985) *Innovation and the Smaller Firm*, First International Technical Innovation and Entrepreneurship Symposium, Utah Innovation Foundation, Salt Lake City.

Rothwell, R. (1989) 'Small Firms, Innovation and Industrial Change', *Small Business Economics*, Vol. 1, pp51-64.

Rothwell, R. and Dodgson, M. (1994) 'Innovation and Size of Firm', in *The Handbook of Industrial Innovation*, Editors M. Dodgson and R. Rothwell, Aldershot Hants: Edward Elgar, pp310-324.

Scherer, F.M. (1980) *Industrial Market Structure and Economic Performance*, 2nd. Edn., Chicago: Rand McNally.

Scherer, F.M. (1992) 'Schumpeter and Plausible Capitalism', *Journal of Economic Literature*, Vol. 30, pp1416-1433.

Schumpeter, J.A. (1912) *Theorie der wirtschaftlichen Entwicklung*, Leipzig: Duncker & Humblot.

Schumpeter, J.A. (1939) *Business Cycles*, New York: McGraw-Hill.

Schumpeter, J.A. (1942) *Capitalism, Socialism and Democracy*, New York: Harper

Uhl, O.M. (1993) 'Innovationsmanagement bei 3M', *ZFO: Zeitschrift Führung+ Organisation*, Vol. 62, No. 4, pp221-224

Vossen, R.W. (1996) *R&D Decisions, Firm Size, and Market Structure*, Capelle a/d IJssel: Labyrint Publication.

Zeitlin, J. (1992) 'Industrial Districts and Local Economic Regeneration: Overview and Comment', in *Industrial Districts and Local Economic Regeneration*, Editors F. Pyke and W. Sengenberger, International Institute for Labor Studies, Geneva, pp279-294.

Zenger, T.R. (1994) 'Explaining Organizational Diseconomies of Scale in R&D: Agency Problems and the Allocation of Engineering Talent, Ideas, and Effort by Firm Size', *Management Science*, Vol. 40, No.6, pp708-729.