From Commodity to Specialty Chemicals: Cellulose Products and Naval Stores at the Hercules Powder Company, 1919-1939

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Consider the following "snapshots" in the life of the Hercules Powder Co. of Wilmington, Delaware:

In 1919 Hercules' total sales were $20.5 million. More than 99 percent of these revenues came from a single line of business: commercial explosives, including gunpowder, smokeless powder, blasting powder, and, especially, dynamite. These products were sold to mine and quarry operators, construction firms, and the general hardware trade, and were, for the most part, indistinguishable from products offered by leading competitors. Hercules managed its assets through a single operating department. The company maintained a small "Experimental Station" on the grounds of one of its dynamite plants to serve the research and testing needs of the entire company. This station operated on an annual budget of about $180,000, a total of less than one percent of sales. The company held four patents and had ten patent applications pending.

Two decades later Hercules' sales exceeded $41 million. The company now produced more than two hundred products ranging from explosives to a variety of cellulosic and rosin-based compounds, paper chemicals, insecticides, and synthetic resins. Most of these products were highly specialized; indeed, most were developed with particular market niches in mind and usually in close cooperation with key customers. In 1939 Hercules conducted its business through six operating units. To support these activities the company relied on a central research laboratory near the corporate headquarters in Wilmington, Delaware, with an annual research budget of nearly $1 million (or about 2.5 percent of sales). Hercules held more than 600 patents and had more than a hundred applications pending.

As these snapshots suggest, Hercules changed dramatically during the interwar years. This transformation, of course, occurred against the backdrop of fundamental changes in the worldwide chemical industry and similar (even more dramatic) changes at other chemical companies. In the two decades after 1910 the modern U.S. chemical industry was born: process technology

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[1]This paper is based on our forthcoming book *Labors of a Modern Hercules: The Evolution of a Chemical Company* (Boston, 1990). The paper draws primarily from chapters 5 through 7 of the book. In addition to the references below, we relied heavily on monthly and annual departmental reports made to the board of directors and/or the executive committee at Hercules. These reports are housed at the Hercules Incorporated Hall of Records in Wilmington, Delaware. We are grateful to Professor John Kenly Smith, Jr. for his comments on this paper at the Business History Conference.

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shifted from simple mixing of materials to high volume, continuous processing of complex chemicals; plants became larger, more sophisticated, and more capital intensive; products became more rigidly standardized and controlled; modern, centralized R&D labs were established; and leading companies diversified to offer a wide variety of products [5,6].

We are learning a good deal about the chemical industry in this period, thanks in part to the recent history of R&D at Du Pont by David A. Hounshell and John Kenly Smith, Jr. [14]. Drawing on this work, as well as his own pioneering research, Alfred D. Chandler, Jr. has argued that Du Pont set the most common pattern of growth for large companies in the chemical industry [2]. Du Pont diversified out of explosives, first into downstream applications of nitrocellulose (a primary ingredient of smokeless powder) such as coated fabrics and celluloid plastics and films, and then into a wide variety of basic chemicals. The company maintained operations in at least ten different product lines by 1931.

According to Chandler, other large chemical companies generally followed suit. American Cyanamid, Dow Chemical, Monsanto, and Union Carbide diversified from their base product lines into related areas in the 1920s. As Chandler's latest research shows, these companies succeeded by exploiting economies of scale and scope [1]. New chemical processes required companies to build large, capital-intensive facilities. To operate these plants efficiently and maintain throughput, producers typically integrated forward to develop new applications, and/or backward to assure a steady source of raw materials. As companies reached the limits of growth through vertical integration, they sought to diversify into related product lines. In the 1910s and early 1920s, the mode of entry was typically acquisition; in the 1930s, however, some companies (again led by Du Pont) increasingly relied on internal development and invested heavily in R&D to fuel profitable growth.

In many respects, the interwar history of Hercules Powder Company is an apt illustration of Chandler's scale and scope thesis. Hercules, like Du Pont, sought to find peacetime applications for wartime technology, skills, and assets. Like Du Pont, Hercules first diversified by exploring possibilities in an existing technology (nitrocellulose chemistry). Again like Du Pont, Hercules quickly saw the limits of such a strategy and sought to diversify into other product lines.

Beyond this, however, the similarities between the two companies end. In its diversified businesses, Hercules followed a different path to growth and arrived at a different destination. Lacking the resources, research capabilities, and "first mover advantages" of its giant rival, Hercules faced limited options in cellulose products, and so diversified more cautiously and narrowly than Du Pont. Hercules concentrated on a few key products offered for specialized niches rather than on a wide array of primary and specialized chemicals and downstream applications.

Hercules' other post-World War I venture, into naval stores, also contrasts with the diversification strategies of its larger rivals. Rather than attempting to capture economies of scale and scope in its existing businesses, the company moved into an unrelated area in which it possessed virtually no chemical expertise, production facilities, marketing know-how, channels of

distribution, or customers. The company eventually succeeded in this line by pursuing a similar strategy as in cellulose products: by upgrading commodity products through research, mounting an intense marketing effort to identify profitable niches, and forging close ties with its customers-- a strategy, in short, of competing as a producer of specialty chemicals.

From Guncotton to Cellulose Products

Hercules Powder Company was organized in 1912 to manage assets divested by Du Pont as part of that company's settlement of a long antitrust trial. At its birth, Hercules was primarily a producer of dynamite and black powder. During World War I, however, the company became a leading maker of guncotton (a highly nitrated form of nitrocellulose). Although Hercules started work on commercial applications of nitrocellulose in 1917 (including nitrocellulose-based coatings and plastics), success in these markets came only after nearly seven years of struggle.

Several reasons account for this delay. The first problem was timing. Unlike Du Pont, Hercules did not diversify during the war itself. Rather, it was preoccupied with scaling up and operating its military ordnance plants. Before 1917, moreover, the company had limited R&D facilities of its own; the court decree that created Hercules in 1912 provided that the company obtain R&D services from Du Pont for a period of five years.

The second problem was limited financial resources. From 1917 to 1920 Hercules pursued an internal development strategy to find peacetime applications of its wartime technology. Ample funding supported such efforts during the war. After the Armistice, however, the company was entirely dependent on the slumping commercial explosives business for its profits. As the economy entered a sharp recession, Hercules faced an unwelcome choice: as treasurer and director George Markell put it, "either we must show our stockholders that we are operating at a loss or we must eliminate development and experimental expenses other than those small enough to be absorbed even by our reduced earnings" [11]. Given these alternatives, the board voted to abandon most efforts to develop new commercial products from its wartime assets and to focus on other avenues of diversification.

Although Hercules continued to produce nitrocellulose after 1920 (the compound was still used in its explosives business), lack of investment capital was a chronic concern. For example, the physical condition of the company's lone nitrocellulose plant in Parlin, New Jersey, was a frequent source of frustration to operating managers. The plant had been constructed hastily during the war. One manager repeatedly lamented Parlin's "general state of decrepitude" in the early 1920s, and pointed out that "very extensive and elaborate repairs" were necessary to keep the plant in working order [10].

Still another problem was Hercules' approach to entering the business: the company was slow to develop a coherent strategy. As a late-comer to the industry, the company encountered stiff competition from entrenched players, including much larger companies such as Eastman Kodak and Du Pont. At the same time, Hercules could ill-afford to buy its way in via acquisition. Finally, it was reluctant to integrate forward into nitrocellulose-based products.

As cellulose chemist (and future Hercules president) Charles Higgins put it, a more prudent course would be "to refrain from getting into a position where we would be our customers' competitors" [12].

Breakthrough

In the early 1920s Hercules thus competed as a merchant producer of nitrocellulose, using spare capacity at Parlin to supply many grades and viscosities to producers of celluloid plastics, photographic film, artificial silk, coated fabrics, and tough materials such as linoleum. Because competition in most of these markets was keen, Hercules focused such development work as it could afford on the more slowly evolving market for nitrocellulose-based lacquers. Although many paint and chemical companies recognized the superior qualities of nitrocellulose as a film-forming ingredient, a key technical problem stood in the way of commercial success: lacquers that were thin enough to be applied easily did not contain enough nitrocellulose to form durable films.

Researchers at Du Pont in 1920 at last solved this problem and in the following years successfully developed low-viscosity nitrocellulose lacquers for mass-produced goods such as appliances, furniture, and, especially, automobiles [14, pp. 139-43]. Du Pont's approach to lowering the viscosity of nitrocellulose came as the final step in the manufacturing process, after the compound was purified and it existed in solution. At this point it was treated with a hydrolyzing agent under pressure to reduce its viscosity. This approach, however, tended to re-introduce impurities that could discolor or cause spots in fine lacquers and paints. In 1923, under the prodding of Higgins, researchers at Hercules found a way to avoid this problem by lowering viscosity during the manufacturing process. The basic insight was to combine viscosity reduction with the purification of freshly-nitrated cotton. At the same time that it washed acids and other impurities away, the Hercules process "digested" the nitrocotton into a low-viscosity solution. The result was a product of uniformly high quality [19].

Hercules quickly found itself an enviable position as a low-cost supplier of a premium product in high demand. By 1925 Parlin was operating around the clock to keep pace with orders. Hercules stepped up its investments in the facility, spending several million dollars to replace temporary wooden structures and increase capacity, and became the largest merchant producer of nitrocellulose in the United States in the ensuing decade. Its advantages of scale helped drive many smaller producers from the business and persuade some key customers to cease captive production.

In support of its strategy to capture economies of scale, Hercules integrated backward into chemical cotton (purified cellulose) to assure a steady supply of high quality raw materials by acquiring the Virginia Cellulose Company of Hopewell, Virginia in 1926. Hercules' engineers at the same time continued to press the company's technological advantage, finding ways to increase scale and throughput and improve the safety of operations at Parlin. In 1929, for example, M.G. Milliken developed a continuous system of

nitration and digestion, a step that automated materials-handling and resulted in greater efficiency and lower levels of personal injuries.

A Strategy for Cellulose Products

In 1928 the expansion of Hercules' new businesses prompted the company to reorganize into a multi-divisional structure, with separate operating departments for explosives, cellulose products, chemical cotton, and naval stores (see below). This new organization was similar to the decentralized structure adopted by Du Pont in 1921. At the same time, President Russell H. Dunham set in motion a train of events that would culminate in the establishment of a new, centralized research facility in Wilmington in 1931.

These organizational changes did not signal a commitment to continuing diversification, however. In the new Cellulose Products Department, the company's lone product was nitrocellulose, of which lacquer grades accounted for nearly two-thirds of outside sales in the late 1920s and early 1930s. (The other third went to producers of photographic film, plastics, and coated fabrics.)

Thereafter, several factors combined to encourage a more general approach to developing cellulose chemistry. First, Hercules' cellulose products businesses suffered terribly during the Great Depression. All end-uses were affected, but none so dramatically as lacquers because the Depression devastated the automobile industry. At the same time, New Deal price supports for cotton farmers served to raise the cost of cellulose products derived from cotton linters, such as those made by Hercules, as compared to competitive materials [7, pp. 286-87].

A second problem-- at first masked by the Depression-- was increasing product substitution. The initial threat came from cellulose acetate, which dislodged nitrocellulose in many film and plastics applications starting in the mid-1920s. Even more alarming were new substitutes for nitrocellulose lacquers in industrial finishes. In the early 1930s, for example, Ford and Chrysler switched from nitrocellulose lacquers to formulations using alkyd resins, as did many appliance manufacturers [6, vol. V, p. 347].

To meet these threats effectively, Hercules was forced to re-evaluate its nitrocellulose business. In particular, the company adopted a four-pronged strategy to defend and improve its position. First, it significantly increased its commitment to R&D in the department. Second, Hercules diversified to make cellulose products other than nitrocellulose. Third, the company defended its position in the protective coatings industry by providing higher levels of technical support and service. And finally, Hercules cultivated new markets for its specialized cellulose products. Along the way, the company moved beyond commodity chemicals into the world of specialty chemicals.

Despite the opening of the new, centralized Experiment Station in 1931, Hercules for several years continued to conduct R&D work as if it were still an explosives company. The senior managers of the Station had been trained as explosives engineers, for whom research consisted primarily of analytical functions such as testing and sampling of materials, and occasional problem-

solving or work on new explosives formulations. At the same time, however, a group led by Higgins (now a vice president and member of the Executive Committee), George Norman (Technical Director), and analytical chemist O.A. Pickett was impressed with the centralized research activities of Du Pont, AT&T, General Electric, and General Motors. These men believed that Hercules' would have to follow suit, given the increasingly technical content of its businesses and the need to develop new products to offset competitive threats. In the spring of 1933 this group used the failure of a major development program for a new explosives primer to force a change of leadership at the Station, where Pickett became acting director [20].

This change heralded a fresh approach to research and development at Hercules. The Station was reorganized to encourage more basic research and promote closer coordination of activities in the laboratory with semi-scale operations and the commercial plants. Hercules also started to recruit scientists from the best universities. By the mid-1930s the Station boasted several renowned cellulose chemists, including Drs. Emil Ott and Harold Spurlin. In addition to their own substantial contributions, Ott, Spurlin, and others kept a close watch on developments in cellulose chemistry in Europe.

These new research personnel helped the company develop a series of new cellulose products in a quick burst of activity during the mid- and late 1930s. The first of these was cellulose acetate. In the summer of 1936 Hercules licensed I.G. Farbenindustrie's manufacturing process and built a plant at Parlin with an annual capacity of 2.4 million pounds [16]. Soon thereafter, Hercules began making other cellulose products, such as ethyl cellulose, cellulose acetobutyrate, and cellulose acetopropionate, often under license from European producers, and with specific markets in mind.

In addition to offering new products, Hercules sought to defend and improve its position with key customers in the protective coatings industry. This industry was in the midst of a chemical revolution in the 1930s: coatings were no longer simple products mixed and stirred on site by the user, but complex mixtures of solvents, pigments, resins, plasticizers, drying agents, and other additives formulated to meet specific requirements. As the technical complexity of coatings increased, so did the need for standardized and controlled ingredients.

Hercules took advantage of the opportunities created by the coatings revolution to strengthen its ties with key accounts. Advertising focused on Hercules' technical capabilities and achievements. In 1936 the company started a new magazine, *The Hercules Chemist*, aimed at keeping customers abreast of new developments in the coatings industry. At the same time, Hercules launched an annual "Industrial Finishes School" for coatings manufacturers. Such moves soon paid off. "We are convinced," said Milliken (now general manager of Cellulose Products), "from many opinions of our customers, that our present method of distribution of technical information accelerates the use of our products and has created a tremendous amount of good will toward our company" [8].

The company also looked outside cellulose chemistry for products that would appeal to the coatings industry. Chlorinated rubber, an additive first

developed in Germany to improve paint's resistance to hazardous conditions, proved to be an extremely successful product for Hercules after 1934.

Finally, the company adapted its approach in the coatings industry to other customers. By the end of the 1930s Hercules nitrocellulose was becoming a valuable ingredient of printing inks, adhesives, and even sausage casings; cellulose acetate was appearing in artificial fibers, films, and molding powders; and ethyl cellulose was finding applications in coatings and as an electrical insulating material.

In 1937, Milliken described Hercules' new cellulose products strategy (which the company pursued for the next five decades) in this way:

> It is not our intention to concentrate on any specific cellulosic material: rather, the object is to make available a wide selection of cellulose materials so that each manufacturer can determine which products best meet his requirements. Technical service is available for all cellulose products. In this way, the individual manufacturer has at his command a fund of technical data and background to help in evaluating each cellulosic material according to specific needs. Active research work is continually being done on a large scale in an effort to search out and produce new cellulosic materials with practical properties, as well as new applications of the present products [17].

In other words, cellulose products had become a specialty chemicals business.

Unrelated Diversification into Naval Stores

As we have seen, opportunities for Hercules to diversify by building on its technical, production, and marketing base in explosives and cellulosics after the war-- that is, to capture economies of scope-- were limited in the early postwar period. But the company still had the resources and desire to diversify, even if this meant entering unknown territory.

Hercules approached this diversification challenge seriously and systematically. In February of 1919 the company summoned its managers to a meeting in Atlantic City to discuss a strategy for the future. At the same time, it established the Industrial Research Department (IRD), charged with the task of investigating potential new lines of business [12,23].

The IRD's resources were impressive: an annual budget of $250,000 and seventeen of the company's most seasoned, talented, and ambitious professionals. The group included engineers of all types, some with expertise in functional areas (maintenance, traffic, accounting), and many knowledgeable not only in aspects of explosives making, but also in unrelated industries such as lumber, paper, textiles, and railroads.

The IRD was given a clearly defined mission: to identify a candidate for acquisition. Since the goal was long-term growth, the candidate was to be a manufacturer of primary products in a healthy, promising industry. But it would not be in a business competitive with consumers of explosives. Finally, Hercules wanted a good buy. For this reason, a company "limping badly or

badly wounded" due to under-capitalization, poor plant management, inept marketing, or other administrative weaknesses was considered an ideal target. As Norman Rood, head of the IRD, explained, "It is the opportunity we want more than just the business ... We [have] a very broad field before us" [23].

This mandate was striking in several respects. At the creation of the IRD, there was little discussion about building on the company's strengths in existing product lines. Rather, Hercules believed it could acquire a floundering company, improve its production and marketing with its own managers, and overcome the problems associated with undercapitalization with its financial clout. The choice of industry seemed secondary.

Despite its broadly-defined mandate, the IRD almost immediately focused its attention on a specific industry and company. The industry was naval stores (producers of rosin, turpentine, and other products gleaned from trees). The company was the Yaryan Rosin & Turpentine Co., which operated plants at Brunswick, Georgia, and Gulfport, Mississippi.

To be sure, the IRD considered dozens of possible ventures, from pharmaceuticals and artificial leather to Oriental rug power looms and automobile heaters. But there were several reasons why it quickly grasped the naval stores opportunity, and never let go.

From colonial times through most of the 19th century the industry had been characterized by thousands of small-scale producers whose uncoordinated efforts, combined with the vicissitudes of weather, caused production levels and prices to fluctuate wildly from year to year. With little capital, many of the thousands of small producers were regularly wiped out by lean harvests or low prices. This began to change by the end of the 19th century. Concern about widespread deforestation arose in the industry (as well as the nation). A less harmful way of tapping trees (called the cup-and-gutter method) ameliorated some of the damage, but loggers, settlers, and fires marched on relentlessly. By the turn of the century, many seriously questioned the future of the naval stores industry [3, 18, 21, 24].

But a new technology offered hope. A few years before the Great War, an entrepreneur named Homer T. Yaryan (whom a contemporary described as "an energetic optimist" who "smoked long, black cigars incessantly and swore like a stevedore") developed a new method of recovering naval stores. The Yaryan method used steam and solvents to distill rosin, turpentine, and pine oil from stumps rather than oleoresins from living trees. After a few failed attempts in the north, Yaryan borrowed heavily to construct a steam-solvent plant along the Mississippi Gulf coast in 1909, and built a second in Georgia three years later. Yaryan was redefining the business, transforming it into large-scale, factory operation [25].

About the same time, a wealthy Milwaukee family named Schlesinger developed a similar naval stores process, but the output of their Newport Rosin & Turpentine Co. was consumed internally (by other Schlesinger companies) to make Kraft paper. Yaryan had problems of his own. Management of the company was spotty. Yaryan's rosin was darker and had a lower melting point than most on the market and his turpentine, quite simply, smelled bad. When the war disrupted exports, the company slipped into bankruptcy.

In short, to Hercules the opportunity to enter naval stores in 1919 appeared as follows. The industry was in the midst of a fundamental restructuring. Government and industry experts were predicting the imminent decimation of the nation's pine forests. Thus, every pine tree felled provided wood naval stores producers who used the new steam-solvent process (Yaryan and Newport) with another source of raw materials while depriving gum naval stores producers of the same. Newport was not for sale, but the faltering Yaryan company could be had for a good price. The choice seemed clear; as its leading advocate, W. R. James of agricultural sales, put it: "Properly managed and financed" under Hercules, "[Yaryan] could be made to control the distillation game in this country" [9].

Although these words were spoken at the first IRD meeting, the Department continued to gather information and file hundreds of reports about the naval stores industry. By the end of 1919, just as top managers in the company were pushing for a decision, events took a unexpected twist. Hercules learned that the Glidden Paint & Vanish Company of Reading, Pennsylvania, had obtained an option on the Yaryan properties. By this time, however, Hercules was so dedicated to the notion of entering naval stores that it changed its strategy and decided it would *build* rather than *buy* a steam-solvent distillation plant. A site was chosen at Hattiesburg, Mississippi.

Then came another unexpected turn. In the summer of 1920 Glidden offered its Yaryan option to Hercules-- which took it, operated the plants for several months under the option, and secured financial control by the summer of 1921. In the end, then, with no experience in the business, Hercules became the world's largest naval stores producer by building a large plant and buying two others. This initial investment totalled about $4 million, an amount equal to roughly one quarter of the Hercules' total permanent assets.

Hercules' headlong plunge into the naval stores industry the summer of 1921 was a bold move-- more daring, in fact, than the simultaneous diversification efforts of many of its competitors. This was because naval stores had little in common with explosives: no shared facilities, no shared technologies (beyond some skills in mechanical and construction engineering), no shared customers, and no shared distribution channels.

Crisis and Response

It would be an understatement to say that the new business did not turn out as Hercules expected. Within months the company found itself in the midst of a major crisis. The business was losing piles of money and would continue to do so for many years. There were several problems. First, it was discovered that the plants, both new and old, were riddled with engineering and design flaws. Second, the postwar depression hit, hurting agriculture severely, including naval stores prices. Third, customers continued to spurn the wood naval stores products because they looked and smelled different from traditional gum products. Fourth, and worst of all, the imminent decimation of America's pine forests failed to materialize, as slash pine and second growth yellow pine sprouted up throughout the cut-over lands [22].

But Hercules remained committed to its new business and developed a strategy to attack these problems on three fronts: engineering, marketing, and research. In the process, Hercules naval stores was transformed into a specialty chemicals business.

Mechanical engineers tinkered with the plants to increase efficiency and designed new wood-pulling apparatus to "replace men with machines." By the end of the decade, yields of all products were improved 100-200%.

On the marketing front, Hercules hired consultants and launched a massive direct mail survey in a effort to adopt "the customer's point of view." To sell more rosin, the company retrained its army of explosives technical salesmen. To sell more pine oil, it developed new applications (disinfecting, deodorizing, ore flotation) for the little-known product.

The greatest gains were in promoting turpentine. Reaching over the heads of paint and varnish manufacturers, Hercules wooed jobbers with better margins, and hardware and paint retailers with jazzy packaging and reams of advertising (featuring two whimsical characters called "Turp and Tine"). At a time when most turpentine on the market was of dubious quality, Hercules touted itself as a "great manufacturing concern" making turpentine of "guaranteed" quality "under chemical control." In the process it transformed a commodity into a nationally branded, differentiated product [4].

Finally, through a series of research breakthroughs during the late-1920s and 1930s, Hercules created more and better naval stores products, including an important process (using furfural) for purifying rosin into lighter grades. This allowed it to supply new customers-- makers of paper, varnish, and soap-- who demanded lighter grades of rosin, in effect increasing the company's potential market share ten-fold to nearly seventy percent.

Except for a couple of years in the late 1920s, Hercules lost money in naval stores consistently until the mid-1930s. Thereafter naval stores became a major contributor to profits. New products such as hydrogenated rosin and synthetic resins continued to emerge from the Experiment Station.

More important, Hercules built new businesses on its growing foundation of expertise in the rosin chemistry and naval stores marketing. In 1931 it purchased its largest naval stores customer, the Paper Makers Chemical Co. for $2.5 million, and later expanded its line of paper chemicals. Hercules created a Synthetics Department in 1936 to market its most chemically sophisticated naval stores products, and continued to add new synthetics to its roster of products. Later, new rubber chemicals (such as synthetic rubber emulsifiers) and agricultural chemicals (such as chlorinated camphene, possibly the most profitable single product in the company's history), all based on the chemistry of rosin and rosin derivatives, emerged as major new businesses.

In sum, although Hercules' diversification into naval stores was disastrous in the short run, in the longer view it achieved its goal of establishing a new foundation, quite apart from explosives and cellulosics, for continuing growth.

Conclusion

The interwar history of Hercules both confirms and contrasts with the general pattern of growth and change in the chemical industry as typified by Du Pont. In the case of cellulose products, the pace of change at Hercules was slower and more deliberate than at Du Pont, in part because of limited resources, but also because of uncertainty about how to establish a viable market position.

Because Hercules was a follower in nitrocellulose products, it had to work hard to find the right opportunity. Once it did (through a process innovation), it was content to exploit its advantage in a single product line, until the Great Depression and competitive threats forced a fundamental revaluation of the strategy. By then, fortunately, an internal debate on the role of research in the company was resolved in favor of developing new products.

Even then, however, Hercules did not really emulate Du Pont's strategy of internal development supported by internal research. Rather, its approach was to stay abreast of the latest technical developments, while concentrating on improving the efficiency of operations and the quality and uniformity of products. It generally introduced new products under license agreements, often with foreign chemical companies. Hercules at the same time worked its way into a tight relationship with its customers, especially in the protective coatings industry. From this base the company sought to expand its product scope by making other additives, but it refused to integrate forward so as to avoid competing with customers.

The company's entry strategy in naval stores was bolder and much less conventional than most diversification moves in the chemical industry after the war. Sensing that opportunities in its existing fields were circumscribed, Hercules moved into a field in which it had little capability or experience, hoping to capitalize mainly on good basic management techniques and personnel.

Thus, the naval stores episode at Hercules also offers an interesting variation on Chandler's scale and scope thesis. To be sure, the company found that it needed to exploit economies of scale and scope in research and marketing to survive and prosper in the business. On the marketing side, Hercules relied on its network of explosives salesmen and built new channels of distribution by advertising heavily, creating nationally branded products, and so on. And in research Hercules eventually unlocked the secrets of rosin and terpene molecules, spawning new, more refined products (first pale rosins and terpene fractions, and later a variety of paper and rubber chemicals, synthetics, and agricultural chemicals).

But although the company's motivation for this unrelated diversification included some thought of capturing economies of scale in production (by using new technology that permitted factory-scale production), little attention was given to the possibility of capturing economies of scope in marketing and research. As one researcher put it, "We were handicapped in having no background in experimental data such as we possessed in the field of explosives" [15].

In both cellulose products and naval stores, Hercules was constrained by its resources in ways that larger and wealthier companies such as Du Pont were not. This circumstance commonly drove the company to search for niches. It was more realistic, Hercules believed, to develop refined, highly-specialized products than to seek to dominate large markets for processed products or chemical commodities. Even by becoming the leading producer of naval stores, Hercules became a "big fish in a little pond."

Perhaps other case studies of middle-sized chemical companies will support some of the generalizations suggested by the Hercules story. Our reading of the interwar history of Rohm and Haas, for example, seems to indicate so [13]. This relatively small company also followed a niche strategy in specialty chemicals. Rohm & Haas, like Hercules, had to choose its opportunities carefully rather than hope to diversify on many fronts or dominate major market segments by exploiting economies of scale and scope.

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