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Innovation, New Industries and New Firms

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Economics identifies technical change with productivity improvement. Process innovation is, and always has been, the focus of the economics of technical progress. With few exceptions, the treatment of innovation has been confined to changes in methods of production, to shifts in production functions or, in the case of classical economics, increases in labor productivity.

The identification of technical change with process innovation is surprising, given that many of the most significant innovations were product innovations (the internal combustion engine, the automobile, the transistor, the computer, to name just a few). While major productivity advances have also occurred, these have rarely taken the disembodied form assumed in economics. Indeed, under the technological conditions of modern industry, it is difficult to imagine productivity improvement without changes in the equipment or materials of production. Technical change is intimately bound up with the introduction and diffusion of new products and cannot be treated in isolation from product development.

This paper investigates product development, the processes through which new industries are formed, and the markets for their products are established and expanded. Its major analytical concern is the Schumpeterian one of the relationship between the development of the economy and the development of firms. Special attention is given to the creation of new industrial concerns. Their role in industrial change is identified and distinguished from the role of large, established enterprises. The interplay between small and large firms in the innovation process, and the specific place of each, requires examination. This will help to shed light on the seeming anomaly of Schumpeterian theory that "new combinations" are carried out by new firms, but cannot occur without the profits of large ones.

Product Introduction

The production and consumption of old products suggest ideas for new

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ones. Recognition of the inadequacies of established goods breeds new product conceptions, and new needs emerge in the course of provisioning existing ones.

As a product ages and its properties are utilized for different purposes and under different conditions, the limitations of these properties appear. The repeated and varied usage of the product manifests the limits of its application, and with the recognition of these limits comes a new understanding of needs. Consumption now seems to have requirements that the attributes of already consumed goods cannot satisfy. A need for the products with the requisite capabilities arises.

Thus, development of the telegraph gave birth to the radio by indicating the desirability of a "wireless telegraphy" that could transmit messages between points which, like from ship to shore, could not be connected by cable. Likewise, the limitations of the vacuum tube, its inefficient use of power, unreliability and bulkiness, sparked the research which led to the transistor. The transistor was the result of efforts to create an electronic component with a reliability high enough and an operating cost low enough to be used in large, complex switching and multichannel transmission systems.[1]

Since new goods satisfy those aspects of the need for old goods which they leave unfulfilled, the markets for the latter become the economic birth places of the former. The innovation is initially tailored to some specialized function that existing goods cannot perform, and is aimed at filling a vacant niche of an established market. For example, the electronic calculator was orginally positioned in the tabulating equipment market, in between the high-powered, yet expensive and complicated to operate large-scale computer, and the low cost, but slow and unreliable electromechanical calculator. The electronic calculator was faster, more accurate, and quieter than the old style calculator, while being much cheaper and easier to handle than the computer.[2]

Product introduction is the process of identifying vacant market niches and the technical means to their profitable exploitation. It entails a special and intimate knowledge of the market for the good whose limitations the innovation overcomes. Not all firms have this knowledge, and only those with special insight into the character of latent needs can become product pioneers.

The identification of a latent need requires being in the right place at the right time; the firm has little, if any, control over its product pioneering opportunities. The number and types of products the firm invents depend not on its innovative aspirations, but on the character of its ongoing operations. These suggest new product conceptions and are the source of the firm's inventions. While the possibility of introducing a product invented by another firm or private individual exists, the firm will not introduce such a product unless the firm's experiences reveal a market gap that the product could profitably fill.

The population of potential pioneers of a product is restricted more by the lack of opportunity to develop the product than by the scarcity of entrepreneurial ability. This opportunity presents itself to just two groups, those established firms which produce or use the goods whose limi-

tations suggest the idea for the product, and those scientists or engineers whose life experiences have brought them into touch with the latent need for the good. While members of either group may seize the chance to pioneer the product, those of the latter group are more likely to do so, for reasons having to do with the speculative character of product introduction, and the opportunities it offers to aspiring entrepreneurs.

Products cannot be introduced solely on the basis of profit considerations. This is not due to the impossibility of making profits by commercializing product inventions, but to the impossibility of determining the profitability of producing any given new product. This profitability rests upon the usages and methods of production of the product, neither of which are known at its birth. Some of the most significant product innovations of the modern era, such as the telegraph, telephone, television, and computer, were originally thought to have no commercial value.[3]

Marketing research can uncover nothing more than the consumer's evaluation of the new product's initial applications. These have little bearing on the future sales of the product, since its properties change after its introduction. Products do not enter the economy fully developed, and their usages alter with their development and integration into the consumption and production practices of society.[4]

Estimating the costs of producing a new good is as difficult as estimating its sales. These costs will depend on how the product's technology develops, the difficulties encountered in the course of this development and the way in which they are surmounted. What the product's production function will look like cannot be known prior to the actual working out of its technology.

To be sure, all investments are risky. Yet, in the case of a new good, the problem goes beyond not knowing whether the profits expected from the investment will materialize. Rather, one does not know what profits to expect. These cannot be determined by evaluating the significance of the innovation, for its significance has not yet been revealed.

If product introduction is such a risky venture, then why is it undertaken? One reason suggests itself, the desire to succeed in the business world, and especially to demonstrate one's ability to do so. This desire drives scientists and engineers into product introduction. They pioneer the product because its pioneering is their only investment opportunity. To establish themselves in business they must overcome the obstacles which stand in the way of commercializing the product invention.

The would-be entrepreneur not only has to take the risk of commercializing the invention. He also wants to take the risk. The riskiness of the venture is precisely what attracts him. For the greater the impossibility of the success, the greater is the ability of the individual who achieves it. The entrepreneur wants to make the profits, achieve the success, not reap its rewards.[5]

The established firm which has the opportunity to recognize the need for the new product does not have to pioneer it to demonstrate profit making abilities. This firm is already successful, and has other less uncertain, and more immediately lucrative, investment opportunities. Of

course, the firm may have to introduce the good to protect existing investments. If the good could develop into a substitute for the products of the firm, then the protection of its market position and the capital invested in goodwill and distribution channels would require the good's pioneering.

Even new goods which could displace the firm's product may not, however, be introduced by it. The chance to invest in a new product can arise at any time. It can arise when the firm is prospering, and expanding and developing its existing areas of operation. To the firm which has not exhausted the profit potential of its product, the pioneering of a substitute good is highly undesirable, for by commercializing the product invention, the firm cuts short the profitable life of its own product.

Since both introducing the product and not introducing it are unattractive to the firm, it most likely will do neither the one nor the other, but will take a middle course in between, making a limited commitment to the new good. The firm will develop the product's technology without actually marketing the product or introduce it in an experimental way. By investing in the product in either of these ways, the firm makes it harder for other firms to market the good, while ensuring the firm's own ability to do so, in the event that this should prove necessary.

Market Creation

Firms that pioneer products must create the markets for them. At a product's birth, it merely confronts a potential market. The pioneers of the product have to convince its potential users of the desirability of consuming it, and this requires much more than just an advertising campaign. Market creation involves nothing less than the determination of the utility and price of the product. Producers must find the product form that best meets the latent need which suggested the product idea. They must also discover the price which will establish the market for the good in the sense of allowing the need for the good to be provisioned through the market mechanism.

The initial need for the good, being only a latent one, is subject to a variety of interpretations. The concrete dimensions of a latent need are necessarily unknown, since the individuals who have it have had no experience with its fulfillment. Diverse product models coexist and custom designed ones are constructed.[6]

The need for the new good becomes determinate through the competition of its producers and their interaction with its users. Since users of the good have the most intimate knowledge of its economic functions, they play a crucial role in the determination of its utility. Users clarify the character of their need for the good by experimenting with its various forms and usages, and producers adjust their product designs to the performance requirements that users discover.[7]

When the understanding of the utility of the product is sufficiently advanced to allow a product model to be produced and sold in significant volume, the industry opens up to competition. The presence of such a model makes the need for the good evident and reveals, in at least a "rough and ready" manner, its character. All firms can now see the need for the good, and entry into the industry begins.

Firms entering an emerging industry are, principally, newly founded. Large, established firms are not attracted into the industry, since its sales are too small to add much to the revenue flow of large enterprises and profits are highly uncertain. The introduction of the product does not significantly lessen the uncertainty surrounding its production, and entrance into an emerging industry is almost as speculative a venture as the pioneering of a product.

Those established companies with the technical knowledge necessary to enter the industry wait on the sidelines until the market shows signs of taking off. While entry costs will be higher after the industry demonstrates its profitability, the established firm can afford them, and need not invest in the industry when it first appears. Moreover, investments in industries which do not become profitable hurt the firm's ability to invest in those that do. For the large, established firm, investing in a new industry is never simply a question of whether to invest, but is always also one of when. The timing of the investment is the critical consideration.

Scientists or engineers who have the knowledge to succeed in an infant industry cannot afford to postpone entry until the industry becomes established. They must enter when the opportunity presents itself, and usually want to do so, for the industry remains attractive to them even if it does not become very lucrative. Profits that appear miniscule to a concern whose sales number in the millions or billions lure a private individual with no wealth earning capacity other than his knowledge and skills.

Entry into an infant industry does require finance, and new firms may find it difficult to raise the requisite amount. Yet, finance is not the critical entry barrier, and in many cases, at least, the amount needed is not outside the reach of the newly founded concern.[8]

In infant industries production occurs on a small scale, brand loyalty is insignificant, and research and development does not require any large scale expenditure. In fact, in the early stages of the growth of the industry, research and development expenditures result more often in losses than profits. Developing any particular product model and its techniques of production does not pay off, since the design of the product changes frequently and radically as the still to be determined product concept is developed.

Success in an infant industry depends more on the ability to improve the functioning of the product, and anticipate the needs of its users, than on access to large finances. Product reconstruction overcomes the most important barrier to entry, the patents and accumulated production experience of the product's pioneers. Firms founded by the former technical employees of the industry's established concerns have the best chance for success.[9]

Firms new to the industry enter not by imitating the product designs of its founders, but by offering alternative ones. In an infant industry, the battle over market share is fought with technological weapons, and the greatest market share goes to the best functioning product. Each firm undertakes major and cumulative product innovations in order to establish the identify of its particular product with the product that defines the industry.[10]

of each other's technical advances and their sales efforts jointly expand the market by publicizing the useful dimensions of the product. Competition widens the range of product conceptions, accelerates the pace of technical progress, and makes it easier for producers and users to decipher the real need for the good.

The result of product design competition is the establishment of a dominant design for the product, one that captures a significant market share and that all firms must copy to remain in the industry. While embodying some innovative features, the dominant design mainly synthesizes past technical developments, uniting these in a form that commands universal acceptance. With the establishment of a dominant design, the determination of the utility of the product is completed. The concrete dimensions of the need for the product have been identified, and objectified in a specific product model.[11]

Innovations which establish the dominant design also establish the price of the product. At the birth of the industry, no determinate price exists for the product. No definite utility adheres to the good, nor does it have a specific or unique cost of production. A multiplicity of cost structures exist, each appropriate to a particular model of the product.

The price initially charged for the product depends more on the characteristics of its first producers and consumers than on any intrinsic properties of the product. Depending on these characteristics, the price falls into one of two categories. It either rapidly recovers the development costs of the product, or speeds the expansion of its market.

Pioneering firms that lack the finance to wait out the product's development will sell the product at the highest price possible. This pricing policy may also be chosen by firms whose patents pre-empt competition. These firms do not have to fear the effect of high profits on the attractiveness of entry into the industry. A pricing policy geared to the quick recoupment of capital expenditures works best in situations where users of the product are more concerned with performance than price. Thus, high prices will occur in new industries that sell their products to government agencies, like the military, or to wealthy individuals.

Firms with the capital to finance market creation, or those which face stiff potential competition, will pursue a market penetration price policy. The latter will want to obtain goodwill as soon as possible, and increase their competitiveness by achieving the economies of large scale production. The importance of market considerations in the pricing decision will also be affected by the economic position of the product's likely users. If these are low income consumers, or small size producers, then they will not experiment with the good unless they can obtain it at a relatively low cost. In some cases, the sale of the good may even call for an introductory price below the cost of the good's production.

Whether firms first charge a high or low price for the new product, they will not keep the price at its initial level for long. Product values change frequently in an emerging industry as its members discover, through trial and error, the market worth of the good. Competition helps this discovery by forcing firms to price the good at its market value. Firms who set prices higher than this value lose customers and market share, and

those whose prices fall below this value cannot earn the profits of their competitors and hence fall behind in the financing of the product development race.

Discovering the market worth of the good entails finding a level for its price that is within the reach of its targeted customers, and in line with their other expenditures and the good's contribution to their economic welfare. The identification of the relevant market, the segments of society that have a need for the good and their distinguishing economic characteristics, is essential. Once the dominant design concretizes the need for the good, the individuals who have this need can be isolated, and the price for which they will purchase the product can be determined.[12]

The series of innovations that achieve a dominant design for the product create its market. By undertaking these innovations, producers of the new product establish its market, and establish themselves in the economy. The formation of markets is simultaneously the formation of firms.

Market Expansion

Infant industries are not very profitable. Sales are low, due to the limited initial usages of the good, and the problems with its performance, and the cost of producing a product whose technology has not yet been worked out leaves little revenue for profit. Large profits, and especially the growth of profits, do not appear in the industry until after the producers have carved out an economic space for the product.

The profitable exploitation of the market for the new product comes about through innovations in the product and its production process. Adapting the product to the need that it satisfies, and the production process to the product, make up, respectively, the tasks of product and process improvement. Through this progressive adaptation, the sales and profit margin of the product increase at an accelerating rate.

The achievement of a dominant design marks the real beginning of product development. Once the product's utility is established in the dominant design, then firms can direct their energies toward satisfying a determinate and concrete need. Indeed, the product cannot be perfected until the product concept is settled. The improvement of the product, or the increase in its ability to fulfill needs, occurs in three different ways.

The first dimension of product improvement encompasses all the innovations designed to perfect the dominant design. Every component of the product has to be brought into line with the product model, and geared to its maximum performance. Innovations in these components, and the product adjustments that they require, create the best workable version of the dominant design.

Product specialization also results in product improvement. The need for the product can be more completely met by disassembling the various dimensions of this need and producing product varieties specifically adapted to each of these dimensions. For example, the automobile was improved by breaking down the need for it into the need for 1) family transport (the sedan), for 2) a recreational vehicle (the convertible or

sportscar), for 3) local, short distance transport (the two-door or, more recently, the compact) and for 4) hauling the bulky personal belongings of families (the station wagon).

Whereas the perfection of the dominant design improves the performance of the product, product specialization expands the range of the good's applications. Both processes escalate the growth of sales. The former does so by speeding the market penetration of the product, and the latter by generating new markets.

The third dimension of product development builds on the first two and particularly on product specialization. When the different aspects of the need for the good become embodied in specific product varieties, it becomes possible to uncover the principle that unites these aspects, and construct a product model that satisfies all of them. Such a model increases the product's utility to its buyers by allowing them to obtain all the uses of the good in a single purchase. Examples of this product universalization include the multipurpose machine, which, through a change in its parts (or computer programs) performs the tasks that a number of different machines used to accomplish, and the hatchback, which satisfies in a single product the need for hauling bulky items, family transport, and a sporty and drivable vehicle.[13]

The dominant design ushers in the development of the production process as well as the product. Before the establishment of a dominant design, the production process has to be flexible enough to incorporate major and frequent changes in the product model. The necessity of quickly shifting the direction of production limits the kind and amount of specialized equipment employed. The adaptation of the organization and inputs of production to the properties of the product is not possible until the dominant design fixes the product concept.

Significant and cumulative cost reduction begins with the establishment of the dominant design, and proceeds with the improvements in the product that expand its market. To meet the growing demand for the product, producers evolve and adopt techniques that increase the output and pace of production. Producers break the bottlenecks of production by improving its organization, and devising, in conjunction with their suppliers, equipment and materials specifically adapted to the particularities of the product's production. Product market expansion permits and necessitates techniques of large scale production, and encourages the invention of cost reducing methods of production, since the profitability of these inventions, to both their inventors and adopters, rises with the scale of their application.

While the growth of demand for the product spurs the development of more efficient methods of production, the relation between the demand for the product and improvements in its production process is not, as Schmookler envisioned, unidirectional.[14] Process innovation contributes as much to market expansion as market expansion does to process innovation. Process innovations enlarge the funds available for the development of the product, and/or allow those price reductions which widen its market, e.g., those that draw low income consumers or small size firms into the market, and those that eliminate the cost barriers that stand in the way of the product's substitution for other commodities.

its sales promotes improvements in its production process, and these contribute to the development of the product and its market. Market expansion furthers innovation, and innovation furthers market expansion, and the result of both is the growth of the industry and its profits.

Competition and Market Expansion

The primary agents of the industry's expansion are not the firms which created it, but those new to it, and especially the ones well established in other sectors of the economy. Entry, and the competitive dynamic engendered by the threat of entry, ensure and speed the product developments which propel the industry's growth.

Entry is greatest during the stage of the industry's expansion. The attractiveness of entry increases sharply as the growth phase begins, and sales and profits rise. Market growth generates space for new firms, and protects them, at least for a time, against the retaliation measures of established concerns. While entry costs are higher than in the infant phase, the requirements of entry are less difficult to meet.

Special insight into need for the product is not necessary for its production, and even knowledge of the good's technology does not act as an effective barrier to enter. Firms with the technical base to develop the product, of course, have a competitive advantage. Yet, this technical base can be acquired, if the firm has the capital to purchase one of the industry's existing enterprises, or pay higher salaries to its technical employees. Market share gains still depend on technical advances, but these depend more on the availability of funds for research and development than on the specialized experience or training of the firm's managers. The systematic search for product applications expends much revenue, as does the "scaling up" of product prototypes, and the adaptation of materials and equipment to the properties of the product.

When the industry moves into its growth phase, finance becomes the main requisite of success. Capital is especially important for success in a growth industry, not so much because of the high cost of production, but because of the high cost of 1) carrying out large scale research and development programs, 2) expanding capacity at the accelerating rate of market growth, and 3) distributing and marketing a mass produced product. Insofar as capital is a less specialized resource than knowledge of needs or technical skills, more firms can scale the entry barriers of the industry after its growth phase begins.

Industry growth particularly induces the entrance of large, successful firms. These have the funds to effectively compete, and find an expanding industry, with its promise of increasing sales and profits, especially conducive to their pursuit of long-run growth. By diversifying into new, growth industries, the firm increases its growth potential, and extends its life beyond that of its existing products.

The industry first attracts firms whose current operations relate, in one way or another, to the business of the industry. They have kept a keen eye on industry happenings, and are ready to spring into action as soon as sales shoot up. As market growth gains momentum, however, other firms also

enter. Those without the requisite technical knowledge take over the industry's smaller, prosperous enterprises. The owners of these enterprises sell out, partly because selling out, the capitalization of their skills by "going public," was the main objective of starting the business, and partly because they lack the finance and managerial skills necessary to take the product through the stage of its mass production.[15]

Entry advances innovation in the industry, and product improvement in particular. Newcomers capture market share by perfecting the performance of the product or extending its applications. Product innovation allows the entrant to overcome brand loyalty and the absolute cost advantages that result from the accumulated production experience of the established concerns. Fundamental advances in the product typically mark the waves of new entry.[16]

In contrast to the newcomer, the firm established in the industry does not need to perfect the product to build goodwill. Product improvement can deepen the market for the product and augment the profits of its producers, but product innovation is not the only way that the firm can enlarge the profits earned in the industry. Process innovation, and backward and forward vertical integration, also enhance the profits of the firm.

A variety of factors encourage the industry's leaders to postpone the development of its product. The first is the fact that the profitability of many types of product innovations decreases with the size of the firm's operations in the industry. In particular, the larger the firm's share of the market for the product, the lower is the profitability of product innovations that perfect the performance of the product without multiplying its forms. For the firm which already produces the product does not stand to gain all the profits expected from the sale of an improved version of the good, but only the difference between these and those currently earned on the product. As the firm becomes more successful in the industry, the attractiveness of these types of product innovations diminishes, and the probability of the firm choosing process improvement over product improvement increases, given that the profitability of process innovation, unlike that of product innovation, rises with the market share of the firm.

Where product improvements available are those that reduce the number of product models, then the likelihood of the industry's leaders postponing product development becomes even greater. This kind of product improvement, i.e., product universalization, can increase the profit potential of the industry without raising the profits of its leaders. While product universalization augments the revenue of these firms, it also makes some, and sometimes all, of their product models obsolete. For the leaders of the industry to benefit from product universalization, it must raise their revenue by an amount great enough to offset the loss of capital that results from the obsolescence of their product line. Innovation of any kind is, in fact, more costly to the firms established in the industry than to its new members since the former have capital invested in the existing production techniques and products of the industry.[17]

Dominant firms in the industry may even be reluctant to improve the product in ways that widen their product line. The appearance of new product varieties changes the terms of competition in the industry, and its leaders may fear the technological warfare that the new models unleash. In addition, the newer models can encroach on the markets of the older ones, the ones that the dominant firms have heavily invested in.

Firms new to the industry introduce the product innovations that the established enterprises postpone, and force these enterprises to evolve product models that incorporate the state of the art technology. Competition, and even potential competition, more effectively moves the firm towards innovation than the promise of an increment to its profits. Industry development, and the pace of this development, depend critically on the possibility of entry, and thus on the presence of firms with sufficient capital to diversify into new industries.

Maturity

If needs and technology remain constant during the life of the industry, then its development ends with the maturation of its product. Product maturity results from the realization of the objectives of product and process innovation. It occurs when the product wholly satisfies the need for it, and the production process fully conforms to the product.

When the industry matures, producers lose control over the factors which affect the industry's profitability. Producers no longer can cut costs by improving methods of production. Production is fully geared to the properties of the product, and the most efficient method of producing the good with the available resources and technical knowledge of society is already in existence. All firms can do is await the opportunity of benefiting from technical advances in other sectors of the economy.[18]

Producers of a mature product have no more control over the sales of the product than they do over its costs of production. Product maturity, by definition, precludes the expansion of sales through product improvement. Sales growth through price reduction is also not possible, since all the potential users of the product, including the lower income ones, have already been brought into the market. Even advertising cannot raise the demand for a mature product. With all the properties of a mature good widely known and utilized within the economy, advertising can do nothing but maintain the sales of the industry, or redistribute them among its members.

The inability of firms in a mature industry to augment its sales does not mean that sales do not grow. Demand for the product of a mature industry can increase, but only as the result of events external to the industry itself. In the case of a consumer good, sales rise if the work force expands, if demographic shifts enlarge the customer base of the good, or if changes in the distribution of income draw more individuals into the socio-economic group that consumes the good. Likewise, demand for a mature producer good grows with increases in the demand for products which require the good in their production.

A mature industry can expand, but its members cannot promote its expansion. Firm growth in a mature industry can occur only by chance or at the expense of other firms. Growth at the expense of other firms is, moreover, difficult to achieve under the conditions of maturity. These conditions preclude the increase of market share through innovation, and confine

market share gains to those which can be won by price cuts, advertising, or style changes.

While the development of the industry terminates in maturity if needs and technology do not change in the industry's lifetime, needs and technology only remain constant during the life of the industry in the static world of traditional economics. Outside this world, the formation of markets and their profitable exploitation are normal occurences. New products and technologies appear, and economic development prevails.

With needs and technology changing, the viability of a product depends on whether its properties can be adapted to alterations in the economic environment. Adapting the product to changes in the circumstances of its consumption entails a new cycle of development, while the failure to do so results in the product's demise. An industry is either developing or declining, with maturity just an empirical pause in the industry's development, or between its development and decline.[19]

The Innovative Roles of New and Established Firms

New firms play, as Schumpeter argued, a critical role in the development of the economy. While their innovative activities are significant, they do not carry out all kinds of "new combinations." New firms undertake only those types of innovations which transform product inventions into marketable commodities. The Schumpeterian conception of technical change is too abstract to take in the particularity of the role of the newly founded concern.[20]

The industries built by new companies are expanded by established ones. They undertake the product and process improvements which diffuse new goods throughout the economy. The major claims of Schumpeterian theory, that "new combinations" are carried out by new firms, but are impossible without the profits that large enterprises earn, no longer appear contradictory when innovation is viewed concretely in terms of the stages that comprise industry development.

Not only is economic development furthered by both young and older enterprises. It is also essential to the success of both. Industry formation opens up the economy to new firms, and sustains the growth of established ones. If there were no new, growth industries for the firm to diversify into, its expansion would slow down when its original product line matured, and pass wholly outside the firm's control. The expansion of the firm would be possible, but firm growth strategies would not. Without economic development, new firms could not become successful, and already successful ones could not affect the pace of their expansion.

The Empirical Studies

Research into the innovative activities of small firms has focused on the extent of their innovative effort. Related empirical work has concentrated on measuring the small firm's contribution to innovation, so that questions like the "research intensity" of small firms, and the size of their inventive "input" and "output" have been the primary concern. Little

attention has been paid to the distinctiveness of the small firm's role in the innovation process, partly because this process has been viewed abstractly as simply the commercialization of invention. Thus, while the empirical literature on technical change contains many studies of the innovative activities of small firms, few of these studies examine the nature of these activities. Those which do support our argument for the importance of new firms in industry formation.[21]

Since technical change research has not been interested in the role of new firms in industry development, very little empirical work has been done that relates to the availability of finance to new high technology enterprises. Moreover, the work which has been done has not dealt with the question of whether the funds available to these enterprises are sufficient to further industry formation. While this issue remains to be investigated, it is clear that the funds needed for entry during an industry's infancy are much less than those required after the industry's establishment, when research and development costs escalate, and product differentiation and scale economy barriers are erected. It is also clear that the commercialization of many of the most significant nineteenth and early twentieth century product inventions (e.g., the telegraph, telephone, and radio) was financed out of the private fortunes of their inventors and promotors, and the capital raised through stock issues in companies they founded.

Financing a new high technology firm is easier today than it was in the past. Stock exchanges are better organized and larger in number. Venture capital institutions have sprung up since the Second World War, and governments have instituted various kinds of support programs for small firms.[22] These factors have considerably lessened the finance problems of new high technology concerns, though they still may have difficulty raising funds in some countries and/or for some purposes. The government may have little interest in the technology the firm is developing, or the technology's development may require sums not normally channeled through existing venture capital instutitions.

The innovative effort of large firms, like that of small firms, has been examined mainly in terms of its quantitative dimensions. Much is known about the extent of innovation in large firms, but very little about its character, and still less about the specific way it advances industry construction. To determine the role of large firms in industrial change, we need to know not whether they innovate, but the kinds of innovations they undertake and, particularly, if they invest in infant industries. These questions have not been systematically investigated, though we do know that in many cases the large firms most likely to enter a new industry played no part in its construction, or entered on a small scale or late in its development.

The British cable telegraph firms were among the last to recognize the commercial possibilities of Marconi's new radio telegraphy, and Baird's television was received by the British radio communications firms with the same indifference as the telegraph concerns had shown towards Marconi's radio.[23] Western Union did not pioneer the telephone, though the company had already begun research on the telephone, and held significant patents on related devices, when it was offered the patent rights to Bell's invention.[24] Companies specializing in the production of electromechanical calculators were slow in introducing electronic calculators and never

invested much in their development.[25] The established transportation equipment manufacturers of the nineteenth century did not build the automobile industry,[26] and the major American valve companies, while some of the first to manufacture and research the transistor, limited their involvement in the industry, and were not the leading forces behind its growth.[27] IBM entered the personal computer market after its establishment, and the large farm equipment and automotive companies waited until others had demonstrated the profitability of recreational vehicles before beginning their production.[28]

While the cases cited above do not demonstrate the reluctance of large firms to exploit product pionerring opportunities, they do suggest the fruitfulness of further research on the role of large firms in industry development. Perhaps through this research the as yet unsettled question of the relative importance of large and small firms in the innovation process can be decided.

Notes

[1]For the history of the radio see Schubert (1971), and for the events leading up to the invention of the transistor see Morton (1971).

[2]Majumdar (1982) discusses the case of the calculator, and other instances of the positioning of new goods in market niches are presented in Utterback (1977).

[3]The commercialization of Morse's telegraph invention was considered such a speculative venture that Morse and his backers had difficulty raising even small amounts of finance, and while the Postmaster General of the United States urged the government to purchase the patent rights to the invention, he doubted that telegraph revenues could be made to cover costs under any feasible rate structure (Thompson, 1947). Western Union apparently thought Bell's telephone invention was not worth the price ($100,000) he was asking for its patent rights (Brock, 1981). When the television first appeared in England, few besides its inventor (Baird) believed it had any entertainment value (Sturmey, 1958), and the computer was initially viewed, by both the business press and the leading tabulating equipment manufacturers (including IBM) as unmarketable (Brock, 1975).

[4]Voice communication over the telephone was initially limited to the distance of twenty miles, and one of its most important original usages was communicating messages which the telegraph transmitted over long distances (Brock, 1981). The radio is not now primarily used for maritime communication, and the electronic calculator found its economic home in the pockets of consumers, not in the offices of firms.

[5]This is emphasized by Schumpeter in Schumpeter (1961) and by Keynes in Chapter 12 of Keynes (1954). Their conception of the entrepreneur is consistent with recent studies of entrepreneurial motivation which indicate that the entrepreneur is more interested in achievement than in financial gain or even power. For a review of the results of these studies see Rothwell and Zegveld (1982).

[6]In the early years of the automobile's development, electric, gasoline, and steam cars were produced, each in a variety of different forms and many to customer order. See Abernathy (1978, p. 10).

[7]The importance of the feedback of users to the development of the product is emphasized in the product life cycle model of international trade. See, in particular, Vernon (1966).

[8]In the past, the capital needed to finance the entrance of a newly formed enterprise into an emerging industry has come from the government, in the form of contracts or grants, or from the personal contacts or wealth of the founders of the firm. More recently, venture capital institutions have provided this finance. The issue of the availability of finance to high technology firms is discussed further in the last section.

[9]Many of the first successful entrants into the electronic components industry were spinoffs from its established enterprises. See Tilton (1971).

[10]Abernathy argues that product performance was the most important competitive variable in the early years of the automobile industry. For other examples of the importance of technological competition in infant industries see Phillips (1971), Porter (1980), and Tilton (1971).

[11]The notion of the dominant design is the central concept of Abernathy's work on the product life cycle. See Abernathy (1978).

[12]The history of the automobile industry nicely illustrates this relation between the determination of the utility and price of the good. In the auto industry, the establishment of a dominant design, the Model T, allowed and, in fact, entailed, the demarcation of a specific market for the product, the rural population, and a particular price, one that farmers could afford. See Abernathy (1978).

[13]Product universalization and specialization receive extensive treatment in Levine (1981), and the perfection of the dominant design is discussed in detail by Abernathy (1978). The latter also provides much of the material for the following discussion of process innovation.

[14]In Schmookler's model of technical change, innovation in the industry depends on the growth of sales, which is given and supposedly unaffected by innovation, even though the evidence Schmookler presents does not clearly support this view. See Schmookler (1966).

[15]Historical factors also have a bearing on the feasibility of entry through acquisition. An organized stock market is necessary, as is the impossibility of a young firm slowly growing into a large one. This route to success was more practical in the nineteenth century when firm size was generally smaller than it is today. As soon as established firms have sufficient resources to diversify into growing industries, the pace of development escalates, and small firms have not the time to grow large through accumulating capital out of their profits.

[16]See Utterback (1979). In producer goods industries, where price reduction in and of itself increases the utility of the product, process innovation is also an effective route of entry.

[17]The lower cost, and greater necessity, of innovation to the new entrant is emphasized in Klein (1979).

[18]In some formulations of the product life cycle model, innovation continues in maturity, though the innovations undertaken are only minor improvements in the product and its production process. The maturation of the industry does not mean the end of its development, as it does in this paper, but the end of any major changes in the industry's product and techniques of production. See Abernathy (1978) and Utterback (1979).

[19]This is brought out in Levine (1981).

[20]In the Schumpeterian theory, the new firm either plays an all important role in the innovation process, or no role at all. The first view of the innovative contributions of the new firm is found in Schumpeter (1961) and the second in Schumpeter (1975).

[21]See Freeman, Clark, and Soete (1982), Rothwell and Zegveld (1982) and Tilton (1971). Porter (1980) also claims that new firms have played an important role in industry formation, and cites cases where this was true.

[22]For the availability of venture capital in different countries and the effectiveness of government efforts to promote the growth of small businesses see Rothwell and Zegveld (1982).

[23]See Sturmey (1958).

[24]See Brock (1981).

[25]See Majumdar (1982).

[26]See Abernathy (1978).

[27]See Tilton (1971).

[28]See Porter (1980). This work also contains other examples of the failure of large firms to seize product pioneering opportunities.

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