



The Growth of the Firm

A Case Study: The Hercules Powder Company

Growth is governed by a creative and dynamic interaction between a firm's productive resources and its market opportunities. Available resources limit expansion; unused resources (including technological and entrepreneurial) stimulate and largely determine the direction of expansion. While product demand may exert a predominant short-term influence, over the long term any distinction between "supply" and "demand" determinants of growth becomes arbitrary.

by Edith T. Penrose

LECTURER AND RESEARCH ASSOCIATE
AT THE JOHNS HOPKINS UNIVERSITY

The following analysis of the growth of the Hercules Powder Company was originally intended for inclusion in my *Theory of the Growth of the Firm*,¹ but was omitted in order to keep down the size of the book. The Hercules case was designed to illustrate the argument of that study; the interpretation of im-

¹ Edith T. Penrose, *The Theory of the Growth of the Firm* (New York and Oxford, 1959).

portant factors in the growth of Hercules is shaped by the case histories of other firms studied. Consequently I shall begin with a brief summary of some of the relevant conclusions presented in my larger work. In doing this I necessarily risk appearing either dogmatic, since oversimplification and absence of supporting argument are unavoidable, or trite, since demonstration of the theoretical and empirical significance of the conclusions is impracticable here.²

A firm is both an administrative organization and a pool of productive resources. In planning expansion it considers two groups of resources; its own previously acquired or "inherited" resources, and those it must obtain from the market in order to carry out its program. All expansion must draw on some services of the firm's existing management and consequently the services available from such management set a fundamental limit to the amount of expansion that can be either planned or executed even if all other resources are obtainable in the market. This is as true for expansion through acquisition as it is for internal expansion, although acquisition permits a faster rate of growth and often facilitates diversification. A firm is not confined to "given" products, but the kind of activity it moves into is usually related in some way to its existing resources, for there is a close relationship between the various kinds of resources with which a firm works and the development of the ideas, experience, and knowledge of its managers and entrepreneurs. Furthermore, changing experience and knowledge of management affect not only the productive services available from resources, but also the "demand" which the firm considers relevant for its activities.

At all times there exist, within every firm, pools of unused productive services and these, together with the changing knowledge of management, create a productive opportunity which is unique for each firm. Unused productive services are, for the enterprising firm, at the same time a challenge to innovate, an incentive to expand, and a source of competitive advantage. It is largely because such unused services are related to existing resources and partly

² NOTE ON SOURCES: This study of the Hercules Powder Company was made possible by a Fellowship granted me by the Foundation for Economic Education in cooperation with the company, which enabled me to spend six weeks studying the company from within in the summer of 1954 with the full cooperation of all of its personnel. The paper was completed in 1956; when I decided to publish it now I inquired of the company about subsequent developments, receiving the following reply: "More recent events, while of great interest within Hercules (and we believe in the industry), are largely a continuation of the types of growth you have shown to be typical and more or less to be expected, except at possibly a somewhat faster rate. Actually, the manuscript can never be quite up to date in an expanding company, nor for your purpose does this seem to be necessary." I agree with the last statement and for this reason have made no attempt to bring it to the present.

because of the pressures of competition that firms tend to specialize in broad technological or marketing areas, which I have called technological or market “bases.” In a sense, the final products being produced by a firm at any given time merely represent one of several ways in which the firm could be using its resources, an incident in the development of its basic potentialities. Over the years the products change, and there are numerous firms today that produce few or none of the products on which their early reputation and success were based. Their basic strength has been developed above or below the end-product level as it were — in technology of specialized kinds and in market positions. Within the limits set by the rate at which the administrative structure of the firm can be adapted and adjusted to larger and larger scales of operation, there is nothing inherent in the nature of the firm or of its economic function to prevent the indefinite expansion of its activities as time passes.

Entrepreneurial services are as much productive services as are the services of management, labor, or even machines. Entrepreneurial incompetence, or general cautiousness, including a conservative attitude toward financing, should be looked on not as a failure to “maximize” profits, whatever that may mean, but as a limitation on the supply of productive services to the firm.

In the explanation of the course of expansion of a particular firm and of the limits on its rate of expansion, it is illuminating to put the chief emphasis on the firm’s “inherited” resources and productive services, including its accumulated experience and knowledge, for a firm’s productive opportunity is shaped and limited by its ability to use what it already has. Not only is the actual expansion of a firm related to its resources, experience, and knowledge, but also, and most important, the kinds of opportunity it investigates when it considers expansion. Moreover, once a firm has made its choice and has embarked on an expansion program, its expectations may not be confirmed by events. The reactions of the firm to disappointment — the alteration it makes in its plans and activities and the way in which it adapts (or fails to adapt) — are again to be explained with reference to its resources.

These relationships are portrayed in the chronology of the changing productive opportunity of the Hercules Powder Company. The history of this company illustrates the nature and significance of the areas of specialization of a firm — its technological and market bases — as well as some of the difficulties encountered when an attempt is

made to move to new bases markedly different from the old. The outlines of the company's diversification are presented in Chart I. The following story elaborates, explains, and discusses the significance of the movements implied therein.

In 1912 a large United States firm, E. I. DuPont de Nemours, then looked upon as dangerously close to monopoly in the explosives business, was broken into three parts by action of the federal courts as a result of an antitrust suit initiated by the federal government in 1907. One of the two "new" firms thus created was the Hercules Powder Company. At the time of its formal organization in 1913 Hercules had a thousand employees and nine plants; it produced explosives only: black powder and dynamites.

During the next forty-odd years this amputated piece of DuPont, like a cutting from a plant, continued to grow.³ It, like DuPont, has over the years branched out in numerous directions in response to external opportunities and internal developments. The parent and its involuntary offspring have not grown in the same directions, and in only a few fields are they in direct competition with each other. Hercules is not only completely independent of DuPont, but has acquired its own personality and its own position in the industrial world quite unrelated to DuPont's position. By 1956 it had 11,365 employees, 22 domestic plants, and total assets of nearly \$170 million, making it the 165th largest industrial company in the United States measured by total assets.⁴

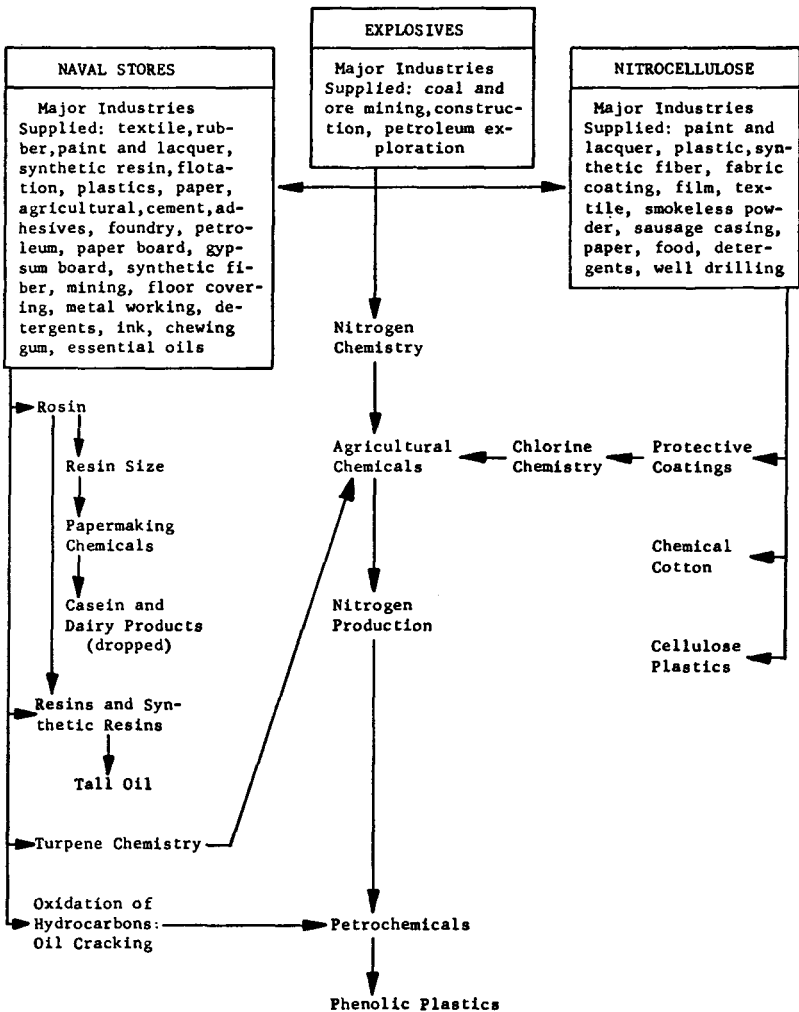
The company's rate of growth has been modest (something over 5 per cent per year in terms of fixed assets) but fairly steady. Its financing has been conservative, virtually all of its growth having been financed with internally generated funds. It has engaged in little acquisition, only eight small companies with total assets at the time of acquisition of less than 10 per cent of the company's present net worth having been acquired in its entire lifetime. Its "entrepreneurship" has been what I have called "product-minded," reasonably venturesome and imaginative, but concentrating on "workmanship" and product development rather than on expansion for its own sake or for quick profits.

³ The story of Hercules also illustrates the point that the splitting up of large companies will often not have an adverse effect on efficiency if the advantages they have in expansion are economies of growth and not economies of size. For a discussion of these two types of economies and their significance see Penrose, *The Theory of the Growth of the Firm*, Chap. VI.

⁴ This rank is the one given in the *Fortune Directory* of the 500 largest United States industrial corporations. Supplement to *Fortune* (July, 1957). In addition to the above, Hercules had three plants in wholly owned subsidiaries abroad and employed some 6,000 workers in government owned Hercules-operated ordnance facilities.

CHART I

DIRECTION OF EXPANSION



DEVELOPMENT OF THE TECHNOLOGICAL AREAS OF SPECIALIZATION

The original technological base of the Hercules firm was explosives and for the first few years of its existence it was kept busy with the expansion of this field. Two new plants were acquired and improvements were made in existing plants and in the processes of production of dynamite, smokeless powder, and cordite. One of the innovations – the production of acetone (a solvent used in the manufacture of cordite) and other products from the giant kelp found on the Pacific Coast – involved an extension of the firm's knowledge and experience in a type of organic chemistry which was to become significant in its subsequent diversification.

The manufacture of explosives is still of considerable importance for Hercules (accounting for 18 per cent of sales in 1951) and at times has been its most profitable operation, providing funds for the extension of activities in other directions. Substantial innovations have been made in the field of semigelatin explosives, smokeless powder, packaging of explosives, and explosive supplies. Some diversification into the production of chemicals used in explosives production, notably nitric acid, anhydrous ammonia, and other nitrogenous compounds, has been made, and this development has contributed in recent years to Hercules' position in the agricultural chemicals industry.

In spite of the innovations and enlarged activity, however, the explosives business was not one to permit extensive growth and development of the firm. In particular, it provided little opportunity for the use of the experience in the field of organic chemistry that had been developed by Hercules men in the course of the firm's operations. Furthermore, at the end of the First World War the plant, organization, and accumulated funds of the firm were much greater than could be used in explosives in view of the drastic decline in demand after the war. In the immediate postwar period numerous opportunities for profitable investment were open on all sides in the expanding, changing economy. But which of them would furnish opportunities for the growth of a still relatively small and specialized explosives company?

Nitrocellulose and New Areas of Specialization

Nitrocellulose is one of the most important basic raw materials in the production of explosives. In 1915 Hercules had bought the Union Powder Company, which had a plant for the nitration of cotton linters (the "fuzz" on cotton seeds and a by-product of cot-

ton production) into nitrocellulose, then used primarily for smokeless powder, but also for celluloid and collodion ("new skin"). Already by 1917 the company was experimenting with the production of nitrocellulose for industries other than explosives, for if it could produce a suitable soluble nitrocellulose it felt sure of a large market supplying the needs of the lacquer, film, and protective coatings industries generally. It succeeded in developing an appropriate product, and by 1923 was firmly established in the field. Between 1918 and 1944 Hercules' production of soluble nitrocellulose increased from 100,000 pounds annually to 28,000,000 pounds and the price was lowered from 75 to 33 cents a pound.

So efficient was Hercules' production and quality control and so well-developed its control of explosive hazards in the manufacture of the basic product and also in its use by customers, that a number of companies withdrew from the field. Some of these were integrated companies, producing for their own use, who found it more economical to buy their requirements from Hercules; others simply withdrew in the face of Hercules' competition. The automobile industry turned out to be the biggest consumer, using nitrocellulose in its lacquers. In consequence, Hercules was in a position to profit from the rapid growth of this then relatively new industry. Nevertheless, here, as in other fields, continual attention to the development of new products and new methods to meet or surpass competitive developments has been required. For example, the advent of baked enamel for automobile finishes, which reduced the labor time required for finishing, was a serious threat to lacquer; and Hercules developed new lacquers which could be sprayed on hot and meet the new competition in cost.

Successful development of nitrocellulose for nonexplosive uses provided for Hercules an extensive technological base as well as an important market area of specialization. The development of the technological base led to expansion in still other markets; the development of the market base furthered expansion into still other branches of chemistry. Broadly speaking, the technological base was that of cellulose chemistry; the market base, supplier to the protective coatings industry.

Cellulose Chemistry

Hercules' base in cellulose chemistry enabled it to take advantage of the growing markets in the artificial fiber and plastics industries. Cellulose acetate, an important raw material in the rayon industry and used for the production of some grades of plastics, soon

became, for the firm's Cellulose Products Department, an important product in quantity, though disappointing in profitability.

The cellulose acetate market is highly competitive, and, in this as well as in most of its other products, one of the firm's biggest competitive problems arises from the ever-present possibility that its customers will integrate vertically and start producing their own requirements. In the long run Hercules can prevent this only by producing a high-quality product and selling it at a price that makes integration unprofitable for customers. Hence a relatively low sales margin is earned and continual research and experimentation are carried on. (Hercules has even experimented with the spinning of fibers in order to acquire knowledge which might be of use to its customers. As we shall see, "technical service" is one of the "utilities" Hercules sells with all of its products in order to maintain its market position.)

With the development of synthetic rubber during the Second World War came a new petrochemical base for cheap plastics (polystyrene) which soon began to displace cellulose acetate in molding powders, the basic material from which molded plastics can be made. Petrochemicals, however, involved a branch of chemistry in which Hercules had only limited experience at the time. Many of the companies producing the new plastic material had developed extensive experience during the war which gave them a new "base" in petrochemicals. Hercules' wartime activities were in very different areas. The firm's lack of an adequate technological base was sufficient to prevent it from taking up the production of polystyrene and similar petrochemical products. Consequently the company attempted to reach new markets with its own cellulose acetate by taking up the production of molding powders.

The extensive knowledge of cellulose chemistry possessed by Hercules has provided a continuous inducement to the firm to search for new ways of using it. For example, during the war Hercules, in an attempt to replace a lubricant no longer available, took up the production of an extraordinary versatile cellulose gum — sodium carboxymethyl-cellulose (CMC). The firm was much impressed with the properties of this chemical composition, but was not sure to what use American industry could put it. Perhaps CMC could be used in the sizing of textiles (Hercules already produced some types of fabric coating). No one knew; nevertheless, advertisements were placed in trade papers describing the qualities of the product and inquiring "What do you see in CMC?"

The product caught on. Here, surely, is an almost perfect ex-

ample of the creation of consumer demand as a consequence of entrepreneurial desire to find a use for available productive resources. The biggest uses for CMC, initially, turned out to be as a stabilizer in foods, ice cream, lotions, drugs, and cosmetics. CMC also proved to have an industrial application in oil-well drilling mud – an outlet the firm had not anticipated. It is now also used in textile sizes, finishes, and printing pastes; in ointment bases, in thickening rubber latex; in can-sealing compounds and grease-proof paper coatings; in tooth paste; in emulsion paints and lacquers; in leather pasting; in ceramic glazes; and as a binder for crayons and lead pencils. Innovations in use and in the product continue. In 1955 a new type of CMC was introduced which was expected still further to expand the market and the variety of uses.

There are other cellulose products and specialties that have been developed by Hercules which we shall not take the time to discuss here, but our account cannot leave out the firm's early diversification into the production of its own requirements for chemical cotton, the raw material for cellulose products of all kinds. In 1926 Hercules purchased the Virginia Cellulose Company at Hopewell, Virginia, in order to produce one of its own basic raw materials and, in particular, to control its quality. The purchasing of cotton linters – of which the second cut is used for chemical cotton – is a highly specialized business. Hercules buys around 40 per cent of that part of the nation's production of cotton linters destined for chemical uses, and supplies not only all of its own requirements but sells outside as well, for production must be on a large scale to be efficient. When Hercules went into production of chemical cotton its chief use was in paper making and in nitrocellulose products. The expanding rayon industry provided a new and growing outlet, and later another important use was found in the manufacture of high tenacity viscose rayon for tire cord.

Developing a New Base – Naval Stores

Broadly speaking, as can be seen in Chart I, the operations of the Hercules Powder Company, apart from explosives, can be divided into two large chemical branches, with a third becoming clearly evident in recent years. They all overlap in the markets they serve, and each leads in its later stages into new areas of chemistry which may well provide new technological bases for further diversification. The movement into new aspects of cellulose chemistry, just described, was an obvious entrepreneurial response to the postwar decline of nitrocellulose markets in the explosives field.

The subsequent branching out of the company was the logical (though not inevitable) effect of its continually increasing knowledge of cellulose chemistry as well as of its developing position in its various market areas. Later we shall discuss the interaction between the technological and market bases of the firm; for the present we are concerned primarily with the technological aspects of its diversification, although clearly technological developments are of use only if profitable markets can be found.

Important as the opportunities were in the field of cellulose chemistry, however, they did not appear to the firm to promise sufficient scope for the entrepreneurial, managerial, labor, and technical services available to it at the end of the First World War. In 1919 the company had created an industrial research department for the express purpose of investigating products Hercules could profitably produce. This department decided that the firm could go into the production of wood naval stores (rosin, turpentine, and pine oil) obtained from the stumps of the long-leaf southern pine — like linters, a waste product of another industry.

Naval stores production was not as obvious an opportunity for Hercules as was cellulose chemistry, but, again it was expected to provide openings for the use of the existing resources of the firm. Hercules believed that it could use its knowledge of organic chemistry to produce a purified wood rosin good enough to compete with the gum rosin when gum prices were high; incidentally, the naval stores operation would also provide a use for dynamite in the blasting out of the stumps. Extensive lumbering operations during the First World War had resulted in a large-scale cutting of suitable trees, and it was widely believed that the consequent reduction in the supply of gum rosin would lead to an extended period of high prices which would make profitable the production of wood rosin.

Consequently, in 1920 Hercules built a plant in Mississippi for the steam distillation of rosin from pine stumps; it also bought another company owning a deteriorated plant but with a large supply of stumps. The mining of the pine stumps produced three joint products: rosin, turpentine, and pine oil, the main product for Hercules being rosin. Hercules did succeed in developing a purified wood rosin suitable as a substitute for gum in many uses, and it improved the productivity of the old plant it had bought, increasing rosin output by one third in three years and liquids production by 100 per cent. But the firm's original expectations of demand for wood naval stores turned out to have been too optimistic. Although wartime lumbering did sharply deplete the

supply of standing pine available for the production of gum naval stores, the second growth of trees came in, output rose, and gum prices fell drastically. Wood rosin could not compete with gum when gum prices were low, and the naval stores business of Hercules went into the red for many years. Notwithstanding its heavy investment in rosin chemistry research, Hercules came close to withdrawing from the business.

Rosin and Terpene Chemistry

But research paid off; unable to sell rosin in its existing forms in competition with gum, Hercules learned how to modify the product by hydrogenation, disproportionation, and polymerization and thus to convert it into various kinds of rosins for which many new uses could be found. Rosin is essentially abietic acid; when esterified with various polyols it makes hard resins valuable in the manufacture of paints and varnishes, and Hercules already had a position in the protective coatings field. Customers could be found for hard resins and rosin esters, and these, together with a variety of specialty resins as well as straight esters, were developed into an important outlet for rosin production. The naval stores operation became the equal of cellulose chemistry as a central technological base of the firm and in 1928 was organized as a separate department. In 1936 still another department was created, charged with the task of developing new uses and new outlets for resin-based products. As we shall see, the knowledge generated in this department, together with its market opportunities, soon led it outside the field of rosin chemistry and into new areas.

Further description of the range of products produced by Hercules and based in rosin chemistry would involve us in too much detail (and, incidentally, in too much chemistry), although we shall return to some of the more interesting developments in our discussion of the interaction between the technological and market bases of the firm. It is fairly easy for small firms and “in-and-out” producers to take up the production of resins; profit margins are consequently low, and the profitability of the industry for Hercules depends on large volume. To sustain its position, the firm has to rely on technological knowledge, low production costs, service facilities to customers, and continual improvements in production, in quality, and in variety of its products. Hardly a year passes without the introduction of several new products or improved varieties of old products, developed under the stimulus of actual or potential competition, the pressures of technical men with ideas to

put across, and the hope of profit from innovations in which the firm has special advantages because of its accumulated experience.

But rosin is only one of the three joint products of the pine stump, and markets had to be found both for turpentine and for pine oil, a relatively new industrial product in the 1920's, derived only from the wood operation. Fractional distillation methods were perfected which permitted the production of higher grades of turpentine and pine oil. In 1929 pine oil outlets were not developing fast enough to keep pace with production, and Hercules intensified its research into pine oil chemistry looking for derivative products. Thanite was developed, a terpene thiocynoacetate providing a toxicant for insecticides, and later toxaphene, a chlorinated camphene. These products put Hercules firmly in the field of agricultural insecticides which in turn stimulated research into agricultural chemicals generally. At times the demand for pinene has exceeded the company's output and it has had to buy crude products from pulp mills for refining. As was the case in cellulose chemistry, a large variety of chemical products and processes has been developed in the field of terpene chemistry. One of the latest processes bids fair to give Hercules a more established base in petrochemicals, a field which, as was noted above, had up to recently been outside Hercules' major fields of specialization, thereby handicapping the firm in its ability to meet competitive developments.

Petrochemicals – A New Base

In several of its manufacturing processes Hercules has always been involved in petrochemical operations. Although the manufacture of explosives is not in itself a chemical process, the production of the essential ammonia is. Nitric acid used for making explosives is obtained from ammonia, and the process used by Hercules to produce ammonia involves the cracking of natural gas. Furthermore, some of the processes in the rosin and terpene operations of its naval stores activities are similar in nature to the cracking of oil. Indeed, some of them can be and are used in oil cracking. Finally, in experimenting with the chemistry of terpenes and with the oxidation of the hydrocarbon by-products of naval stores, Hercules developed a reaction that utilized benzol and propylene and that resulted in a new process for making phenol. These developments opened up two new branches of chemistry for the firm: air oxidation processes and petrochemicals; new plants have been built for operation in both areas. The phenol plant, established near an oil refinery, uses a by-product of the refinery. Among the

important uses of phenol is the manufacture of synthetic resins for phenolic plastics; it is also used in the manufacture of varnishes, enamels, herbicides, and pharmaceuticals. Lack of any raw material "base" in petrochemicals had prevented Hercules from participating fully in the rising markets for rubber-base paints and for phenolic plastics. One of the primary hopes of management in establishing the phenol plant was to open the way for the acquisition of further knowledge in order to provide a base for expansion in this wide field of chemistry, as well as to put the company in a position to keep up with competitive developments arising in petrochemistry and affecting the market for some of its major products.

Finally, Hercules in 1955 took up the production of polyethylene for plastics. The technology was based on the work of German scientists who had discovered in experimenting with new types of catalysts that ethylene could be polymerized at low pressures to give a new type of high molecular weight polyethylene. This not only further extends Hercules' activities in plastics, but also takes it further into catalytic chemistry, which may, in time, lead into still further technological areas.

INTERACTION BETWEEN TECHNOLOGICAL AND MARKET BASES

Hercules is a producer of chemical products for other industries; it does not manufacture final products for the nonindustrial consumer. To obtain knowledge of the "demand" for its products, one of its principal tasks is to watch industrial developments in all relevant sectors of the economy in order to discover where its products might be made to supply the requirements of industrial consumers as well as or better than existing products. It is a conscious policy of the firm systematically to review its resources with an eye on external developments, asking the question, "What have we got to offer?"

Because of the nature of its market, Hercules stresses "technical service" to customers; salesmen are for the most part technically trained men. In selling their products the salesmen are expected to take an active interest in the production and market problems of their customers. This permits them to acquire an intimate knowledge of the customers' businesses and not only to demonstrate the uses of their own products and to suggest to customers new ways of doing things, but also to adapt their products to customers' requirements and learn what kinds of new products can be used. It is standard practice in the development of new products to get

customers to try them out on a "pilot plant" basis and thus to assist Hercules in the necessary research and experimentation.

Obviously, it is in those areas where Hercules' personnel have the greatest experience and the most extensive relationships with customers that the opportunities for the sale of existing products and for the promotion of new products will be widest. Hence, in spite of the enormous variety of possible end uses of Hercules' chemical products, the firm nevertheless remains in a relatively few broad "areas of specialization." Approximately 40 per cent of the total value of sales are accounted for by three industry groups: protective coatings, paper, and mining and quarrying, and an additional 40 per cent by six others: synthetic fibers, plastics, agricultural chemicals, petroleum, rubber, and identifiable military uses (the last including fees obtained from the operation of government owned ordnance plants).

The interaction between the market opportunities of the firm and the productive services available from its own resources can be seen in the development of almost any field we examine. A few examples will illustrate.

Paper-making Chemicals

The biggest customer of rosin is the paper-making industry which uses rosin largely in the form of rosin size, a sodium soap of rosin. As a result of the close association with the paper industry consequent upon its entry into naval stores production, Hercules in 1931 acquired the Paper Makers Chemical Corporation, a diversified, loosely organized company producing a variety of industrial chemicals. On acquiring the corporation, Hercules reorganized its productive activities, consolidating production in the more efficient plants and getting rid of others; it eliminated alum production and the jobbing activities of the old company. Eventually a separate department, called the Paper Makers Chemical Department, was created to take over the remaining collection of activities.

Although the basic reason for the acquisition of the old PMC was the outlet it provided for rosin and the possibilities for growth that Hercules saw in the rosin-size business, the activities of the new department in Hercules rapidly extended not only to many other chemicals useful in the paper-making industry but also to other industries using the same or similar chemicals. Thus, with the advent of synthetic rubber production, Hercules looked into the possibilities of using rosin soap as an emulsifier in the production

of synthetic rubber, and now sells a very large proportion of its rosin soap to the synthetic rubber industry.

This in turn stimulated interest in the general field of synthetic rubber production, now one of the more important areas of Hercules' research. Hercules' interest in the paper industry, arising from rosin sizes, has in recent years been substantially reinforced by the growing uses of chemical cotton in paper making. Much research has gone into the characteristics imparted to paper when chemical cotton is substituted for other raw materials. As a result, Hercules has been able to establish its raw material for many uses in paper making.

Among the activities of the old Paper Makers Chemical Corporation when it was acquired by Hercules was the production and sale of casein, a milk product used in the paper industry. Hercules retained this business for some twenty years and attempted to develop the field. For a while the operation was profitable, but owing to rising support prices of dairy products, imported casein became so much cheaper than the domestic product that it was no longer profitable to produce it. On the other hand, since the firm had an organization and a sales staff that it wanted to use, attempts were made to develop a chemical to displace casein in paper manufacturing. These attempts continue, but the casein operation itself was finally discontinued in 1953, after many years of unsatisfactory performance.

Protective Coatings

Protective coatings is a broad term including paints, lacquers, and other forms of providing a "coating" to protect wood, metal, cement, textiles, and other materials. Hercules' market position in this field goes back to its early production of soluble nitrocellulose for the lacquer industry; it was subsequently extended as the firm developed rosin products, also valuable in the paint and lacquer industry. The interest in the general market area of protective coatings imparted by these important uses of its basic raw materials led to developments within the firm which took it into the production of other products from other raw materials, but products that served the same types of customers and involved similar types of technological processes.

One of the early successful innovations in the field was the development of Parlon, a chlorinated rubber, valuable as an ingredient in paints for chemical plants and in other places where resistance to alkalis and acids is important. This product is pro-

duced in the large cellulose products plant of Hercules but is not related to cellulose through either raw materials or production processes. It was introduced to broaden the firm's base in the market for protective coatings. During the Second World War, rubber was in short supply and the firm, in order to use its plants, produced Clorafin, a chlorinated paraffin used as a plasticizer in synthetic rosins and as an ingredient in compounds for imparting flame, water, and mildew resistance to textile materials. After the war, the production of this product was continued and the production of Parlon resumed.

Development of the general field of protective coatings and of plasticizers also led the Synthetics Department beyond its original specialty of finding outlets for rosin in various forms, into research with chemical materials, unrelated to rosin, for the manufacture of new ingredients for protective coatings, new types of plasticizers, polyols used in rosins, and raw materials for synthetic fibers. By 1951, substantially more than 50 per cent of the sales of this department were of nonrosin-based products.

Agricultural Chemicals

All three of the major technological fields of Hercules have combined to give it an interest in the field of agricultural chemicals. The fact that nitrogen chemistry, in particular ammonia, is important in the manufacture of explosives and also one of the major bases of commercial fertilizers early gave Hercules a connection with agriculture. With the progressive development of chlorine and terpene chemistry and the introduction of the new insecticides, Thanite and toxaphene, mentioned above, this interest broadened. Although the original stimulus to the entry of Hercules into agricultural chemicals stemmed directly from the types of resources it possessed, once the firm had entered the field in a major way and created a technical and sales force to serve this market, the market possibilities became the primary stimulus. Extensive research activities were undertaken to develop further the firm's position in the field. A new laboratory for research into agricultural chemicals was opened in 1952, and in 1954 Hercules, together with the Alabama By-Products Corporation, set up the Ketona Chemical Corporation to produce anhydrous ammonia using by-product coke-oven gas as a raw material, the first ammonia plant to use this process in the United States. The plant produces for both agricultural and industrial nitrogen users in southeast United States.

Plastics

Celluloid, which is virtually nothing but nitrocellulose and camphor, was the forerunner of modern plastic materials (and, incidentally, is still important in many uses). This product was produced by Hercules from the very beginning; the development of cellulose acetate further committed the firm to the plastics industry. The various kinds of chemical plastics, which in a broad sense can often be regarded as the same "product," are made by substantially different chemical processes. Hence, the widening of Hercules' position in the plastics field stems from different types of chemical technology, the development of which has itself been stimulated by the firm's attempt to maintain and improve its position as a supplier to manufacturers of plastic products. Thus much research effort has been directed specifically toward the development of plastics, not only based on the firm's primary raw materials and on chemical processes used in its several other operations, but also going far afield into new processes and new raw materials. Hercules' research is broad and many different areas of activity are being explored, but which of the possible products are finally selected for "basic" expansion depends on the firm's estimate not only of the new markets they may create for the firm but also of how they fit in and can be developed along with existing resources and market areas. Many of the technological developments discussed above, such as the development of phenolic chemistry, were to a large extent stimulated by a desire to take full advantage of the growing opportunities in plastics.

Oil Additives

The story of Abalyn, tall oil, and Metalyn, is a minor one in the history of Hercules but is interesting from our point of view as an illustration not only of an interaction between technological and market bases, but also of the way in which new raw material sources can be developed in order to maintain an existing market position.

We have noted that rosin is one of the primary raw material bases of the firm. Under the pressure of the 1947 recession, Hercules was eagerly looking for new outlets for rosin. As we have seen, one of the primary measures adopted by the firm lay in the conversion of rosin to other products for which markets could be found. Among these products was Abalyn, a methyl ester of rosin, useful as an oil additive in high pressure greases because of its ability to hold grit and other foreign matter in suspension. The

important competitive substitutes were lard and sperm oil, which were expensive compared to rosin when Abalyn was introduced. These, however, fell in price and Abalyn became relatively expensive. To keep its markets, Hercules decided to buy tall oil, a by-product of paper mills, from which rosin could be obtained more cheaply than from the naval stores operations. This by-product, esterified, yielded a substance which used the same equipment as Abalyn for its production, did the same or better job as an oil additive, and was substantially cheaper. The product, called Metalyn, became an important product of the Synthetics Department, but at the same time lost for the firm an outlet for its own rosin. On the other hand, tall oil became a new and significant raw material for Hercules, and in 1954 the firm announced plans to build a plant for the processing of crude tall oil and the manufacture of rosin and fatty acids from it, thus establishing itself in another new field also based on a by-product of another industry. This development may be of especial importance in the future in view of the fact that the naval stores production is essentially a mining operation (the supply of existing stumps is being steadily depleted and no new stumps are being "produced"). Hence this source of wood rosin will eventually run out and substitutes will be required.

Food Industries

Finally, the latest venture of Hercules again illustrates the constantly changing and cumulative process involved in the interaction between the resources and markets of a firm. In 1956 Hercules acquired the Huron Milling Company, a small firm processing wheat flour to produce amino acids, food supplements, and wheat-based food flavoring, including monosodium glutamate. At first sight this acquisition looked rather far afield, although Hercules did have earlier connections with the food business through its CMC, discussed above, as well as chewing gum (a rosin derivative) and antioxidants for food products. Hence, although food chemistry and food markets had not been of primary concern to the firm, they were not completely alien to its experience. Nevertheless, the primary incentive for this particular acquisition and for the choice of this specific direction of expansion was somewhat different.

It will be recalled that Hercules produces its own chemical cotton from cotton linters. Production is carried on in the Virginia cellulose plant and the scale of activity depends not only on the demand for the product but on the supply of linters, which is a function of the size of the cotton crop. The supply of linters has not

been sufficient in recent years to employ fully the services of the personnel connected with the Virginia cellulose operation, and the firm has been looking for some suitable activity to absorb these "unused services." The Huron Milling Company was on the market. It was a family firm whose owners wanted to get out and retire from business and also to put their assets in a different form. (Estate tax considerations may well have had something to do with their desire to sell.) At the same time, the firm's activities were of such a nature that Hercules saw an opportunity to extend its knowledge in the food field, especially in the chemistry of amino acids, and to use the personnel of the Virginia cellulose plant. The Huron Milling Company was accordingly purchased with an exchange of shares and is now operated as the Huron Milling Division of the Virginia Cellulose Department. Whether a new base will develop for Hercules remains to be seen, but a start has been made which, if it fits in well with the general nature of Hercules' activities, may not only mean new markets for the firm, but new technology as well.

THE CHANGING PRODUCTIVE OPPORTUNITY OF THE FIRM

The diversification of the Hercules Powder Company, while unique in its details, is by no means unique in its general pattern and will be found repeated in greater or less degree in the story of any number of long-established successful firms. The company's history illustrates the impossibility of separating "demand" and "supply" as independent factors explaining the growth and diversification of a firm. The Hercules story illustrates the crucial role of changing knowledge about its own resources in the determination of a firm's course of expansion; at the same time it illustrates the restraining influence of a firm's existing areas of specialization, in particular its technological bases. Whether or not the appearance of new industries, of new "demand," in the economy as a whole will provide profitable opportunities for the expansion of a particular firm depends largely on whether that firm has, or can obtain, an adequate "base" in the relevant field.

Although no single group of industries served by Hercules accounts for more than around 16 per cent of Hercules' sales, two of its primary technological bases, cellulose chemistry and rosin and terpene chemistry, have until recently accounted for over three quarters of its business, with nitrogen chemistry a third important base. Within these bases new products and new markets are continually being created; at the same time petrochemicals have become a

leading activity and the emergence of new bases for future operations can already be discerned. By 1926, a bare thirteen years after the firm's creation, new product lines accounted for 35 per cent of total sales; by 1952, 40 per cent of its sales consisted of products that had originated from the firm's research activities after 1930.

The market-creating activities of Hercules are of two kinds; we have discussed one, its extensive reliance on "technical service" to its customers. The other lies in extensive promotion activities related to its customers' products and only indirectly to its own products. For example, Hercules does not manufacture hot lacquers, but it devotes considerable effort to developing the market for these lacquers; only if the end product is extensively used will the demand for the components made by Hercules be high. The firm even goes as far as to promote the sale of aerosol lacquers (lacquers packaged in aerosol cans under pressure), although it produces neither the lacquers nor the cans.

Because of the nature of its market, Hercules is peculiarly sensitive to business fluctuations. When the demand for final products falls off in the economy, the decline in sales affects the intermediate products and raw materials produced by Hercules in magnified form. The question of the desirability of vertical integration therefore arises, for a producer of intermediate products can usually reduce the sensitivity of its total activities to fluctuations in demand by itself undertaking to produce products destined for the final consumer. This has been a solution adopted by many firms, but it is a solution largely denied Hercules by the nature of its market connections. Forward integration would immediately adversely affect one of the pillars of the sales and market policy of Hercules, for customers would no longer be willing to open their plants, disclose their processes, and discuss their problems with the technical servicemen of Hercules. The technical relationship with customers so carefully cultivated and so important for the creation of new opportunities would be impaired if customers had any reason to fear that Hercules would itself become a competitor.

The Rate of Growth of the Firm

The discussion so far has been concerned exclusively with the direction of expansion. What about the rate of growth of the firm? Hercules has not grown so fast as some other firms in related fields of activity, but it has grown faster than industry as a whole. Can one identify a basic factor limiting the firm's rate of growth? Here,

of course, we can only speculate, draw inferences from the course of events, and attempt to interpret statements made by the officials of the firm.

Practically all of the growth of Hercules has been financed with internally generated funds. There has been some criticism within the firm of its conservative financing, and the allegation is made by many, particularly by junior executives who feel that their opportunities have been unnecessarily limited on this account, that the firm's growth has been restricted by its preference for internal financing and its insistence on a strong "cash position." On the other hand, one of the older executives, long a senior official in the firm, asserted categorically that it was not finance but rather the availability of profitable opportunities for expansion which controlled the firm's rate of expansion. He said that if Hercules found new opportunities for profitable investment exceeding its own financial resources it would borrow the money (or preferably raise it from existing stockholders) to take advantage of them.

The same executive stated that neither was expansion held back by the ability of the firm's personnel. He felt that the war record of the firm showed that if the opportunities were there it could do a great deal more than it was doing. In contrast, another senior executive took a different view: "Give us the men," he said, "and we will do the job."

These appear to be conflicting explanations of the limits on the rate of expansion of the firm. Although it is obvious that an insistence on financing all expansion from retained earnings would limit the firm's growth, it is unsafe to assume that this has provided the effective limit on expansion merely because little outside capital has in fact been raised. On the other hand, it is undoubtedly true that from a purely managerial point of view the administrative organization of Hercules could have been expanded much more rapidly than it was. In other words, it is probable that the managerial services available from the administrative and technical staff of the firm have rarely been fully used. Under these circumstances we must examine the nature of the firm's "entrepreneurship."

Hercules has clearly been imaginative, versatile, and venturesome in the introduction of new products, even at times going into production on a small scale before any market for a particular product was clearly evident; at the same time it has been cautious and conservative in entering new and alien fields of technology. It has been willing to venture extensive funds in speculative research in new fields; it has been unwilling to move into production and invest

in plant and equipment in new fields before it had established a research base of its own. And it has been conservative in the methods chosen for entering new fields. For example, it was long after petrochemicals had become an important and growing aspect of the field of industrial chemistry that Hercules decided to enter in a significant way, and then it moved cautiously, relying largely on production processes the firm itself had developed. Another firm, technologically less conservative, might have entered much earlier and through extensive acquisition; Hercules has tended to emphasize the importance of establishing a technological position based on some specialty arising from its own experience. On the other hand, once the firm has become "basic" in a field, as some of the officials of the firm like to put it, this conservatism largely disappears and the variety and quantity of product is expanded as rapidly as developing technology and markets will permit.

This means, in effect, that the growth of the firm is fundamentally constrained by the knowledge and experience of its existing personnel. Hercules has apparently been loath to go into new fields of activity except through the relatively slow process of building up its internal technical resources. New people are continually being brought into the firm and trained in the processes and methods of the firm; new ideas are eagerly sought from the outside, particularly from abroad, and incorporated into the firm's research program. But new *bases* are not acquired "ready-made," so to speak, through extensive and rapid absorption of new people in new fields that are not easily integrated with some existing and internally developed unit in the firm.

The profitability of opportunities for expansion is examined not only in the light of the expected market for certain products or types of products, but largely in the light of how Hercules, with its existing resources and types of operation, could take advantage of and develop them. If the growth of the firm has been restrained by a "lack" of profitable opportunities for expansion, this merely reflects the lack of entrepreneurial confidence in the profitability *for Hercules* of areas of activity with which the officials of the firm are insufficiently familiar. Since a "technological base" consists not of buildings, kettles, and tubes, but of the experience and know-how of personnel, the basic restriction comes down to the services available from existing personnel; the problem of entrepreneurial confidence is fundamentally a problem of building up an experienced managerial and technical team in new fields of activity. Here, again, we can see the nature of the market as a restraining influence

on expansion. To the extent that limited opportunities in existing fields force firms to go into new ones, the rate of growth is retarded by the need for developing new bases and by the difficulties of expanding as a coordinated unit. The speed with which firms *try* to move, however, is to a large extent a question of the nature of their "entrepreneurship."

The above interpretation of the growth of Hercules is based on a study of past history and of recent attitudes. It is clear that entrepreneurial attitudes, the "firm's conception of itself," have had a pervasive influence not only on its direction of growth but also on the method of growth and on the rate of growth. Whether these attitudes will persist depends on the way in which the entrepreneurial resources of the firm change as time goes on. Hercules takes pride in the long service of its people and in the fact that its board of directors is not only a "working board" but is also drawn from men who have spent a great part of their working life within the firm. The first president of the firm served in that capacity for 26 years, was chairman of the finance committee until 1952, and only retired from the board in 1956; of the 15 members of the board in 1950 all but 2 had been with the firm at least 25 years. As the men who built up the firm and carried it through its first few decades retire, it remains to be seen whether the growth of Hercules will be shaped in the future by the same considerations as it has in the past, for in spite of the importance of technological and market considerations, the entrepreneurship of a firm will largely determine how imaginatively and how rapidly it exploits its potentialities.