Federal Trade Commission

Staff Report on the DEVELOPMENT and STRUCTURE of the U.S. ELECTRIC LAMP INDUSTRY

Robert P. Rogers

Bureau of Economics

February 1980

ECONOMIC REPORT

FEBRUARY 1980

THE DEVELOPMENT AND STRUCTURE OF THE U.S. ELECTRIC LAMP INDUSTRY

by

Robert P. Rogers

Staff Report of the Federal Trade Commission

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

FEDERAL TRADE COMMISSION

This report has been prepared by the Bureau of Economics of the Federal Trade Commission. It has not been reviewed by, nor does it necessarily reflect the views of the Commission or any of its members.

ACKNOWLEDGMENTS

This is an Economic Report to the Federal Trade Commission by the Bureau of Economics, William S. Comanor, Director. The author of this report is Robert P. Rogers.

The author is grateful to the many persons who contributed to this report. Ronald S. Bond and H. Michael Mann reviewed the manuscript and made many helpful comments and suggestions. Bess Townsend and Jean Hugh provided valuable editorial assistance. Annette Shanklin and Patricia Allen typed the bulk of the successive drafts of this report, and Dianne Jones, Betsy Zichterman, Darence Wilson, Vera E. Chase, and Linda Hill, also provided help with the typing.

Finally, the author would like to thank the numerous individuals from the various manufacturers who provided data and their own knowledge of the industry. Especially helpful were William J. Barron of the General Electric Company and Herbert A. Anderson of the Durotest Corporation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

CHAPTER I

Introduction

With 1974 shipments of over $1 billion and a four-firm concentration ratio of 87 percent, the electric lamp industry is both large and highly concentrated. There is also rather convincing evidence that the industry is highly profitable: although the industry is not particularly capital intensive, the 1967 price-variable cost margin for electric lamps was 82 percent above the average for all manufacturing industries. The combination of high concentration and high profitability makes the lamp industry a particularly interesting case for economic analysis. An examination of the industry can shed light on problems often encountered in the development of public policy toward concentrated industries. The study concludes that scale economies and product differentiation may explain much of the present concentration.

Scale economies are major determinants of concentration in many industries, and they are present in the lamp industry. In this study, an examination is made of plant economies, and some hypotheses on firm multiplant economies are developed. High concentration also results from the household consumers' apparent preference for the lamps of the larger firms, particularly General Electric. Although economies of scale and product differentiation seem to be the most important determinants of present industry structure, the industry's history of innovation and antitrust action appear also to have had an impact upon structure, and they are analyzed accordingly.

The following plan is used in the study. First, chapter II sketches the history of the industry. Chapter III describes the structure of the industry. Special sections are devoted to the problem of scale economies and product differentiation. Next, chapter IV examines past antitrust cases in the lamp industry with the objective of determining why they failed to change the structure of the industry. Also, the introduction of the fluorescent lamp, which altered somewhat the structure of the industry, is analyzed. Chapter V discusses the currently available information on performance; and, finally, chapter VI offers some conclusions.

CHAPTER II

A History of the Lamp Industry

A. Introduction

The history of the lamp industry can be divided into four periods. Between 1875 and 1897, the industry emerged and a large number of firms began to produce electric lamps. Research leading to important improvements and forces leading to increased concentration characterized the second period, from 1898 to 1912. Between 1913 and 1944, the development of the tungsten filament and the gas-filled lamp in combination with a 1911 antitrust decision led to a period of General Electric hegemony. Finally, the development of the fluorescent lamp and the expiration of the General Electric patents led to increased market share for Westinghouse and Sylvania from 1945 to the present. These periods are described in detail below.

B. The Beginnings: 1875-97

In the early and middle parts of the 19th century, many experiments were carried out with electrical lighting, but no good source of electricity existed; therefore, the experiments were abandoned. When efficient sources of electricity were developed in the 1870's, the interest in electrical lighting revived. A number of inventors worked on various methods of lighting, but the most interest was shown in two methods of electrical lighting: arc lighting[1] and incandescent lighting.[2]

The development of the electric incandescent or filament lamp was initially slower than that of the arc lamp. Early filament lamps either gave insufficient light or used materials so expensive that they were not economical. Accordingly, research focused upon finding a cheap filament material that could provide light at a cost competitive with other sources. Many men were involved in filament research, among them Moses Farmer, Hiram Maxim, St. George Lane-Fox, William W. Sawyer, Albon Man, and Willam W. Swan. Although some of the lamps developed by these men went into commercial production, it was Thomas A. Edison who developed the first commercially successful incandescent lamp.

Edison's success in lamp development was due not only to his superior filament, but also to his systematic approach. Edison made it a policy not to work on any project until he was quite certain of its commercial feasibility. He first studied the

---

1 In arc lighting the light is provided by an electrical arc through the atmosphere between two electrodes. In 1878, the first commercial installation of arc lighting was made. This event stimulated a number of experimenters, including Elihu Thomson, Edwin J. Houston, Charles Brush, and Wallace Farmer, to develop arc lighting further. Arc lighting became important in many applications in the 1880's and 1890's and remained important well into the 20th century.

2 With an incandescent lamp the light comes from a glowing wire or filament enclosed by the bulb.

characteristics of gas illumination, the electric light bulb's chief competitor, hoping to keep the best while eliminating the worst features of gas. Edison also decided to develop a complete system for delivering electricity to the lamps. His objective was not to sell individual lamps but to sell a whole system of light delivery. Once he set down his objective, Edison's first major task was to find a good filament. His lamp, using a carbonized bamboo filament in a vacuum, was patented in the United States and in other countries in 1880. To complete his system Edison also developed a special dynamo and special wiring arrangements for his lighting system.

The first commercial installation of Edison lamps occurred in 1880, and within a few years other firms began to manufacture incandescent lamps. Some firms used Edison's patent, some used other patents, and some infringed on patents. By the late 1880's, three firms came to dominate the incandescent lamp industry: the Edison organization,[1] Westinghouse, and the Thomson-Houston Electric Company. Not only because it held the basic patents, but also because it employed many skilled workers and managers, the Edison organization had the largest market share in electrical lamps as well as in most other types of electrical equipment.

---

[1] Before 1889, the Edison organization was a loose collection of firms manufacturing devices used by the Edison systems. In 1889, all these firms were merged into Edison General Electric Company.

Westinghouse developed a sizable market share because it was the first firm to exploit the advantages of alternating current. With alternating rather than direct current, much larger distribution systems could be used. The Edison interests resisted alternating current even after its superiority was obvious,[1] and Edison's intransigence gave Westinghouse a chance to increase its market share.

The third firm, Thomson-Houston, was originally an arc lighting manufacturer. Its chief asset was superior management. The president of Thomson-Houston, Charles A. Coffin, had been a successful shoe manufacturer who saw promise in the electrical industry, and he brought into the company a number of financial and engineering experts who were able to build up an efficient organization. All three firms were engaged in other electrical manufacturing activities such as the production of street cars and electric motors.

---

[1] With alternating current, the electrical flow changes direction (in the U.S., 120 times a second), whereas with direct current, the electrical flow goes in one direction. With alternating current, the amount of current or amperage can be changed. When one increases (decreases) amperage, the voltage decreases (increases). The device for changing amperage is called a transformer, and it can be used only with alternating current. The problem with direct current is that it is generated at a high amperage, and large conductors are needed to carry this amperage. With alternating current and a transformer, the amperage can be lowered at the plant and relatively small conductors (wires) can be used to transmit the electricity. At the point of use, the amperage can be increased by a transformer to fit the needs of the user.

During the late 1880's, the Edison interests belatedly tried to enforce the patent rights to the carbon filament, succeeding in 1889. Other firms, however, developed filament lamps that did not infringe on the Edison patent, and the Edison patent expired in 1894.[1]

A problem more important than any one patent was the proliferation of patents for the large number of devices used in an electrical system. Consequently, it became difficult to set up and merchandise an electrical system without infringing upon one or more patents.[2]

Surmounting the problem created by the proliferation of patents was the major incentive for the next change in the industry, the consolidation of the Edison and Thomson-Houston firms into General Electric in 1892. The management of the new firm thought they could develop "a tremendously powerful

---

1 The normal period for patent protection in the United States is 17 years, but at that time the U.S. law stated that U.S. protection lasted only as long as the protection of any nation with an earlier patent on the same device. Edison had received his lamp patent in Canada before he had it in the United States, and Canadian patent law allowed only 15 years of protection.

2 Accentuating the problem was the uncertainty surrounding the validity of many patents. Many devices were developed independently by different people at the same time. It was also often difficult to ascertain to what each patent pertained. Therefore, the value of many patents was uncertain because the validity and extent of the patent rights were not clear. As a result, firms were often reluctant to obtain patent licenses because they might not be of any value.

patent position."[1] And there also were financial incentives for the merger. The Edison firm had more liquid capital than did Thomson-Houston.

The merger may also have been partially motivated by the spirit of the times. The decade of the 1890's was an era of business consolidation. J. P. Morgan had been influential in the Edison General Electric Company, and he encouraged this merger.[2] The new General Electric Company was a large firm for the time; it had 10,000 employees and a capitalization of $35,000,000 (compared to $12,000,000 for Westinghouse), and it dominated the lamp and electrical equipment industries.

With the expiration of the Edison patent in 1894, some new firms entered the market, but due to its superior manufacturing techniques, General Electric was able to maintain its dominance in electric lamps.[3] In 1896, General Electric and Westinghouse established a cross-licensing agreement allowing each access to the patents of the other. As of 1896, General Electric and Westinghouse had about 50 and 10 percent respectively, of the lamp market while several firms shared the rest.

---

[1] A. A. Bright, <u>The Electric Lamp Industry: Technological Change and Economic Development from 1800 to 1947</u> (New York: MacMillan Company, 1949), p. 94.

[2] J. P. Morgan, a New York banker, had encouraged business consolidation in many other areas. Although the most notable consolidation was U.S. Steel, he was also active in the railroad consolidations.

[3] A. A. Bright, *op. cit.* pp. 229-232.

After the invention of the Edison filament, lamp quality was gradually improved. Better carbon filaments were developed, and the efficiency of the lamp was improved from about 1.4 to about 3.3 lumens per watt between 1879 and 1893.

Although production increased, production techniques remained of the handicraft variety. The manufacturing technique required skilled workers to blow the glass bulb sleeves[1] and place the mounts and bases on the lamps.[2] A major manufacturing improvement was the development of a superior method of creating a vacuum in the bulb. In spite of the relatively slow changes in technique, U.S. lamp production rose from 70,000 units in 1883 to 25,000,000 in 1899.[3] Many experiments were carried on that anticipated future improvements, but most of them were unsuccessful. Among these experiments were metallic filaments and gas-filled bulbs. But the standard lamp of the late nineties was really only an improved version of Edison's original carbon filament device.

---

1 A number of terms have been used to refer to the glass bulb part of the lamp. Bulb sleeve was used by one of the manufacturers of these items; it is the term used in this report.

2 The mounts are that part of the lamp supporting the filament and the wires connecting the filament with the source of electricity. The base is the metal part of the lamp which is inserted or screwed into the fixture.

3 A. A. Bright, _op. cit._, pp. 77 and 489.

The Consolidation of the Lamp Industry: 1898-1912

In the period 1898 to 1912, the electric lamp industry became more consolidated, and the efficiency of the average lamp increased greatly. In 1897, the Incandescent Lamp Manufacturers Association was organized. Its basic purpose was to set price and allocate market share.[1] At first, the Association consisted only of General Electric and six smaller companies. Later, however, Westinghouse and ten other lamp manufacturing firms joined.

Small companies found it difficult to compete with General Electric. To solve this problem, several firms banded together into a larger organization called the National Lamp Company. Each firm continued to operate its plant separately, but the group pooled the costs of research, engineering, and some marketing functions. To set up the research and engineering facilities, the firms needed financing. This problem was solved when General Electric purchased the majority of the stock in the company.

---

1 The activity of this organization is discussed more fully in ch. IV.

Although General Electric was not active in the management of National Lamp, it granted licenses to National and other firms for many of its patents. General Electric had adopted the trade name "Mazda" for its best lamps, and other firms were licensed to use the name if the lamps met a certain standard. Through its licensing agreements and the Incandescent Lamp Manufacturers Association, General Electric indirectly controlled all but three percent of the lamp industry. Table II-1 shows the market share breakdown for 1910.

As a result of a 1911 antitrust decree, General Electric bought out the minority stockholders in National Lamp and took over the operation of the company.[1] Thus, by 1912, General Electric had a market share of 80 percent.

The period was one of great innovation in the industry and General Electric assumed leadership in the innovation. By 1900 the carbon filament had reached the limits of its efficiency, and experimenters were beginning to look for alternative filament materials. Refractory oxides, osmium, tantalum, and other metals all proved to be improvements on the carbon lamp and were in production for a short period of time. Table II-2 shows the extent of the improvements in lamp efficiency as judged by lumens per watt. But, as the table also shows, tungsten eventually won out. Credit for the tungsten lamps goes to the research laboratories of General Electric.

---

[1] See U.S. v General Electric Co. (1911) 1 D&J 267.

TABLE II-1

Market Share Breakdown in the U.S.
Electric Lamp Industry as of 1910

Company	Market share (percent)
General Electric	42
National Lamp Company	38
Westinghouse	13
Other General Electric-National licensees	4
Independent lamp firms	3

Source: A. A. Bright, The Electric Lamp Industry: Technological Change and Economic Development from 1800 to 1947, (New York: MacMillan Company, 1949), p. 151.

TABLE II-2

The Improved Performance of
Incandescent Lamps: 1881-1910

Year	Type of filament	Initial efficiency per watt[a] (lumens)	Approximate useful life (hours)
1881	Carbonized bamboo	1.68	600
1884	"Flashed" squirted cellulose	3.4	400
1888	Asphalt-surfaced carbonized bamboo	3.0	600
1897	Refractory oxides	5.0	300 or 800[b]
1899	Osmium	5.5	1,000
1902	Tantalum	5.0	250 or 700[c]
1904	GEM (Metallized carbon)	4.0	600
1904	Non-ductile tungsten	7.85	800
1910	Ductile tungsten	10.0	1,000

[a] Efficiencies apply to the sizes most commonly used for general illumination, 16-candlepower for the carbon lamps and 50 or 40-watts for the GEM and later metal-filament lamps.

[b] The smaller figure applied when the lamp was used with direct current; the larger, when it was used with alternating current.

[c] The smaller figure applied when the lamp was used with alternating current; the larger, when it was used with direct current.

Sources: Franklin Institute, Incandescent Electric Lamps, 1885; Schroeder, The History of the Incandescent Lamp, 1927; Schroeder, History of Electric Light, 1923.

The early tungsten research was done by the Austrians, Alexander Just and Franz Hanaman, who developed a nonductile tungsten lamp. Although nonductile tungsten is very fragile, it was put into commercial production. Other researchers started to develop a method of improving the tungsten lamps.

In 1900, General Electric founded one of the first industrial laboratories in the United States. The laboratory employed scientists who were given a free hand in their research which applied to various problems confronting General Electric. One researcher, William O. Coolidge, developed a method of making ductile tungsten from which wire could be drawn. With the development of ductile tungsten the incandescent light reached a new level of efficiency. As shown in Table II-2, the ductile tungsten lamp had over twice the efficiency of any nontungsten lamp, and its filaments were much more durable than the nonductile ones. Tungsten lamps were put on the market by General Electric.

Many other lamps were first developed in this period; some became important; others faded from significance. Among the latter were various other filament lamps and the Cooper Hewlitt electric discharge lamp. Among the former were the predecessors to the modern electric discharge lamps.[1] Several other

---

1 Electric discharge lamps give off light by maintaining an arc through heated metallic vapor (usually mercury). Examples of electric discharge lamps are the fluorescent lamp, the high intensity mercury vapor street light, and the neon sign.

innovations were made in the manufacture and design of electric lamps. First, various parts of the lamps, such as bases, were standardized as were required voltages. Second, many of the work processes were mechanized. Methods of exhausting lamps were improved, and more efficient gas-filled lamps were introduced. Also many special purpose lamps were introduced.

The great improvement in incandescent lighting brought about mainly by the discovery of tungsten filaments led to the decline of gas and electric arc lighting. As of 1912, incandescent lighting was triumphant in America.

D. General Electric Hegemony: 1913-45

The era of General Electric hegemony from 1913 to the 1940's began with the development of the ductile tungsten lamp and an antitrust case with an ironic result. In 1910, the Justice Department had brought a suit against General Electric, National Lamp, Westinghouse, and some smaller firms for their activities in the lamp industry. These activities included price fixing, market share allocation, and patent pooling and will be discussed further in chapter IV. Another Government charge claimed that National Lamp was a "bogus" organization set up by General Electric to help fix prices. As will be noted later, the validity of the charge is questionable.

The result of the case was a consent decree which required General Electric to merge with National Lamp, thereby eliminating the so-called "bogus" company and giving General Electric 80 percent of the market. General Electric dominance of the lamp industry remained unchallenged until the early 1940's principally because of General Electric's superior patent position. With its patents, General Electric could produce a much superior lamp, and although the patents did not go unchallenged, General Electric was able to control the situation through vigorous legal action against infringers and through a system of licensing. Table II-3 displays the major patents and their issue and expiration dates. The patents were related primarily to tungsten lamps.

Through its licensing system, General Electric had control of about 90 percent of the market throughout this period. The GE patent licensing system consisted of two classes of licenses. The first, the class A license, was granted only to Westinghouse, and it gave the licensee the right to produce a given percentage of General Electric's lamp output as well as the right to a given set of patents and copyrights.

The second type, the class B license, gave the licensee the right to produce an output equaling a smaller percentage of General Electric's lamp output, and it gave the licensee access to a more limited number of patents. One major difference between class A and class B licenses was that only the class A licensee could produce Mazda lamps. Each class B licensee was allowed to make only certain types of lamps. When firms exceeded their production quotas, they had to pay a higher license fee for the production in excess of the quotas. Over the years many of the "type B" licensees disappeared. Table II-4 shows the firms remaining as of 1924 and their allowed percentage of GE sales.

TABLE II-3

Principal Patents Covering Incandescent Lamps Owned by General Electric: 1912-47

Patent no.	Application date	Issue date	Inventor	Source	Subject	Normal expiration	Court record
1,018,502	July 6, 1905	Feb. 27, 1912	Just and Hanaman	Purchased from Austrians	Tungsten filament	Feb. 27, 1929	Upheld
1,082,933	June 19, 1912	Dec. 30, 1913	Coolidge	General Electric Employee	Ductile Tungsten	Dec. 30, 1930	Partly invalidated 1929
1,180,159	Apr. 19, 1913	Apr. 18, 1916	Langmuir	General Electric Employee	Gas-Filled lamp	Apr. 18, 1933	Upheld
1,410,499	Feb. 20, 1917	Mar. 21, 1922	Pacz	General Electric Employee	Non-Sag Tungsten	Mar. 21, 1939	Invalidated 1938
1,423,956	Mar. 20, 1919	July 25, 1922	Mitchell and White	General Electric Employees	Tipless bulb	July 25, 1939	Upheld
1,687,510	June 29, 1925	Oct. 16, 1928	Pipkin	General Electric Employee	Inside-frosted bulb	Oct. 16, 1945	Invalidated 1945

Principal source: Official Gazette of the U.S. Patent Office, Washington, 1912-1928.

TABLE II-4

The Class B Type General Electric
Patent Licensees as of 1924

Company	Plant	Type of lamp manufactured	Percentage of total GE sales allowed by license
Hygrade Sylvania Corp.	Salem, Mass. & St. Mary's, Pa.	Large incandescent	8.2242
Consolidated Electric Lamp Co.	Lynn, Mass.	Large incandescent	3.89093
Kentucky Electric Lamp Co.	Owensboro, Ky.	Large incandescent	1.7584
Economic Lamp Co.	Malden, Mass.	Large incandescent	0.8998
Tung-Sol Lamp Works, Inc.	Newark, N.J.	Miniature incandescent	26.71956
Chicago Miniature Lamp Works	Chicago, Ill.	Miniature incandescent	2.975

SOURCE: A. A. Bright, The Electric Lamp Industry: Technological Change and Economic Development from 1800 to 1947 (New York: MacMillan Company, 1948), p. 260.

In addition to its patent positions, General Electric had a cost advantage resulting from some scale economies (discussed in chapter III) and from the generally superior manufacturing techniques it developed. Since the firm was the leading innovator in lamp production, its entire cost curve was lower than those of its competitors.[1] These advantages manifested themselves in the high rates of profit of the GE Lamp Division.

> Profits in lamp making continued high for the leading concerns. In incandescent lamps alone from 1935 to 1939 General Electric made average net profits of between $16,000,000 and $21,000,000 on net sales which averaged around $45,000,000. These figures represented profits of 64 to 88 percent on costs, 39 to 47 percent on net sales, and 20 to 30 percent on invested capital. Since total net profits on the General Electric Company ranged only from $28,000,000 to $63,000,000 during the same years, it is evident that far greater profits on sales were achieved in lamp making than in the other phases of the company's business. In fact, the lamp department of General Electric contributed from one-third to two-thirds of total profit while adding only about one-sixth of total sales.[2]

The smaller firms selling lamps at a slightly lower price were making much smaller returns. Accentuating General Electric's and Westinghouse's profit positions was the greater consumer acceptance of their lamps.

> The names General Electric and Westinghouse are almost as old as the electrical industry, and they are known in connection with almost every type of electrical equipment from turbines and generators to fuses and flashlight lamps. The reputation of each company in every other field tended to enhance its reputation in the production of electric lamps. Continued heavy advertising by all divisions of each

---

1 This subject is discussed below.

2 A. A. Bright, op. cit., p. 270.

> company in amounts unapproachable by smaller producers aided in increasing consumer acceptance for all General Electric and Westinghouse products.[1]

The Mazda lamp, produced by General Electric and Westinghouse, was favored by many utilities which often bought lamps for their customers. The manufacturers of lighting fixtures set up their specifications to fit Mazda lamps, thereby giving General Electric an additional advantage. By the 1930's, most of the smaller companies were restricted to narrow specialty markets and exports.

In the 1920's, the General Electric dominance came to be questioned, first by the State of New York and then by the Federal Trade Commission. General Electric itself requested a Justice Department investigation. The Department then attacked the General Electric licensing and consignment system of distribution, but the Supreme Court ruled against the Government. This case is described in greater detail in chapter IV.

In spite of its advantages, General Electric lost some of its market share in this period. Table II-5 shows the relative market share of General Electric and various other firms in the industry from 1912 to 1941. After 1912, the combined market share of National Lamp and GE dropped from 81.5 percent to 64.2 in 1914. This contraction was mainly due to the activity of small independent firms infringing on GE's tungsten patents.

---

1 Ibid., p. 286.

TABLE II-5

The Market Share Breakdown for the Major Firms and Others in the Lamp Industry for Selected Years Between 1912 and 1941

Year	General Electric	Westinghouse	Type B licensees	Independents and imports
1912	81.5	NA 1/	NA 1/	NA 1/
1914	64.5	11.3 2/	NA 1/	NA 1/
1921	69.0	16.0	8.0	7.0
1923	61.0	16.0	9.0	14.0
1928	63.4 2/	19.3 2/	13.3	4.0 3/
1931	58.2	19.8 2/	12.7	9.3 3/
1934	57.9 2/	19.7 2/	9.5	12.9 3/
1937	58.3 2/	19.9 2/	8.5	13.4 3/
1941	56.7 2/	19.4 2/	9.7	14.8 3/

1/ NA means Not Available.

2/ These figures are based on the market share agreement between General Electric and Westinghouse in the licensing agreement for General Electric's patents.

3/ The percentage breakdown between the independent firms and imports are respectively 2.3 and 1.7 for 1928, 3.5 and 5.8 for 1931, 6.4 and 6.5 for 1934, 8.8 and 4.6 for 1937, and 14.3 and .5 for 1941.

Source: A. A. Bright, The Electric Lamp Industry: Technological Change and Economic Development from 1800 to 1947 (New York: MacMillan Company, 1949), pp. 238, 242, 265.

Even after vigorous patent enforcement actions by General Electric, the independent firms still held a 7 percent market share in 1921. The independents increased their market to 14 percent in 1924, but the share fell to 2.3 percent in 1928. With the expiration of some important General Electric patents and the company's failure to prove the validity of others in court, the market share of the independents and imports (mainly from Japan) increased in the 1930's. The close relationship between General Electric and an international cartel consisting of German, Dutch, and other European firms helped prevent European imports from reaching more than marginal importance.

Although General Electric's major patents expired in the 1930's, its many minor patents and its sharing with licensees of production technology still made its licensing system attractive to the involved firms. At the end of World War II, General Electric remained the dominant firm in the industry, but two events were to weaken its position: the development of the fluorescent lamp and the destruction of the licensing system. Before describing these changes, it is useful to survey the technological changes that had occurred in the previous 30-year period. The technological innovations concerned both the production techniques and the quality of the lamps.

By 1915, lampmaking machinery had been automated. Each operation, however, was done in a separate department and the output sent to yet another department for further processing. In 1918, W. R. Burrows, the manager of the General Electric Lamp works at Harrison, New Jersey, started to reorganize the plant. He moved machines into groups or units, each group consisting of a set of machines performing successive operations in the final assembly of the lamp, synchronizing the speeds of the machines. This reorganization cut costs and improved output per man-hour. Soon, the rest of the plants of General Electric and its licensees adopted the group or unit method.

Over the years, the group plan was further developed, and great improvements were made. The typical group hourly output rose from 400 units per hour in 1920 to 1,000 units per hour in 1942. Some groups were up to 1,200 units per hour.[1] Output per man-hour rose from 18 lamps in 1920 to 100 lamps in 1942. This innovation turned lamp assembly into a truly mass production activity.

Production efficiency also increased in the manufacture of glass bulbs. Throughout the early years of the industry, many new bulb-blowing machines were developed. By 1926, the best machines could produce 5,000 large bulbs per hour. In 1927, however, a revolutionary new device was introduced: the Corning ribbon machine. The original machine could produce 50,000 bulbs per hour.[2] A very few machines could produce most of the

---

1 The present group production rates for high volume lamps are between 3,000 and 3,500 units per hour.

2 As of 1976, the fastest ribbon machines making small automotive bulbs were producing up to 120,000 bulbs per hour, while the fastest machines making large bulbs were producing 66,000 per hour.

bulbs used in the country. Corning, which also produced bulbs, licensed General Electric to make bulb sleeves, and General Electric installed its first machine in 1933.

The major improvements in lamp quality included the gas-filled lamp, the non-sag tungsten filament, the tipless bulb, and the inside frosting of the bulbs. The first improvement, introduced by scientist Irving Langmuir, involved filling a tungsten lamp with a mixture of argon and nitrogen; the gas mixture resulted in longer life and greater brightness. This discovery was the <u>coup de grace</u> for large-scale use of arc and gas lighting. The development of the non-sag filament by Aladar Pacz also improved the brightness of the average lamp.

Until 1919, the air was exhausted from the top of most lamps. This method left a tip on the top of the bulb. Not only was this tip sharp, dangerous, and unattractive, but it also made the glass weak. General Electric developed a practical cheap method of exhausting air from the bottom of the bulbs.

The last important improvement, the inside frosting of glass, was an old idea, but it was not until 1925 that Marvin Pipkin developed a practical method of frosting the bulb. With the frosting of the bulb, a lamp's brightness became more diffused, making it more pleasant to use. In this period, several other improvements were made in such parts of the lamp as the filament and the getters.[1] Also the incandescent lamp was

---

[1] A getter is a chemical agent that is used inside the bulb to assist in obtaining a vacuum, to reduce bulb discoloration, or to improve the quality of the lamp in other ways.

being adapted to a wider variety of uses; new types, such as reflector, sealed beam automotive, photoflash and projection lamps, were developed.

While the incandescent lamp was being improved, new substitutes were being examined. Neon lighting came to occupy its specialized niche in the advertising field. Mercury vapor and sodium vapor lamps were introduced in the lighting of streets and large buildings.[1] The greatest innovation, however, was the development of fluorescent lamps.[2]

Numerous experiments had been conducted with fluorescent type lamps, but it was the late 1930's before practical results occurred. General Electric, in collaboration with Westinghouse which had some relevant experience in mercury vapor lamps, developed a fluorescent lamp. A small company, Hygrade Sylvania, also developed its own fluorescent lamps which were based on that of General Electric and Westinghouse.

Even with their headstart, General Electric and Westinghouse were slow to market the fluorescent lamp for several reasons. Since, presumably, they wanted to introduce the fluorescent lamp in a way that would maximize income from both incandescent and fluorescent lamps, they decided to move slowly in the fluorescent

---

1 Mercury and sodium vapor lamps are high intensity electric discharge lamps where the light comes from an arc inside a quartz or ceramic tube placed inside a large glass bulb.

2 A fluorescent lamp is a tube shaped lamp where ultraviolet waves emitted by a mercury vapor arc are changed to light by phosphors on the inside surface of the bulb or tube.

lamp field. Another constraint was the attitude of the utility companies, which feared that the increased efficiency of the fluorescent lamp would decrease the demand for electricity. General Electric and Westinghouse were large suppliers of utility equipment and were understandably concerned. In spite of the reluctance of General Electric and Westinghouse, the public acceptance of fluorescent lighting was favorable, and orders soon outran production.

Taking advantage of this situation, Sylvania began to market its fluorescent lamps aggressively. With only about a 5.5 percent market share allowed under its class B license, Sylvania did not have a great stake in the incandescent field. It acquired a patent position on its fluorescent lamps to counter the position of General Electric and Westinghouse, and it soon had 20 percent of the fluorescent lamp market. In the 1940's, Sylvania also moved into the production of radio tubes and acquired Wabash Appliance, one of the leading makers of photoflash bulbs. With these new lines of business, Sylvania's total sales increased from $11.0 million in 1938 to $128.8 million in 1945, and the firm emerged as a large electrical equipment manufacturer and a major factor in several product lines, including lamps.[1]

A second development changing the industry in the early 1940's was the destruction of the General Electric patent system.

---

1 For the figures on sales, see Moody's Industrial Manual, 1958.

Two major occurrences probably explain this development. Most of General Electric's major and minor patents expired. It was definitely easier to make a competitive lamp without infringing on a General Electric patent in the 1940's than in earlier decades, and this fact is revealed by the increasing market share of the independent lamp manufacturers. Their market share rose from 2.3 percent in 1928 to 14.2 percent in 1942.[1] The antitrust case brought by the Government in 1941 also affected the patent situation. General Electric, Westinghouse, Corning Glassworks, and other firms were accused of using patents to help monopolize the industry. Although the case was delayed by World War II, it seems apparent that this case induced General Electric to abolish its patent licensing system. In 1944, the B license system was abolished, and in 1945, the license arrangement with Westinghouse was terminated. General Electric and Westinghouse both dropped the Mazda trademark from their standard line of lamps.[2]

In 1946, the antitrust case was tried, and the court rendered a judgment in 1949. The Justice Department had requested that General Electric Lamp Division be split into two companies and that the consignment system of distribution, whereby General Electric owned its lamps until they were bought

---

1 A.A. Bright, op. cit., p. 265.

2 On the patent license system, A. A. Bright states, "The pending antitrust action seems to have been partially responsible for the termination of the scheme." It is difficult to verify totally this assertion, but the provisions of the eventual antitrust settlement seem to bear him out. See Ibid., p. 294.

by the consumer, be abolished. These requests were refused. Nevertheless, the court did grant certain of the Government requests. First, all patents on lamps or lamp parts then held by General Electric and other defendants[1] were licensed free of charge to any firm that wanted them. Second, existing GE patents on lampmaking machinery were to be licensed at a "reasonable royalty" to any firm desiring them. Third, for the next five years any future patents on lamps, lamp parts, or lampmaking machinery were to be licensed at a reasonable fee upon request. General Electric also had to share its technical information on the various processes used in manufacturing lamps.

Finally, various trademarks were forbidden for a wide selection of lamps. For instance the "Mazda" trademark could be used only for a small selection of lamps. Although the court decree eliminated much of the patent advantage of General Electric and its licensees, only time would reveal its longrun effect.[2]

E. The Postwar Period: 1945-Present

Generally, the period between the mid-1940's and the present has been one of stability in structure and general industry growth. Innovation has had only a minor effect on structure, and no Government action has radically altered the industrial environment.

---

1 They were N. V. Philip of the Netherlands, Consolidated Electric Lamp Company, Sylvania, the Chicago Miniature Lamp Works, and Tung-Sol Electric, Inc. (now part of Studebaker Worthington).

2 In chapter IV, this case is analyzed in greater detail.

General Electric has continued to be the leading firm, though its market share probably declined in this period. No accurate market share figures exist for most of this period. In 1941, General Electric had about 56 percent of the incandescent lamp market, and probably a higher share of the much smaller fluorescent market. In 1972, General Electric probably had about one-third of the industry employment which would probably indicate a larger share of industry sales (see table III-5). Westinghouse has probably retained its secondary position in the industry.

Sylvania, which merged with General Telephone to become GTE Sylvania, has increased its product line from incandescent, photoflash, and fluorescent lamps to include some types of miniature and electric discharge lamps. If GTE Sylvania is not the second largest firm in the industry, it is close to it.

A major development has been that Sylvania and Westinghouse have built glass tube plants for their fluorescent lamps and the tubular parts of the other lamps. These moves were probably a result of unsatisfactory relationships with their former supplier, Corning. Another major change since the 1940's involves the smaller fringe firms. Many have dropped out and some have been absorbed by conglomerate firms. For instance, Tung-Sol was first acquired by Wagner Electric which was then acquired by Studebaker Worthington. The Chicago Miniature Lamp Works was acquired by General Instruments.

Perhaps of most importance to the industry are the activities of North American Philips and Durotest; they have emerged respectively as the fourth and fifth largest firms in the industry. Philips has essentially combined three small, old firms into one lampmaking organization. Philips acquired Radiant Lamp Company in 1968, Verda-Ray Corporation in 1971, and the Champion Lamp Company (a subsidiary of International Telephone and Telegraph Corporation) in 1973. At present Philips seems to be continuing to sell the predecessor firms' older lines, and it is applying the manufacturing and marketing know-how of its European parent, N. V. Philips. Durotest has grown into a $50,000,000 a year corporation by developing high quality specialty lamps. North American Philips and Durotest are checks on the complete domination of the industry by the largest three firms. Also providing an alternative to the Big Three is Action Tungsram which has been importing large household lamps from Hungary. It opened a U.S. lamp assembly plant in New Brunswick, New Jersey in October 1978.

Postwar innovations while having only a small effect on industry structure were important. General Electric has continued to be the major innovator; table II-6 lists its important developments. The other large firms, however, have made some contributions. The efficiency and life of the incandescent lamp have very slowly increased. For a standard 100-watt lamp, the efficiency has increased from 16.3 lumens per watt in 1947 to

Table II-6

Innovations Originated by General Electric in the Lamp Business Since 1940

Innovation	Year
Circline fluorescent lamps	1945
New phosphors	1949
Rapid start fluorescent lamp fixtures	1952
Power Groove in fluorescent lamps	1956
Aluminum ceramics for sodium vapor lamps	1958
Photographic flash cubes	1965
Multi-vapor lamps	1965
Lucalox lamps (high-pressure sodium vapor)	1968
Warm light phosphor coating	1968
Magi-Cubes (percussion Photographic Flash Cubes)	1970
Photographic flashbars	1972
Flip-flop flashbars	1975
Elliptical side reflector incandescent lamps	1976

Source: General Electric Company

17.1 lumens per watt in 1976; for 60-watt lamps, the increase was from 13.9 to 14.2. In the 1960's, Durotest and Westinghouse introduced lamps using krypton instead of argon gas. The new lamps give 16 percent brighter light with no loss in lamp life. The lamps are expensive, however, because krypton is a rare element.[1] Fluorescent lamps have been improved since the 1940's mainly by simplication of the required fixtures. In both incandescents and fluorescents, product lines have been expanded to accommodate new uses. Many new varieties of photoflash lamps have been developed for new and different cameras. The variety of sodium vapor and mercury vapor lamps has also increased.

Postwar change has probably been greatest, however, in lighting engineering. A new industry has developed, consisting of firms which design and maintain the lighting systems of large buildings. Durotest has always participated in this market, selling to many customers an entire lighting system instead of individual lamps. GTE Sylvania and Philips have set up their own lighting maintenance firms and have gained acceptance in many areas. Due to the small capital outlays required, however, small firms continue to be important in this field.

Government intervention has had little effect on the industry in the last 30 years, although the abandonment of the excise tax on lamps in 1965 has lowered the cost of lamps to the

---

1 See New York Times, June 15, 1968, p. 49.

consumer. In the 1960's, the large companies encountered much criticism on the life of the incandescent lamp. In 1966, the Committee on Government Operations of the U.S. House of Representatives published a report concluding that the life of the standard bulb is too short, although the companies have raised objections to this conclusion.[1] The major result of the report was probably the promulgation in 1971 of the Federal Trade Commission Trade Rule Relating to Incandescent Lamps. The rule set forth labeling requirements for incandescent lamps sold to consumers. The effect of the rule has not yet been ascertained.

In an antitrust suit brought by the Justice Department, the courts ruled in 1973 that the General Electric consignment system was illegal. The company subsequently abandoned the system. (The effect of this move will be discussed in chapter IV.) The structure of the industry does not yet seem to have been affected by the change.

Of course, the industry also continued its growth during this period. Table II-7 compares the size of the various sectors in the lamp industry in 1945 and 1974, and it shows that total production has grown by over 300 percent. A large part of this

---

1 U.S. House of Representatives, Government Activities Subcommittee, Committee on Government Operations, The Short Life of the Electric Light Bulb (Washington, D.C.: U.S. Government Printing Office, 1966). There is an inverse relationship between light efficiency and the life of an incandescent lamp given equal wattage and voltage.

TABLE II-7

Comparison of 1945 and 1974 Shipments of Various Types of Electric Lamps

Type of lamp	1945 shipments	1974 shipments	Percentage change
	(thousands of units)		
Photographic	36,447	2,406,332	6,502.3
Large incandescent	794,402	1,532,039	92.9
Miniature	337,325	964,016	185.8
Fluorescent	42,781	284,529	565.1
Total (all lamps)[1]	1,250,689	5,395,942	331.4

[1] These figures are total lamp production, and they include categories not listed. The unlisted categories are not available for comparison between the two periods, but those listed are the major categories both in production quantity and value.

Source: U.S. Department of Commerce, Bureau of the Census, Current Industrial Report: Series MQ-36B(74)-5, Electric Lamps, 1975; and U.S. Department of Commerce, Bureau of the Census, Facts for Industry: Electric Lamps, 1946.

gain is accounted for by the development of the photoflash lamp which has become much cheaper during this period. On the other hand, even the demand for conventional lamps has increased. Large incandescent lamp shipments almost doubled, and miniature lamp shipments have almost tripled. The growing acceptance of fluorescent lamps is also apparent from the figures in table II-7. This growth, however, has not changed the basic structure of the industry. The larger three firms have retained their market share by keeping pace with demand.

CHAPTER III

The Structure of the Electric Lamp Industry

A. Market Definition

The most relevant product market includes those lines in Bureau of the Census Standard Industrial Classification (SIC) Industry 3641 and SIC groups that supply it. The most relevant geographic market is the geographic area of the United States.

Product Market: To determine the relevant market in product space, both the demand and supply sides of the market must be considered. On the demand side, several segments can be delineated. Electric discharge lamps, for example, tend to be purchased by industrial firms and governments. And, although household consumers buy both photographic lamps and incandescent or fluorescent lamps, the lamps are used for different purposes. Furthermore, buyers of many specialized lamps tend to be people other than the usual buyers of ordinary lamps.

The market appears to be more cohesive on the supply side than on the demand side, however. Electric lamps can be divided into seven general groups: photographic lamps, large incandescent lamps, miniature sealed beam auto lights, other miniature incandescent lamps,[1] fluorescent lamps, other electric discharge lamps, and specialty lamps.[2]

---

[1] Miniature lamps are defined as lamps used on a low voltage circuit (usually under 15 volts). While most of them are also small in size, they are not necessarily so. Sealed beam lamps are quite large.

[2] Specialty lamps are defined as lamps which have specialized uses and which have characteristics and/or technologies radically different from other categories of lamps.

Among seven of the larger companies, two producers, General Electric and Westinghouse, make lamps in all seven categories and three, GTE Sylvania, North American Philips, and Durotest, make bulbs in most categories. It seems apparent that the skills needed by a corporation to make one type of lamp can usually be transferred to other types.

The only subcategories where firms tend to specialize in a few product lines are the sealed beam and other automotive lamps and the specialty lamps. Studebaker Worthington and General Motors are large manufacturers of sealed beam and other automotive lamps, but they have shown no inclination to move into other areas. On the other hand, GTE Sylvania, while very important in the other areas of the lamp industry, does not participate in the sealed beam segment. Nor do Philips and Durotest. Also there are several firms that manufacture specialty lamps such as xenon tubes, neon lights, and ultraviolet lights, but which do not seem interested in the other types of lamps. In summary, despite segmentation on the demand side of the industry, the firms accounting for most of industry output seem to be able to market in many different demand segments, with the possible minor exception of specialty lamps. Therefore, it is reasonable to view SIC 3641 as the relevant market.

Geographic Market: The most relevant geographic market definition for the lamp industry is the geographic area of the United States. It can be demonstrated that individual light bulb plants supply the entire United States. The 1967 Census of Transportation shows that only 51.9 percent of the ton miles accounted for by SIC 3641 was for products shipped under 1,200 miles whereas 37.8 percent of the ton miles was for products shipped over 2,000 miles.[1]

One company representative estimated that, on the average, transportation costs consisted of 3 percent of delivered cost. This figure will vary by location, and different companies may have different averages, but it does suggest that transportation costs are not overwhelmingly important. Of the 46 lamp assembly plants owned by the seven largest lamp manufacturers, 29 are north of the Ohio River and east of the Mississippi River.[2] While these firms have no lamp plants on the west coast, they sell on a nationwide basis.

It can also be shown that the United States cannot be regarded as a segment of a world or hemispheric market. The tariffs on various types of lamps range from free (on various Canadian items) to 55 percent (on lamps used in surgical procedures from unfavored, usually Iron Curtain, nations). Table III-1 shows the U.S. value of shipments, exports, and imports in SIC 3641 for the years 1967 to 1973. During that time, imports

---

[1] U.S. Dept. of Commerce, Bureau of the Census, Census of Transportation, 1967, Volume III, Commodity Transportation Survey, Part 3, Commodity Groups (Washington, D.C.: U.S. Government Printing Office, 1970), pp. 94, 95.

[2] The seven largest firms are General Electric, Westinghouse, GTE Sylvania, North American Philips, Durotest, Studebaker Worthington, and General Motors.

TABLE III-1

United States Value of Shipments, Exports, and Imports for SIC 3641: 1967-73 (Millions of Dollars)

Year	Value of Shipments	United States Exports*		United States Imports*	
1967	781.8	30.6	(3.91)	22.6	(2.89)
1968	863.9	54.6	(6.32)	23.8	(2.75)
1969	842.5	39.5	(4.69)	25.6	(3.04)
1970	891.6	37.8	(4.24)	35.3	(3.96)
1971	961.9	40.3	(4.19)	41.9	(4.36)
1972	1069.1	46.0	(4.30)	63.5	(5.94)
1973	1165.6	60.7	(5.21)	79.2	(6.79)

* The figures in parentheses are the percentages of total value of shipments.

Source: U.S. Dept. of Commerce, Bureau of the Census, Census of Manufactures, 1972, Industry Series Electric Lighting and Wiring Equipment, MC72(2)-36C (Washington, D.C.: U.S. Government Printing Office, 1975); U.S. Imports Consumption and General SIC Based Products by World Areas, 1967-1973 FT 210; and U.S. Exports of Domestic Merchandise SIC Based Products by World Areas, 1967-1973 FT 610 (Washington, D.C.: U.S. Government Printing Office, 1968 through 1974).

never accounted for more than 6.79 percent of total domestic value of shipments while exports never accounted for more than 5.21 percent. When imports are added to value of shipments and exports subtracted from the whole, consumption can be found. Between 1967 and 1973, 93 percent of the total lamps consumed in the United States were manufactured in the U.S. In the same seven-year period, 94.8 percent of the lamps manufactured in the United States were used in the U.S.[1]

B. Concentration

Having defined the market, concentration in the lamp industry may be explored. Fortunately, one can use the available national concentration figures for SIC 3641, Electric Lamps, to describe concentration in lamp assembly, but concentration in lamp components is more difficult to determine.

Lamp Assembly: Concentration in the lamp assembly sector, SIC 3641, is given in Table III-2 part a. The 1972 four- and eight-firm concentration levels were 87 and 93 percent, respectively. A slight downward trend in these levels is apparent, but it is difficult to judge whether or not it is significant. The Census of Manufactures shows that, although 103

---

1 For discussions of geographic market definition see K. Elzinga and T. Hogarty, "The Problem of Geographic Market Delineation in Antimerger Suits", The Antitrust Bulletin, vol. 18, no. 1 (Spring 1973), pp. 45-82; and Thomas F. Hogarty, "Geographic Scope Energy Markets: Oil, Gas and Coal", in Thomas D. Duchesneau, Competition in the U.S. Energy Industry (Cambridge: Ballinger Publishing Company, 1975), p. 203.

TABLE III-2

Concentration Levels in SIC Industries and Product Classes Involved in the Manufacture of Electric Lamps, 1954 to 1972

a. SIC Industry 3641, Electric Lamps.

Years	Value of shipments	Concentration (percent) 4-firm	8-firm	20-firm
1972	1068.9	87	93	98
1967	756.4	88	93	98
1963	545.9	89	95	99
1958	393.6	90	96	99
1954	309.7	93	96	99

b. SIC Product Class 32292, Lighting and Electronic Glassware.

Years	Value of shipments	Concentration (percent) 4-firm	8-firm	20-firm
1972	394.6	83	91	98
1967	328.9	92	96	99
1963	210.3	85	91	98

SOURCE: U.S. Dept. of Commerce, Bureau of the Census, Census of Manufactures, 1972, Special Reports Series: Concentration Ratios in Manufacturing, MC 72 (SR)-2 (Washington, D.C.: U.S. Government Printing Office), pp. 104 and 140.

firms operated in SIC Industry 3641,[1] the top 20 firms accounted for over 98 percent of the value of shipments. Concentration may be both higher and/or lower in the various market segments for the lamp types, but data are unavailable. Table III-3 shows total and relative value of shipments for various product lines. Many of the small firms are manufacturers of highly specialized lamps such as infrared light sources, and they do not represent a threat to the dominance of the larger firms. According to a telephone survey based on a list of companies submitted to the National Electrical Manufacturer's Association, there were 38 firms manufacturing some kind of lamp in early 1976.

The four-firm concentration ratio is deceptive in that three of the four largest firms account for a much larger share of the market than the fourth firm. Nonetheless, the exact values of the various firms' market shares cannot be determined from public data. Most of the largest lamp producers are conglomerate type firms, and they do not report product line data to the public.

Even for specialized firms, lamp sales are often difficult to determine. Durotest, for example, is also a lighting engineering firm, and revenue from engineering cannot always be

---

1 See U.S. Dept. of Commerce, Bureau of the Census, Census of Manufactures, 1972, Special Report Series: Concentration Ratios in Manufacturing, MC 72 (SR)-22 (Washington, D.C.: U.S. Government Printing Office, 1975), p. 39.

TABLE III-3

Breakdown of Value of Shipments of SIC 3641, Electric Lamps, by Type of Lamp, for Major Lamp Types: 1974

Type of lamp	Quantity shipped (1000's)	Value of shipments (1,000,000's)	Percentage of total value
Total	5,395,942	$1,176.4	100.0
Photographic Incandescent Lamps	2,406,332	248.4	21.2
Large Incandescent Lamps	1,532,039	398.9	33.9
General Lighting including 3-way)	1,208,864	221.5	18.8
Other Large Incandescent	323,175	177.5	15.1
Miniature Incandescent Lamps	964,016	194.0	16.5
Automotive Sealed Beam Lamps	92,377	81.8	7.0
Other Automotive Miniature Lamps	572,831	52.3	4.4
Other Miniatures	298,808	59.9	5.1
Electric Discharge Lamps	493,555	335.1	28.5
Fluorescent Lamps	284,529	246.0	20.9
General Lighting Electric Discharge Lamps	8,742	68.1	5.8
Other Electric Discharge Lamps	200,284	21.0	1.8
Christmas Tree Lamps (All Types)	*	*	*

* Not available

Source: U.S. Dept. of Commerce, Bureau of the Census, Current Individual Reports, Series MQ 36B(74)-5,Electric Lamps, Summary for 1974 (Washington, D.C., 1975).

distinguished from revenues from manufacturing.[1] But some information about the dominance of the three largest manufacturers can be gleaned from the number of establishments that the three larger firms have devoted to the manufacture of lamp parts and the assembly of lamps. Table III-4 shows the number of lamp establishments owned by the seven firms most likely to be the largest. The large number of plants owned by the three largest firms suggests their relative dominance compared to the other firms. These data, however, are inadequate for comparison among the three. While it is generally acknowledged that General Electric is the largest firm, comparison of numbers of plants would overstate its dominance in the industry. Firstly, General Electric is more integrated than the other two firms, especially in glass bulb sleeves. Secondly, General Electric has a tendency to spread its activities over a larger number of plants. For instance, where Westinghouse and GTE Sylvania have centralized most of their production engineering activities at their lamp headquarters, General Electric has three such engineering shops for its lamp division.

<u>Lamp Components</u>: Establishments primarily engaged in manufacturing glass parts for lamps are classified in SIC Product Class 32292, Lighting and Electronic Glassware. Some lamp components,

---

1 Durotest has a very large sales force which not only supplies the perceived needs of buyers of lamps, but also helps them develop their lighting systems. The sales force expense is carried under overhead expense. It is impossible to determine what part of this cost can be attributed to engineering.

TABLE III-4

The Number of Establishments Devoted to the Assembly of Lamps and the Fabrication of Lamp Parts and Other Lamp Activities Owned by the Seven Largest Lamp Manufacturers in 1976

Firm	Number of establishments devoted primarily to the assembly of lamps	Number of establishments exclusively devoted to the fabrication of parts and other lamp activities
General Electric	18	24
Westinghouse	10	2
GTE Sylvania	9	5
North American Philips	3	0
Durotest Corporation	2	1
Studebaker Worthington	2	0
General Motors	2	0

Source: The respective firms listed.

such as supports, filaments, lead-in wires, and electric discharge electrodes, along with unrelated products, are classified in SIC Industry 3699, Electrical Machinery, Equipment, and Supplies, Not Elsewhere Classified.

Table III-2 part b shows the concentration levels in SIC product class 32292 for the years 1963, 1967, and 1972. Concentration information is not available for SIC 3699 and probably would not provide much insight in any case, because the category includes products other than those used in lamps.

Like SIC Industry 3699, SIC Product Class 32292 contains products other than lamp inputs. Nonetheless, some useful information can be derived. Glass items used in lamp manufacturing are essentially of two types--tubes and bulb sleeves. Relatively easy to fabricate, the glass tubes are manufactured by General Electric, Westinghouse, GTE Sylvania, and Corning Glassworks. Corning supplies lamp firms other than the Big Three. Other glass firms undoubtedly could easily enter the glass tube market if Corning were to price its products too high.

Bulb sleeves, however, are made on ribbon machines each of which can produce a significant portion of total United States demand. At present, only two firms, General Electric and Corning Glassworks, have ribbon machines. Corning Glassworks is the supplier of bulb sleeves to the lamp manufacturers other than General Electric. The only likely entrants in this field are GTE Sylvania and Westinghouse. The relationship between these firms and Corning Glassworks is similar to that of monopsony or oligopsony.[1] One would expect Corning Glassworks to be somewhat subdued in its pricing because of the knowledge that these two firms might acquire their own ribbon machines. Although the 1972 four-firm concentration ratio for SIC 32292 of .83 may be a good indicator of market structure in the glass tube market segment, a ratio of 1.00 is a better indication for the bulb sleeve segment.

C. Market Shares

Although the public data for concentration in the lamp industry are fairly good, little information is available on market share distribution. As stated above, the glass bulb sleeves for incandescent and photographic lamps are made by only two firms, General Electric and Corning Glassworks. General Electric supplies itself exclusively, and the rest of the industry depends on Corning Glassworks. Therefore, the market shares of the two firms in this sector would be approximately equal to the market shares of General Electric and the other lamp manufacturers in lamp types using bulb sleeves.

Four companies, General Electric, Westinghouse, GTE Sylvania, and Corning Glassworks, manufacture the glass tubing

---

1 In the 1940's Sylvania faced a similar problem with regard to glass tubing "... Although Sylvania has considered the desirability of making its own glass, it has been able to secure price concessions from Corning which has made that unnecessary." (A.A. Bright, The Electric Lamp Industry. . ., MacMillan Company, 1949, p. 413). It seems that when Sylvania considered building a glass tube plant, Corning would give them a price concession. After it decided not to build, however, Corning would increase prices. Eventually this situation became unsatisfactory to Sylvania, and it built its own glass tube plant at Hillsboro, New Hampshire.

used for all mount assemblies and fluorescent tubes.[1] The lamp bases are made by the big three lamp manufacturers who sell these bases to the other firms. Although nitrogen and argon are bought from a number of chemical producers,[2] General Electric, Westinghouse, and GTE Sylvania are the sole suppliers of tungsten wire. General Electric and Westinghouse refine their own tungsten; GTE Sylvania buys the refined metal. These three firms supply the rest of the industry with either wire or coiled filaments. Except for the lamp gas ~~area,~~ the lamp components sector seems to be more concentrated than the lamp assembly sector.

Data on the market share distribution in the lamp assembly sector are scarce and inaccurate. Table III-5, part a gives an estimate of employment shares among six of the larger firms. Because of diversity of product types and production techniques, employment shares may differ from market shares. The estimates probably understate the share of the largest firms since the largest firms manufacture lamps with longer production runs and employ less labor intensive techniques.

Table III-5, part b shows one estimate of dollar shipments for six of the largest lamp firms, but this estimate may be based on faulty information about some plants, and it does not take

---

1 The term "tubing," refers to (1) the outer tubes on fluorescent lamps and (2) the smaller glass tubes upon which the filament or electrodes, supports, and lead-in are mounted in both incandescent and fluorescent lamps.

2 See 1976 Directory of Chemical Producers, Stanford Research Institute, Menlo Park, California, 1975, p. 393.

TABLE III-5

Employment and Shipments for the Six Largest Lamp Manufacturers in SIC Industry 3641: 1972

a. Market Shares (Employment)

Firm	Employment	Share of total employment
1. General Electric	10,000	31.9
2. Westinghouse	6,100	19.5
3. GTE Sylvania	5,800	18.5
4. Studebaker Worthington	1,600	5.1
5. North American Philips	1,400	4.5
6. Durotest	1,000	3.2
Total for Industry	31,300	100.0

$CR_4 = 75.4$ $CR_6 = 83.1$

b. Estimated Market Shares (Shipments)

Firm	Shipments (Millions of dollars)	Share of total shipments
1. General Electric	$310	31.6
2. GTE Sylvania	250	25.5
3. Westinghouse	220	22.4
4. North American Philips[1]	65	6.6
5. Durotest	30	3.1
6. Studebaker Worthington	20	2.0
Total for Industry	981	100.0

$CR_4 = 86.1$ $CR_6 = 91.2$

[1] What is now North American Philips, but which in 1972 consisted of the combination of the ITT Lamp Division and other plants then owned by Philips.

Source: Marketing Economics Key Plants 1973, Marketing Economics Institute, New York, 1973 for company employment and for the industry total employment. Special Studies: Lighting Devices, Predicasts Inc., Cleveland, Ohio 1974 for shipments.

into consideration the output of General Motors. General Motors probably produces over half the bulk-packed sealed beam lamps in this country because of its large market share in automobiles. But, although these data give only a rough idea of the dominance of the largest firms, they do suggest that the big three dominate the industry.

Data on the distribution of market share in the various categories of lamps are unavailable. All that is available are lists of the firms in each lamp sector. A telephone survey of lamp manufacturers listed by the National Electrical Manufacturers Association has produced a list of firms manufacturing each of the general product categories. Table III-6 shows this list of firms and the number of plants that each firm has in each category.

Certain generalizations can be made about the breakdowns in table III-6. The category with the largest number of firms is the large incandescent lamp category with 18 companies. The diversity in the number of firms in each category can probably be explained by differences in entry barriers in the different sectors (entry barriers are discussed in the next section).

The second generalization is that in most of the categories, the Big Three each operate more than one plant while most smaller companies do not. Indeed, smaller firms making more than one category of lamp often operate only one plant. In the large incandescent lamp category, 16 of the 33 plants are operated by

TABLE III-6

List of Firms Manufacturing the
Six General Categories of Lamps: 1976

Category and Firm	Number of Plants*
Photographic Incandescent Lamps	
1. General Electric Co.	3
2. GTE Sylvania, Inc.	2
3. Westinghouse Electric Corp.	1
Total	6
Large Incandescent Lamps	
1. Cascade Lighting Products, Inc.	1
2. Commercial Lighting Products, Inc.	1
3. DIC Tool Co.	1
4. Dura Electric Lamp Co., Inc.	1
5. Durotest Corp.	1
6. ELT, Inc.	1
7. General Electric Co.	8
8. GTE Sylvania, Inc.	4
9. Heidt Electric Products, Inc.	1
10. Industrial Lighting, Inc.	1
11. Lighting Manufactures & Distributors, Inc.	1
12. Lite-ronics, Inc.	1
13. Marvel Manufacturing Co., Inc.	1
14. North American Philips Corp.	3
15. Pennsylvania Illuminating Co.	1
16. Westinghouse Electric Corp.	4
17. Westron Corp.	1
18. Wright Lamp Co.	1
Total	33
Automobiles Sealed Beam Miniature Lamps[1]	
1. General Electric Co.	2
2. General Motors Corp.	2
3. Studebaker Worthington Corp.	2
4. Westinghouse Electric Corp.	1
Total	7

TABLE III-6 (Cont.)

List of Firms Manufacturing the
Six General Categories of Lamps: 1976

Category and Firm	Number of Plants*
Other Miniature Lamps[2]	
1. Commercial Lighting Products, Inc.	1
2. General Electric Co.	4
3. General Instruments Co.	1
4. General Motors Corp.	2
5. GTE Sylvania, Inc.	1
6. Herzog Miniature Lamps Works, Inc.	1
7. Studebaker Worthington Corp.	2
8. Westinghouse Electric Corp.	1
Total	13
Fluorescent Lamps	
1. Commercial Lighting Products, Inc.	1
2. Dura Electric Lamp Co., Inc.	1
3. Durotest Corp.	1
4. General Electric Co.	3
5. GTE Sylvania, Inc.	2
6. Heidt Electric Products, Inc.	1
7. Interelectric, Inc.	1
8. Industrial Lighting Co., Inc.	1
9. Marvel Manufacturing Co., Inc.	1
10. North American Philips Corp.	1
11. Verilux, Inc.	1
12. Westron Corp.	1
13. Westinghouse Electric Corp.	3
Total	18
Other Electric Discharge Lamps	
1. Commercial Lighting Products, Inc.	1
2. Durotest Corp.	1
3. General Electric Co.	2
4. GTE Sylvania, Inc.	1
5. Monroe Lighting, Inc.	1
6. North American Philips Corp.	1
7. Public Service Lamp Corp.	1
8. Verilux, Inc.	1
9. Westron Corp.	1
10. Westinghouse Electric Corp.	2
Total	12

TABLE III-6 (Cont.)

List of Firms Manufacturing the
Six General Categories of Lamps: 1976

Category and Firm	Number of Plants*
Other Lamps	
1. Amglo Corp.	1
2. General Instruments Co.	1
3. E. G. & G, Inc.	1
4. Englehardt Hanovia, Inc.	1
5. General Electric Co.	1
6. GTE Sylvania, Inc.	2
7. Illumination Industries, Inc.	1
8. Kenlite, Inc.	1
9. Quartz Radiation, Corp.	1
10. Sperti, Inc.	1
11. Superior Quartz Co.	1
12. Ultra Violet Products, Inc.	1
13. Tensor Corp.	1
14. Western Electric Corp.	1
15. Westinghouse Electric Corp.	1
Total	16

[1] Miniature lamps are defined as lamps using a current of less than 15 volts. Some miniature lamps are actually larger in size than large incandescent bulbs.

[2] This category includes non-sealed beam automobile miniatures.

* These plants are not necessarily devoted to merely one product category. Often plants will make lamps of two or more categories or more categories or types. For instance, a firm might make both incandescent and discharge lamps in one plant. Another might make both incandescent and miniature and photographic lamps in one plant. The variations in product mix are numerous.

Source: The Firms in the Industry.

the Big Three. The other categories exhibit a similar distribution of plants. Since the plants of the large firms are usually larger than those of the smaller firms, these figures tend to understate relative market shares.

The third generalization that can be drawn is that there is a fairly large number of small firms in the market. At least 38 firms manufacture lamps. Most of the small ones, however, make odd lot items. Many stated that they could not compete with the larger firms on standard items because of economies of scale. Generally, the available data on concentration and market share distribution show that the electric lamp industry is highly concentrated with a large number of small fringe firms.

D. Costs and Entry Barriers

This section attempts to determine whether the cost structure of the lamp industry explains present concentration. Before proceeding, however, it is appropriate to note the limitations of the analysis. Firm level cost data are not publicly available. Furthermore, if some cost data were available, it would be difficult to make generalizations. Over 5,000 types of lamps are manufactured in this country. Among firms and plants, there are wide variations in item volume and other characteristics. Different firms have different product mixes and face varying supply conditions. Therefore, it is impossible to construct a cost curve for a typical lamp firm or plant. Nevertheless, certain factors are common to many lamp plants, and some generalizations can be made. Observations of plants and discussions with management personnel have provided some insights into the cost structure and its influence on concentration.[1]

1. Scale Economies in Lamp Components

Although only a few firms produce lamp components in each subsector, economies of scale probably have an important impact upon price only in bulb sleeves. General Electric, GTE Sylvania, and Westinghouse are the sole domestic producers of tungsten wire, but the Big Three's power to set supracompetitive prices is limited by the ability of the other firms to obtain the wire abroad. Tungsten wire has a high value per pound so that shipping costs affect price very little. Similarly, only the Big Three participate in the manufacture of lamp bases, but the production process is relatively simple (metal stamping), and many other firms produce similar items.

The Big Three as well as Corning Glassworks manufacture glass tubing. General Electric has four plants producing glass tubing for its lamp operations, Westinghouse has two, and GTE Sylvania, one. The rest of the industry is supplied by Corning Glassworks. The number of plants suggests that economies of scale are not overwhelming. Some of the firms have built glass plants at places which facilitate their lamp assembly operations. While perhaps not one of the smaller lampmakers has the volume to justify a glass tubing plant, the pricing power of Corning is somewhat attenuated by the ability of (1) the larger lampmakers

---

1 The author visited plants owned by General Electric, GTE Sylvania, North American Philips, and Durotest.

to sell their tubing to other lamp firms and (2) other glass firms such as Owens-Illinois to enter the industry.

In the manufacture of bulb sleeves for incandescent and metal vapor lamps, however, considerable economies of scale exist, and the present firms probably have some ability to set supracompetitive prices. As noted above, only two firms make bulb sleeves: General Electric and Corning Glassworks. The former company supplies itself, and Corning supplies the remainder of the industry.

The ribbon machine is used to produce most of the items with a volume of over 500,000 units a year.[1] Any one of these machines can produce a considerable proportion of the lamp sleeve demand for a given year. Table III-7 shows examples of the types of bulbs produced by machines of various pitches and the approximate hourly and yearly production rates. From this table, it is apparent that only a few machines are required to produce most of the lamps used in the industry.

The production from one machine working 16 hours a day accounts for from 21.5 to over 100 percent of the yearly demand for various bulb types.[2] The types of lamps listed in

---

[1] "Only bulbs produced in high volumes (approximately 500,000/year) are considered suitable for production on a ribbon machine." GE response to specific questions asked of the electric lamp manufacturers, June 10, 1976.

[2] Two caveats are necessary. First, many ribbon machines work only eight hours a day. Second, variation in the shape of the bulbs within an SIC product class makes it economical for firms to use different machines for bulbs of the same 7-digit SIC Class. On the other hand, one machine can produce bulbs of different shapes when the molds are changed. Some lamp firms producing peculiarly shaped lamps own the molds which are kept and used at the Corning plant.

TABLE III-7

The Approximate Production Rates on the Ribbon Machine for Selected Types of Lamps Compared to Total Yearly Production for Those Lamp Types (Production in thousands)

Type of lamps	Machine[1] pitch	Approximate hourly production rate	Approximate 5-day, 48-week yearly rate assuming 8-hr. day	Approximate 5-day, 48-week yearly rate assuming 16-hr. day	Total U.S. production 1974	Percentage accounted for by one ribbon machine 8-hr. day	Percentage accounted for by one ribbon machine 16-hr. day
Automotive Miniature Lamps other than sealed beam SIC Product Classes 3641033 3641034	2.0 in.	110	211,200	422,400	558,042	37.8	75.7
Household General Lighting Incandescent Lamp SIC Product Classes 3641008 and 365109	3.0 in.	60	115,200	230,400	1,069,908	10.8	21.5
Larger Incandescent and High Intensity Electric Discharge Lamps SIC Product Classes 3641012 and 3641052							
150W-200W	3.5-4.0 in.	25	48,000	96,000	49,577	96.8	193.6
200W-1000W[2]	5.0-6.0 in.	15	28,800	57,600		58.1	116.2

1 The pitch is defined as the distance between the molds on the lower belt; larger size lamps are made on larger pitch machines.

2 Figures are not available for a breakdown of different bulb sleeves within SIC 3641012. The percentages given will tend to understate the proportion of the market handled by one ribbon machine.

Sources: General Electric and Corning Glassworks. GE provided the types of product for the machine pitches and Corning provided the hourly production rate. For the total production figures, the source is table III-3.

table III-7 accounted for over 83 percent of the 1974 production of large and miniature incandescent lamps. In order to make differently shaped bulbs, each plant usually has more than one ribbon machine. For example, General Electric has three machines in its Pitney Works. Consequently, it is not surprising that there are only two firms making bulb sleeves in this country.

The entry of GTE Sylvania and Westinghouse into sleeve production is likely because they often appear to be dissatisfied with Corning prices. At present, only Corning sells sleeves to the small lamp firms. Corning's pricing policy is constrained only by the potential entry of GTE Sylvania or Westinghouse and by the possibility that General Electric will start selling to the other lampmakers. In fact, General Electric officials have said that they do sell small numbers of sleeves to other firms. Even with these potential competitors, Corning probably has a wide latitude in pricing.

2. Scale Economies in Lamp Assembly

Lamp assembly plants usually consist of a group of centralized operations combined with several lamp assembly groups. The centralized operations are interfaced with the assembly groups so as to minimize total costs.

Whether certain operations are centralized depends on the situation at the particular plant. For example, if only a small volume of a plant's output is coated,[1] it may be cheaper to

---

1 On many lamps, the inside of the bulb is coated with a kind of paint which changes the color of the light. All fluorescent lamps are so coated, as are the popular "soft light" bulbs and colored decorative lamps.

attach a small coater to the machine group making the particular lamps. If a large portion of a large plant's output is coated, a centralized coating operation may be most economical. On low volume items, it is often more economical to package by hand, whereas on high volume items, it is cheaper to run centralized packaging machinery. There are some economies in spreading various centralized facilities over a large output, but often the capacity of these facilities can be adjusted to the size of the output. Therefore, it is difficult to make any general statement about the influence on plant costs of the centralized facilities.

The major factors influencing assembly costs are the physical size, the complexity, and the planned volume of the product. The effect of the first variable is relatively simple. The larger a product, the more material will be used in its manufacture; therefore, the cost will be higher. The second factor, complexity, also has an effect on production costs. The more complex a lamp, the more difficult and costly will be its assembly and production. For example, the mercury vapor lamp with its arc tube and intricate stem[1] is much more costly to assemble than an ordinary incandescent lamp.

---

1 The stem is the part of the lamp on which the filament, electrode or arc tube is mounted.

The volume effect is the most relevant to the subject of industry concentration. That the effect is important can be seen from table III-8 where the labor and capital costs of machine groups with differing production rates are shown. These production rates indicate planned volume because the machine groups are designed to operate at a given speed throughout their entire economic life. The per unit labor and capital costs of a 2,000 units per hour incandescent lamp machine group built by Baddalex, Ltd., a British lamp machinery manufacturer, are less than 50 percent of the per unit labor and capital costs of a 1,000 units per hour machine group.

For fluorescent lamps, the per unit capital and labor costs of a 2,000 lamp per hour machine group are about 60 percent of the capital and labor costs of a 1,000 lamp per hour machine group. Data on materials costs are not available.

The overhead costs such as buildings, management, and the in-house fabrication of the components are not included in the cost estimates given in table III-8. It can be safely concluded that most of those costs are probably of a less variable nature. Management costs as well as the costs of accounting and sales can be spread over a larger number of units when machine group capacity is increased. In some of the centralized fabrication functions, scale economies exist. Given these conditions, it seems that the unit cost decreases associated with greater volumes may be even larger than those shown in table III-8.

TABLE III-8

Indexes of Cost Components of Various Machine Groups Designated to Operate at Different Production Rates for Large Incandescent and Fluorescent Lamps

Production rates	Per unit labor cost index	Per unit capital cost index[1]	Weighted average of labor and capital indexes
Large incandescent lamps			
1000	1.00	1.00	1.00
2000	0.32	0.71	0.40
3000	0.21	Not Available	Not Available
Fluorescent lamps			
1000	1.00	1.00	1.00
2000	0.50	0.73	0.60

Note: The above indexes have assumed a 10-year depreciation period, and total labor costs of $7 per hour for machine operators and $10 per hour for mechanics.

1 The capital cost index is based on Baddalex prices for machinery at the exchange rate of $1.59 per pound. The capital costs include only the cost of the machine groups themselves; building and other ancillary costs are not included.

Source: Baddalex, Ltd., a British manufacturer of lamp machinery.

There are, however, limits on the volume which machine groups can produce. There is a point at which greater "machine speeds can be quickly offset by increased shrinkage (breakage) and maintenance costs and greater depreciation expenses."[1] Over time, the optimum speed of the machine groups has increased. At present, the highest speed appears to be 5,700 lamps per hour. As shown in table III-9, however, the highest volume machine groups in general use produce approximately 3,500 units per hour. Perhaps these limits will increase.

Casual perusal of table III-9 also suggests that the high volume lamps tend to be made on high volume machines. Moreover, data from the Durotest Corporation indicate a significant correlation between the highest production rate machine used by Durotest and total U. S. 1974 production.[2] And interviews with industry experts confirm that planned volume is positively associated with machine speed.[3]

---

1 General Electric response to specific questions asked of electric lamp manufacturers, June 10, 1976, p. 5.

2 The Spearman correlation coefficient between Durotest machine speeds and 1974 U.S. lamp type volume for 7-digit SIC classes was .5659. With a computed t-ratio of 2.377 for 14 observations, it was significant at the .05 level. It must be realized that while Durotest has a low market share in many SIC groups, in some it has a high share. Therefore, the low correlation coefficient is not surprising because Durotest has a very small share of the total market.

3 Interviews were conducted with personnel from General Electric, GTE Sylvania, North American Philips, Durotest, Baddalex, a lamp machinery firm, and several smaller lampmakers. This assertion is also implied in A. A. Bright, op. cit., pp. 349, 350.

TABLE III-9

Hourly Production Rates of Machine Groups Making Certain Lamp Types

Type of lamp	High volume machine group	Medium volume machine group	Low volume machine group
Large Incandescent Lamp	3,000 -3,500 D	1,000 -1,700 D	500 -800 D
Sealed Beam Automotive Lamp	600 -900[1] B		
Other Miniature	2,500 - 3,000[1] B	1,500[1] B	
Fluorescent Lamps	2,000 - 3,500 D	800 -1,250 D	250 - 600 D
High Intensity E.D. Lamp	1,200 D		100 -200 D

Note: Information was not available for photographic lamps. The letters B and D designate the suppliers of the estimate, B for Baddalex, and D for Durotest.

1 Baddalex advises they know of no faster machines.

Sources: Baddalex, Ltd., and Durotest Corporation.

Two factors account for this situation. First, using high volume groups for low volume items leads to greater inventory costs. Second, slower machine groups are usually more flexible, and one group can be used to make a variety of low volume items over a given time period. It is easier to understand these effects if they are considered separately.

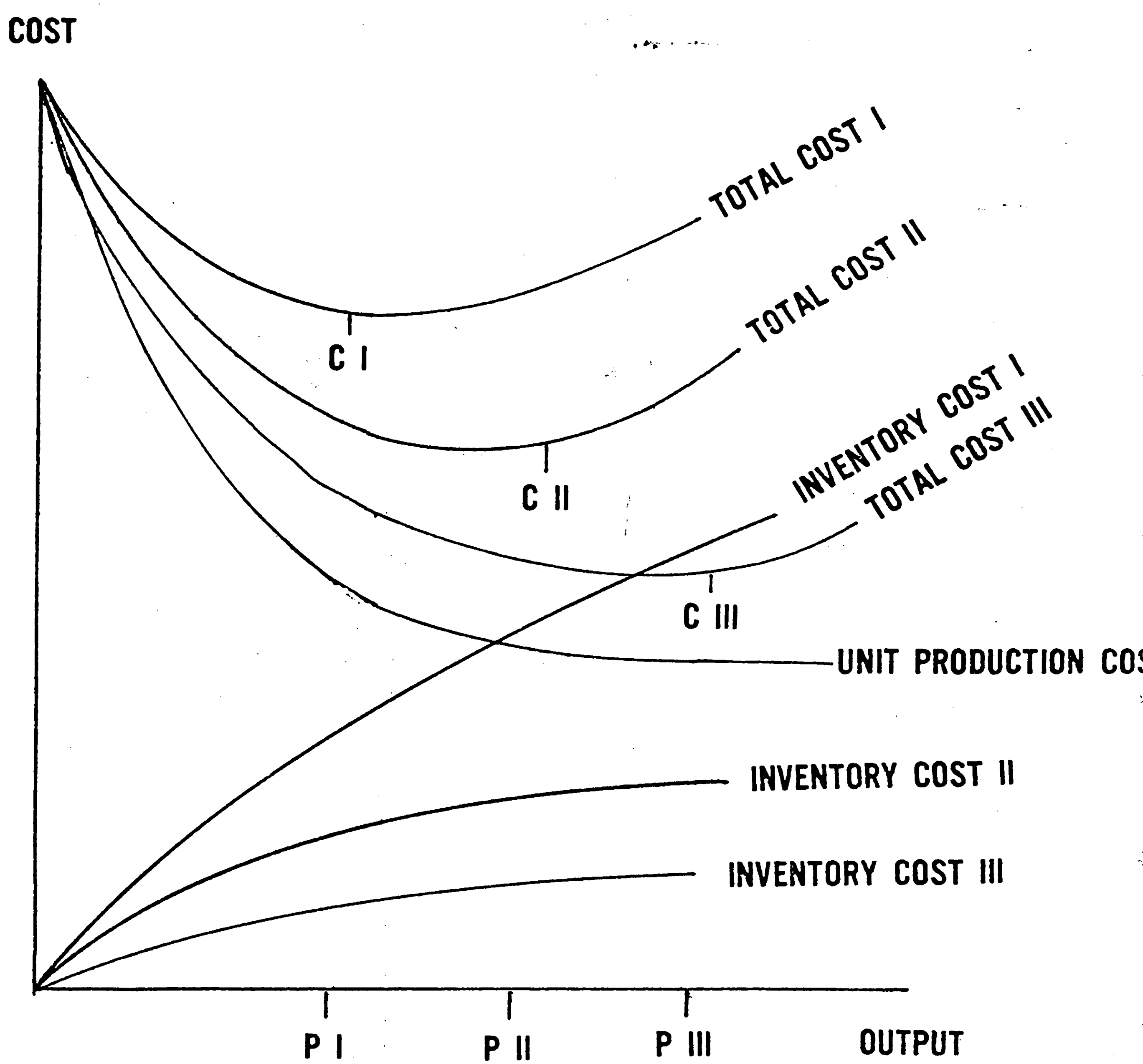
First, the inventory effect is described. When one increases the production rate of a machine group intended to produce a given yearly demand volume, one increases the timespan between producing and selling the product. As the production rate of the machine group increases, production time for a given demand decreases. This leads to items staying in inventory for longer periods of time thereby raising the average inventory cost. Therefore, for a given yearly volume, increasing inventory costs will often more than offset the decrease in costs associated with increasing rates of production. Figure III-1 shows this tradeoff for three different volumes of lamps. Inventory Cost Curve I represents the relationship between production volume and unit inventory cost for an item with a low demand volume; Inventory Cost Curve II represents the relationship for a medium volume item, and Inventory Cost Curve III, for a high volume item. A low cost point is reached at point CI on Total Cost Curve I for the low volume item. Here the rising inventory costs offset the decreasing production cost. Points CII and CIII are the low cost points for the larger two demand volumes. When a firm plans its response to market conditions, it will consider the combined unit production and inventory costs. Given the volumes posited in figure III-1, it would choose machines with production rates of PI, PII, and PIII.

The second factor leading to the use of slow machine groups for low volume items is the difference in flexibility between the fast and slow machinery groups. Generally speaking, as rates of production on machine groups increase, capital is substituted for labor. For example, most low and medium volume lamps are packaged by hand, whereas high volume lamps are often packaged by machines. Similarly, with low volume items, the components often will be moved from place to place by hand, but with high volume lamps, components are moved by belts and other mechanical transfer devices.

There is substitution in other functions as well. Machines can usually operate at a much higher speed than can a human; therefore, it is natural that high speed machine groups will be more automated. Yet humans can more readily adjust to changes in procedures than can machines. Consequently, if a firm uses a machine group to make many types of lamps, the group will tend to be more labor intensive than a machine group producing only one type of lamp. For low volume items, firms often will use a machine group to produce several different lamps, changing the group from one lamp production to another as demand conditions dictate.

FIGURE III-1

The Trade-Off Between Machine Group Rates,
Production Costs and Inventory Costs for a Given Volume of Lamps

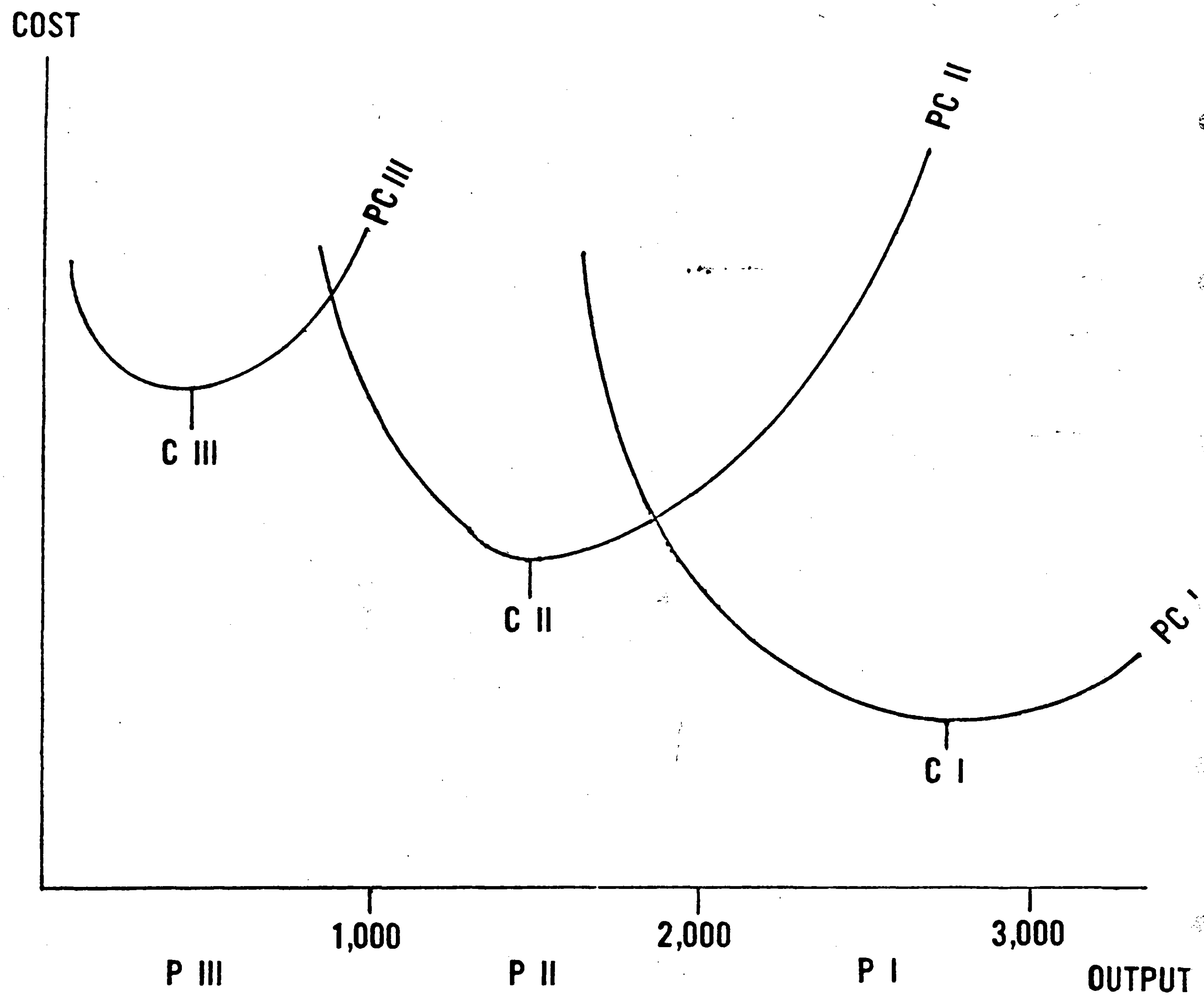


Another characteristic in the production process is the trade-off between flexibility and speed in the machines themselves. As the speed of the machine is increased, flexibility is usually sacrificed. "Flexible" machines are generally more complex than "inflexible" devices. Therefore, making these complex machines operate at high speeds can be prohibitively costly. Also the probability of breakdown and the rate of depreciation will be increased when very complex machines are made to operate at high speeds. Hence, when making relatively low volume items, firms will tend to use relatively slower machines.

Different product configurations result in different optimal production rates. A firm or plant making a large number of low volume items will employ slow moving machine groups, whereas a firm or plant producing a few high volume items will use high production rate machine groups. Therefore, due to the differences in flexibility between labor and machinery and between slow and fast machinery, the costs of producing different configurations of product will have a variation quite independent of inventory costs. Figure III-2 illustrates this variation. PCI represents the cost curve of a machine group configuration producing only one high volume lamp type (for instance, a 60-watt household bulb). PCII represents the curve of a group producing a few medium volume items (perhaps some commonly used decorative lamps), while PCIII represents the cost curve of a group producing a large number of low volume items. With PCI, the

FIGURE III-2

Cost Curve of Machine Groups Making Lamps
With Different Lamp Type Configurations



PCI Group Configuration of One High Volume Lamp Produced in a Given Year.

PCII Group Configuration of a Number (say 5 to 10) of Medium Volume Lamps Produced in a Given Year.

PCIII Group Configuration of a Large Number (say 15) of Low Volume Lamps Produced in a Given Year.

problems of increased breakage, maintenance, and depreciation begin to overcome scale economies at CI, while with PCII and PCIII, this situation is reached at CII and CIII, respectively. Since labor costs, overhead costs, and capital costs per unit of output are lower on faster machine groups, unit cost at CI is less than at CII and unit cost at CII is less than at CIII.

Overhead costs and space requirements are about the same for fast and slow machinery groups. Often faster machines require less labor than slower machines. Given all these conditions, firms selling various types of lamps have to take into account the interaction of the differing cost trade-offs on machine groups with the various other costs such as plant overhead, inventory, and distribution costs.

To summarize, high speed machine groups lead to lower costs and are used to produce high volume lamps.

3. Plant Entry Barriers in the Lamp Assembly Sectors

This section examines the effect of the machine groups' speeds on plant entry barriers in the lamp assembly sector. Table III-10 shows the percentage of total 1974 U.S. production accounted for by one high volume machine group for various types of lamps. Machine speed data are available for only 17 of the 40 seven-digit SIC product classes, but the technology for the bulk of the other products is similar, and these figures give an indication of the influence of machine group scale on the other product lines. A high volume machine group can account for from 1.8 to over 100.0 percent of the production in various SIC product classes. Since the pooling of overhead costs can be important, column (3) of table III-10 shows the percentages of product class output that can be accounted for by a plant with four machine groups. These percentages range from 7.2 to over 100.0 percent. If Bain's entry barrier classifications are used, and one assumes that a one machine group plant is viable, then the entry barriers range from not important to very important.[1] If one assumes that four machines are needed in a plant, the entry barriers range from moderately important to important.

The larger the proportion of the market accounted for by a new entrant of minimum efficient scale, the greater the potential

---

1 Joe S. Bain, Barriers to New Competition, (Cambridge: Harvard Press, 1962) p. 81. Bain considers a minimum efficient scale of over 10 percent of total industry sales to be a very important barrier to entry, a minimum efficient scale of 5 to 10 percent moderately important, and a minimum efficient scale of less than 5 percent, not important.

TABLE III-10

The Percentage of Total U.S. 1974 Production Accounted for by High Volume Groups for Selected Types of Lamps

SIC code	Type of lamp	(1) High volume hourly production rate	(2) Percentage of total U.S. production accounted for by one machine on 80-hour week 50-week year	(3) 4 x (2)
	Incandescent Lamp			
3641008	General lighting (white)	3500	3.1	12.4
3631009	General lighting (other)	3500	2.3	9.2
3641019	R-type reflector	3000[1]	51.1	**
3641016	traffic light	3000	*	**
3641017	Rough service	3000	49.9	**
3641007	Decorative lamp	3000	27.0	**
	Miniature Lamps			
3641-30-31 32-37	Automobile sealed beam	900	3.9	15.6
3641033-36	Other auto lights	2500	1.8	7.2
641034	Flashlights	2250	15.7	62.8
	Electric Discharge Lamps Fluorescent Lamp			
3641043	Slimline	1500	13.0	52.0
3641044	Below 40 watts	3500	35.6	**
3641045	40 watts and above	3500	8.4	33.6
	Other E.D. Lamps			
3641052	General lighting	1200	54.5	**

* One machine group makes more than total U.S. production.

** Four machine groups make more than total U.S. production.

[1] The writer assumes, on the basis of plant observation, that these types of lamps are made on machine groups with the given speed.

Source: Table III-9 and U.S. Dept. of Commerce, Bureau of the Census, Current Industrial Reports, Series MQ 36B (74)-5, Electric Lamps, Summary for 1974, Washington, D.C., 1974, p. 2.

impact of his entry on price. If one needs a sizable portion of the market to be cost competitive, entry will be more risky. In such situations, potential entrants may take their resources elsewhere. From table III-10 it is apparent that entry with a high speed machine group would result in a fairly large market share in most market segments. Even if a firm were to enter segments such as general lighting lamps (other) SIC 3641008, or other auto lights, SIC 3641033, where minimum optimal scale is relatively low, a four machine group plant would still produce 9.2 and 7.2 percent of the respective markets. Such percentages would probably make the entrant the fourth or fifth largest firm in the market segment. It seems likely that prices would be affected if a technically efficient firm were to move into those markets.

The small firms that do exist appear to do so by concentrating on specialty items. The usual production plan of these firms is to produce one or two house specialties and then, to obtain orders for short runs of other lamp types.[1] Smaller firms manufacture specialty items which the large companies either cannot or do not choose to duplicate. Since the consumers of these specialty lamps may be looking for certain qualities that they cannot obtain from the larger firms, they will pay a premium. This premium will often be enough not only to cover the small firm's higher production costs but also to earn the desired

---

[1] This statement is based on an interview on October 22, 1976, with W. J. Worsdell of Baddalex, Ltd., and Lawrence W. Rocheleau of the American Cam Corporation.

rate of return. Therefore, a new entrant is likely to be interested primarily in specialty lamps.

Since volume is low for specialty lamps, machine groups are switched from one item to another. Consequently, the slow machine groups are the most economical for these items. Table III-11 shows the speeds and percentages of total 1974 U.S. production accounted for by the Durotest and Baddalex low volume machine groups. Because low volume equipment is more labor intensive, there is less need to spread capital over larger outputs. Therefore, 40-hour work weeks are common with these types of machine groups, and the assumption of a 40-hour week is made in Table III-11.

Even low volume machine groups can account for sizeable portions of total volume in some market segments. In SIC product classes 3641015 and 3641016, one low volume machine group accounts for over 10 percent of the market. For 10 of the SIC product classes, a four machine group plant would account for over 10 percent of total 1974 U.S. output. Therefore, in many sectors of the lamp industry, an efficient new entrant would have to produce a large share of the market even with specialty type low volume machine groups. Although minimum optimal scale in some high volume markets may not appear to account for nearly as high a percentage of total output as minimum optimal scale in the specialty classes, it must be remembered that there are many subcategories in the high volume SIC product classes. In its 1974 Authorized FSS Lamp Catalog, for example, General Electric

TABLE III-11

The Percentage of Total U.S. 1974 Production
Accounted for by Low Volume Machine Groups
For Selected Types of Lamps

SIC Code	Type of lamp	(1) Hourly production rate	(2) Percentage of U.S. production accounted for by one low volume group with a 40-Hour Week 50-Week Year	(3) 4 X (2)
Incandescent Lamps				
3641008	General Lighting	800	.36	1.44
3641012	Above 150 watt	700	2.82	11.28
3641013	3-way light	650	3.02	12.08
3641014	Par Shaped Reflector	600	4.32	17.28
3641019	R-Type reflector	600	5.11	20.44
3641015	Infrared	500	18.80	75.20
3641016	Traffic Light	800	21.11	84.44
3641017	Rough Service	800	6.65	26.60
3641007	Decorative	800	3.60	14.40
Electric Discharge Lamp Fluorescent				
3641043	Slim-line	450	1.94	7.76
3641044	Below 40 watt	600	3.11	12.44
3641045	40 watt & above	600	.72	2.88
Other E.D. Lamps				
3641052	General Lighting	200	4.54	18.16
3641053	Miscellaneous E.D.	200	*	**

* The volume from running this group full time is greater than U.S. 1974 production.

** The volume from running this plant full time is greater than U.S. 1974 production.

Sources: Baddalex, Ltd.; Durotest Corporation; and U.S. Dept. of Commerce, Bureau of the Census, Current Industrial Reports, Series MQ-36B (74)-5 Electric Lamps Summary for 1974, (Washington, D.C., 1974), p. 2.

lists 1,190 types of incandescent lamps, 723 types of miniature lamps, and 234 types of fluorescent lamps. Consequently, with a specialty lamp categorized in a high volume SIC product class such as Incandescent General Lighting (other), entry may have a considerable impact on the price of close substitutes. Therefore, generally speaking, an entrant in the lamp industry must obtain a considerable portion of at least the immediate submarket if it is to employ its machine groups efficiently.

4. Plant Overhead Cost

Another important cost consideration is plant overhead. Generally, considerable economies can be effected by putting more than one machine group in a plant. The extent of plant overhead economies tends to vary with circumstances, however, and it is difficult to make a general statement about them. In order to show the effect of plant overhead on entry, total production for two plants in the industry is estimated and compared with the total 1974 production in the market segments in which they operate. This gives an estimate of the market share required for entrants to obtain costs comparable to present producers. Estimates are also made of the market share accounted for by a high volume plant for one other general market. Whether the estimated market share is in fact the minimum necessary to achieve efficient scale is not certain and will be further discussed at the end of this section.

The approximate outputs of two high volume lamp plants ar now estimated. One plant is an actual high volume incande lamp plant and the other an actual high volume fluorescent l plant; both are owned by one of the largest lamp firms. Tables III-12 and III-13 show the approximate yearly output of these plants. Since the firm preferred not to reveal the actual machine speeds or plant production, the total figures are based on estimates of the machine speeds. Three estimates based on different speed assumptions were used in the computations for each plant. The estimates of the incandescent lamp plant were from 11.5 to 16.0 percent of the total U.S. large incandescent lamp production in 1974. The yearly production of a similar high volume incandescent lamp plant, Westinghouse's at Little Rock, Arkansas, has been estimated at between 200 million and 250 million lamps per year, respectively 13.1 and 16.3 per cent of 1974 U.S. production.[1] It is doubtful such a plant would produce very many items in the other lamp categories. The three estimates on the fluorescent lamp plant show that the scale barriers may be even higher. The range of estimated market share accounted for by this plant is between 13.0 and 29.7 percent. It is apparent that to manufacture lamps on the scale that the large firms operate, one would have to enter the industry on a scale which might well lead to excess capacity and thus drive down prices.

---

1 The estimates for the Westinghouse plant were based on Testimony of Clinton Turnage, President, Union Local no. 1136, International Brc[illegible]herhood of Electrical Workers (IBEW), AFL-CIO before the [illegible]ational Trade Commission in the Matter of [illegible]e [illegible]ent Lamps from Hungary, August 22, 1978. Mr. [illegible]t the Little Rock plant had produced between [illegible] scent [illegible]00 per day during the period between 1962 and [illegible] figures cited are based on a 5-day week and a [illegible] amp [illegible]

TABLE III-12

Estimates of Yearly Output of an Actual High Volume Incandescent Lamp Plant

Estimate[1]	Yearly production[2]	Percentage of total large incandescent market
Low	168,400,000	11.5
Medium	200,200,000	13.7
High	234,000,000	16.0

[1] This lamp plant is divided into three Parts, A, B, and C. In Part A are 11 low volume machine groups; in Part B, 8 medium volume machine groups, and in Part C, 9 high volume machine groups. The low estimate is based on the following assumptions about the machine rates for the three parts: Part A, 11 groups making 500 lamps per hour; Part B, 8 groups making 1,200 lamps per hour; and Part C, 9 groups making 3,000 lamps per hour. The medium estimate is based on the following assumption: Part A, 11 groups making 800 lamps per hour; Part B, 8 groups making 1,500 lamps per hour; and Part C, 9 groups making 3,250 lamps per hour. The high estimate assumes: Part A, 11 groups making 1,000 lamps per hour; Part B, 8 groups making 2,000 lamps per hour; and Part C, 9 groups making 3,500 lamps per hour.

[2] These estimates assume an 80-hour week in a 50-week year.

Sources: For the plant configurations, the source was the firm. The machine speed estimates were based on Baddalex and Durotest information and for the total U.S., 1974 production, the source was U.S. Dept. of Commerce, Bureau of the Census, Current Industrial Reports, Series MQ36B(74)-5, Electric Lamp Summary for 1974, (Washington, D.C., 1974,) p. 2.

TABLE III-13

Estimates of the Yearly[1] Output of an Actual Fluorescent Lamp Plant

	Yearly production[2]	Percentage of total fluorescent 1974 production
Low estimate	36,000,000 lamps	13.0
Medium estimate	60,000,000 lamps	21.7
High estimate	82,000,000 lamps	29.7

---

[1] This assumes an 80-hour week and a 50-week year.

[2] This lamp plant has two horizontal machine groups and nine vertical machine groups. With horizontal groups the lamp is in a horizontal position throughout the production process. With vertical groups the lamp is in a vertical position when the two mounts are put on. The former is the more advanced process. The low estimate is based on the following assumptions:

1. Five vertical machine groups with a production of 500, and four with a production of 1,000 lamps per hour.

2. Two horizontal groups with a production of 2,500 lamps per hour.

The medium estimate is based on an assumption of:

1. Nine vertical groups with a production of 1,000 lamps per hour.

2. Two horizontal groups with a production of 3,000 lamps per hour.

The high estimate assumes:

1. Nine vertical groups with 1,500 lamps per hour.

2. Two horizontal groups with 3,500 lamps per hour.

Source: For the plant configuration, the source was the firm. The machine speed estimates were based on Baddalex and Durotest information. For the total U.S. production the source was U.S. Dept. of Commerce, Current Industrial Reports, Series MQ36 (74)5 Electric Lamps Summary for 1974, (Washington, D.C., 1974), p. 2.

Plant estimates are not available for other segments of the industry, but the similarities in technology between the large and miniature incandescent lamp types are such that estimates of a high volume miniature lamp plant can be made. Baddalex estimates of machine group production rates are used. To construct a hypothetical high volume plant making only miniature lamps, the assumption is made that this plant would make both sealed beam and other types of miniature lamps. It is also assumed that four machine groups would be devoted to making sealed beam lamps and 15 machine groups to making other miniature lamps.[1] Table III-14 shows three estimates of the production for this hypothetical plant and the percentages of total U.S. production of sealed beam and other miniature lamps accounted for by such a plant. The percentages would range from 10.4 to 15.6 for sealed beam lamps, and from 13.8 to 20.6 for other miniature lamps. Therefore, such a plant would produce a considerable portion of the total U.S. production of these products. It is obvious that with firms operating such large plants those sectors of the lamp industry would be concentrated.

Table III-15 shows the range of the four-firm concentration ratios for the large incandescent, miniature, and fluorescent

---

[1] Not enough information was obtained on photographic lamps to make such a plant estimate. High intensity electric discharge lamps are produced in such low volume at present that a large part of the assembly process is by hand, and it is not possible to construct a model high volume plant based on machine speeds. A typical configuration would be difficult to ascertain.

TABLE III-14

Estimates of the Yearly[1] Output of a Hypothetical Miniature Lamp Plant

Estimate		Yearly production of lamps	Percentage of total U.S. production
Low:	Sealed beam lamps	9,600,000	10.4
	Other miniature lamps	120,000,000	13.8
Medium:	Sealed beam lamps	12,000,000	13.0
	Other miniature lamps	130,000,000	14.9
High:	Sealed beam lamps	14,400,000	15.6
	Other miniature lamps	180,000,000	20.6

Note: This plant is assumed to have 4 sealed beam lamp machine groups and 15 miniature lamp machine groups. The low estimate assumes the 4 sealed beam groups to have production rates of 600 lamps per hour, and the 15 other miniature groups to have production rates of 2,000 lamps per hour. The medium estimate assumes that the 4 sealed beam groups produce 750 lamps per hour and that 10 of the 15 other groups produce 2,000 lamps per hour, and the 5 of the 15 groups produce 2,500 per hour. The high estimate assumes the 4 sealed beam groups have production rates of 900 lamps per hour, and the 15 groups have rates of 3,000 lamps per hour.

[1] This assumes an 80-hour and a 50-week year.

Sources: Baddalex, Ltd.; and U.S. Dept. of Commerce, Bureau of the Census, Current Industrial Reports Series MQ36P(74)-5 Electric Lamps Summary for 1974, Washington, D.C., 1975.

TABLE III-15

Hypothetical Plant-Justified Four-Firm Concentration Ratios in Large Incandescent, Miniature, and Fluorescent Lamp Sector

Type of lamp	Concentration ratios in production (percent)
Large Incandescent	46.2 - 64.1
Fluorescent	66.5 - 100.0
Sealed Beam Miniature	41.6 - 62.4
Other Miniature	55.2 - 84.2

Sources: Tables IV-11, IV-12, and IV-13.

lamp sectors if each of the top four firms in each sector operated one plant such as those described in tables III-12, III-13, and III-14. But these sectors would probably not be as concentrated as they actually were in 1972. Large scale production in any one or even a few sectors could not explain the present concentration ratio in SIC Group 3641, however. First, although a firm with an efficient plant would have to produce a substantial share of the output in one sector such as large incandescent lamps, it would not have to produce a substantial portion of the output of other types of lamps. But with the exception of automotive lamps, the same firms dominate all the subsectors of the lamp industry. This may suggest some economies to diversification within the lamp industry.

The second and more important problem with attributing present concentration merely to plant economies is that the potential entrant entering with a limited line of lamps might not build plants as large as those described above. The plants described above are typical of the plants in which most lamps are produced, but a firm could enter specialty markets on a smaller scale. In fact, both North American Philips and Durotest operate with plants much smaller than the ones described.

The third problem associated with using the above estimate of plant-justified concentration is that, at present, even the largest firms do not totally depend on such large plants for all their production. The seven largest lampmakers operate 37 lamp assembly plants in the large incandescent, miniature, and fluorescent lamp sectors. Studebaker Worthington, General Motors, and Durotest each operate more than one plant.

Another possible reason for the variety of plant volumes and sizes is that there is a great variety of lamp types. Different types of lamps may require different plant sizes. Furthermore, specialty items or low volume lamps may require different size plants than do other items. The evidence of variety in machine group production rates would seem to suggest this. One explanation for this size dispersion is that the cost penalty from operating a smaller than optimal size plant is not very great. In an industry with high profits and the implied high prices, it is possible for both large and small firms to operate such plants at a profit. Also many of these plants may have been built when supply and demand conditions were different. At present, however, it may still be optimal to produce from these plants rather than build new ones since the equipment depreciates slowly.

5. Multiplant Economies

Given the multiplant character of the largest lamp firms, the possibility of multiplant economies cannot be overlooked. Two questions must be answered: first, are there economies for the firm in producing one type of lamp in more than one plant? Second, are there economies in producing a number of different lamps in more than one plant?

At present, evidence on multiplant economies in lamps is scanty or nonexistent. This is a reflection of the lack of public data on the lamp industry and a lack of theory and research on multiplant economies in general. The major facts we have on multiplant operations in the lamp industry are that they exist and that they are extensive.[1] Just why they exist and what the consequences are is not clear. In the one major general study on multiplant economies, F. M. Scherer et al., list eight possible sources of multiplant economies.[2] Some may be relevant to the lamp industry.

First, the selling and promotional advantage of one firm may be so great that a multiplant operation is necessary to meet the demand for its products. This could be the case with General Electric. Household consumers appear to prefer General Electric lamps, and such preference could at least partially explain some of General Electric's multiplant operation.

Second, economies of obtaining capital could confer an advantage upon a multiplant firm. Large multiplant firms may appear less risky to investors and, accordingly, may find capital easier to obtain than do small single-plant firms. But this does not necessarily mean that multiplant operations within the same industry give large firms an advantage. Large conglomerate firms, like General Electric, GTE Sylvania, and Westinghouse, may have an advantage in obtaining capital due to their overall size, but the overall size is only partly explained by their high

---

1 See tables III-4 and III-6.

2 F. M. Scherer, Alan Beckenstein, Erich Kaufer, and Richard D. Murphy, The Economics of Multiplant Operation: An International Comparison Study (Cambridge: Harvard University Press, 1975).

market shares in lamps. Given equal earning prospects, a large conglomerate firm with a small market share in lamps, such as North American Philips, should encounter the same cost of capital in lamp production as General Electric or GTE Sylvania.

Third, multiplant economies may arise through vertical integration. In the procurement of bulb sleeves, all the firms except General Electric face a monopolist with a considerable scale advantage. If another lamp firm were to integrate vertically into bulb sleeves, it would need to produce a considerable volume of lamps.

For example, the General Electric Pitney works has three ribbon machines.[1] Producing bulb sleeves for household lamps, the largest single sector, a three-machine plant could supply 66 high volume lamp assembly machine groups, each making 3,000 lamps per hour. With an 80-hour week and a 50-week year, a firm with such a plant could produce 792 million bulb sleeves a year--about 54 percent of the total large incandescent production for 1974. Due to the problems of coordination and labor supply in a given area, it is unlikely that 66 groups would be most economically placed in one plant.

There may be economies from spreading central staff over multiplant operations in the lamp industry. Among the economies are those of massed reserves when the need for staff service

---

1 There are economies to putting more than one ribbon machine in the same plant. The most important is the scale economies associated with a larger glass oven.

fluctuates randomly over time and those of a richer division of labor, allowing greater use of specialists.[1] Both of the foregoing economies appear to be relevant in the lamp industry. Economies of massed reserves may be important in the industry since it employs a group of occupational specialties not employed in other industrial sectors. Among these occupations are illuminating engineers, lighting salesmen, and lamp production engineers. The production of lamps employs a combination of gas flames and high speed indexing machinery that is used in almost no other industry.[2] Therefore, specialists in these areas can sell their services only to lamp manufacturing firms. A single-plant lamp manufacturer may not be able to make full-time use of such a specialist and, therefore, may be at a disadvantage when competing with a multiplant lamp manufacturer able to employ specialized personnel.

Economies from specialization may be important in the lamp industry because of the importance of research and development. Historically, General Electric has been the technological leader in both product development and production innovation.[3] It is questionable whether smaller firms could support an R&D program on a scale similar to that of General Electric. Without

---

1 F. M. Scherer et al., op. cit., p. 321.

2 Similar technology is used to make radio vacuum tubes, but that seems to be a dying industry.

3 In recent decades, however, GTE Sylvania may have assumed the lead in the development of production machinery.

the support of a multiplant operation such as General Electric, it is doubtful that various large, specialized research programs on lamps and lighting would be undertaken in the private sector. Consequently, a multiplant, multiproduct firm is perhaps needed to support large scale R&D efforts.

The product-line diversification of the large firms can also be explained by some of the same economies associated with multi-plant operation. Many inputs are common to all types of lamps. Tungsten wire is used for filaments or electrodes in almost all lamps. Glass tubing is used for the stems of all lamps and for the fabrication of bulb sleeves for fluorescent and most miniature lamps. Similar types of bases are used in a wide variety of lamps. Given economies of scale in some of these components, it is quite conceivable that a firm would have to offer a wide range of products to justify the in-house production of the parts. Without in-house production of these components, a firm is at present dependent on one of the three large lamp producers, plus Corning Glassworks for glass items.

Specialized personnel can be used to produce all or many types of lamps. The combination of glass bonding by gas flame and the use of indexing machinery is found in almost all lamp production. Experts in the production of one type of lamp can be employed in the manufacture of another type. In fact, the production machinery for the newer lamp types, such as flourescent and high-intensity metal vapor lamps, was developed by personnel with experience in incandescent lamp manufacturing.

In marketing, illumination engineers and salesmen must often choose between different types of lamps to achieve optimal lighting results. In order to employ these people fully, a firm may have to produce a wide range of lamps.

Finally, the sales volume required to cover research and development may imply that a firm must sell a wide range of lamp types. Moreover, a successful R&D program may lead firms into the manufacture of other lamp types. The fluorescent lamp was developed by General Electric, and much of the earlier work on high-intensity metal vapor lamps was done by Westinghouse. Consequently, the R&D effort may both lead to and result from multilamp firms. The result is probably in the consumers' interest. In lamp market segments (such as sealed beam lamps or photographic lamps), where some of the large lamp firms do not participate, the price policy of the present firms is constrained by the potential entry of the other large lampmakers. Moreover, the freedom to expand into other lamp market segments is a strong incentive for R&D effort.

6. Lamp Distribution

There appear to be no significant entry barriers connected with lamp distribution other than on the apparent preference of consumers for General Electric lamps (discussed below). It is true that large conglomerate firms such as General Electric, GTE Sylvania, Westinghouse, and North American Philips have nationwide warehousing systems. It is also true that their warehousing overhead can be spread over a number of products other than lamps. There are, however, numerous independent distributors who would be willing to handle a successful new company's lamps. And there are also buyers who are constantly looking for new sellers in order to lessen their dependence on the established firms.

7. Summary

Scale economies appear to be fairly significant in the lamp industry. A plant producing over 10 percent of the output appears to be necessary for entry at the minimum optimal scale in most high volume lamp sectors. Yet, low volume specialty items are often made by small firms. The potential for these small firms to expand into high volume items somewhat attenuates the market power of the larger firms, but the Big Three probably still have wide latitude in pricing. Overhead spreading of management, engineering, R&D, and captive input production resources probably explain the extent of multiplant operations, but it is not known whether the high degree of multiplant operations exhibited by the existing firms is necessary to achieve such economies.

E. Product Differentiation

The lamp industry sells its output to two general classes of buyers: industrial and governmental customers and household consumers. The two groups can be expected to exhibit different purchasing behavior. Whereas industrial and governmental customers are likely to use purchasing agents who carefully consider lamp specifications and prices, household consumers are likely to find that the cost of gathering such information exceeds the benefits. Lamps constitute a small part of the typical consumer's expenditures. Indeed, the per capita value of shipments for the incandescent sector was $1.85 in 1974.[1] Where items account for a small portion of a household budget, economic theories of information predict that limited search will take place.

Limited consumer search may have led to a product differentiation advantage for certain firms, and it also may have led to a system of distribution, which enhances the profits of lamp manufacturers and retailers.

Because of the tendency of consumers to rely on past experience and reputation General Electric has at least a limited product differentiation advantage. Due to innovations and patents, due to a probably misguided antitrust decision (discussed below) and also undoubtedly due to its product quality, General Electric developed an early lead in incandescent lamp manufacturing. Over the years, General Electric's major patents have expired, and its competitors have developed lamps of equal or nearly equal quality. But industry experts note that General Electric continues to dominate the household consumer market. During interviews, three Washington, D.C. chain stores, Safeway,

---

1 It must be realized that the value of shipments is actually less than what the consumer paid for lamps due to the middleman's markup. In 1976, the gross margin in the supermarket sector, where most of the lamps are sold to consumers, was about 55 percent of the retail price of the lamps. Since the bulk of the lamps bought by consumers are incandescent, the analysis in this section mainly pertains to them.

Lucky, and Grand Union, stated explicitly that consumer brand loyalty to General Electric was the reason they would not privately label light bulbs. At that time, the wholesale price of General Electric lamps to retailers was higher than that of most other lamps, especially privately labeled lamps. This higher price for the national brand is evidence of recognition by the manufacturer that the demand for the national brand is greater than that for the private label.

A survey of retail lamp prices in eight stores in the Washington, D.C. area demonstrated that General Electric's lamps do sell for higher prices.[1] With a two-way analysis of variance to adjust for certain qualitative differences, the price of General Electric's lamp was found to be significantly higher than those of other lamps.[2] Since it might be asserted that

---

1 The stores in the survey are Townhouse Food Store (part of Safeway), 2060 "L" St., N.W., Washington, D.C.; Dart Drug, 1200 19th St., N.W., Washington, D.C.; Peoples Drug, 7th and Pennsylvania Ave., S.E., Washington, D.C.; S.S. Kresge, 666 Pennsylvania Ave., S.E., Washington, D.C.; Sears, Roebuck and Co., 2800 Wilson Blvd., Arlington, Va.; Safeway Stores, Inc., 3713 Lee Highway, Arlington, Va.; and Cherrydale Hardware, 3805 Lee Highway, Arlington, Va. Although this sample is not random by population, income level, or lamp sales, it does represent a wide selection of different types of outlets, and the stores are located in areas with differing income levels.

2 A two-way analysis of variance was used in order to allow for differences in lamp qualities. The three qualitative categories used were white light, long life, and ordinary frosted lamps. When the analysis was done, an F value of 8.67 was found for the difference in the prices of the different types of lamps and an F value of 13.65 was found for the differences in price between General Electric and other companies' lamps. There were 16 observations in the sample. The findings were statistically significant at the .05 level.

the lamps of GTE Sylvania and Westinghouse have as much consumer acceptance as the General Electric lamps, the smaller firms were eliminated from the sample, and another test was made. Again, the price of the General Electric lamps was found to be significantly higher than the price of other lamps.[1, 2]

A further result of high consumer search cost may have been to facilitate cooperation between the large manufacturers and retailers so as to develop a system whereby they both enjoy high profit margins. Robert Steiner of the University of Cincinnati and the Federal Trade Commission hypothesizes that the large manufacturers have been able to prevent other smaller firms from penetrating the consumer market by allowing stores a large retail margin.[3] In 1976, the margin for lamps was 55 percent of

---

1 The F values in this sample were 27.06 for the price difference between the types of lamps and 15.88 for the difference between companies but there were only 10 observations. The findings was statistically significant at the .05 level.

2 Other evidence shows that while brand loyalty does exist in lamps, it is weak. A survey conducted by Charter Publishing Company shows that 9 percent of a sample of women shoppers were guided by brand selection in choosing the store where they brought lamps and electrical accessories. Therefore, while some people based their store selection on brand, more did not. Almost half, 48 percent, choose the stores where they bought lamps on the basis of convenience. Consequently, while a brand preference does seem to exist, it is limited. See Charter Publishing Company, Charter Publishing Company's 1978 Redbook Study of General Merchandise Purchasing Fourth Annual Survey of Consumer Attitudes and Actions, (New York, N.Y.: Charter Publishing Company, 1978).

3 This analysis is developed in the forthcoming book, Robert L. Steiner, Brand Advertising and the Consumer Goods Economy, (Washington, D.C.: American Enterprise Institute for Public Policy Research, 1980).

retail price, the third highest margin in the non-food part of the grocery stores.[1] An interaction between high search costs, low demand elasticity, and exclusive distribution may underlie the apparent success of this system.

F. Chapter Summary

Economies of scale combined with the favorable consumer acceptance of one firm's product, combined with a peculiar relationship with retailers have led to a four-firm concentration level of almost 90 percent in the lamp industry. Although plant economies may present rather substantial entry barriers, it seems doubtful that they alone could lead to such high concentration. It is possible that multiplant economies are important in this industry. But evidence also indicates that some of the concentration is probably accounted for by General Electric's product differentiation advantage and its position with the large consumer lamp retailers.

---

1 Chain Store Age/Supermarkets, July 1977, p. 320. The two items with higher margins were Sewing Notions and Holiday Supplies which had much smaller volumes than did lamps. Certainly with the latter, special inventory problems exist due to seasonality.

CHAPTER IV

Conduct

A. Introduction

This chapter first discusses the conduct that led to the four major antitrust cases in the history of the lamp industry as well as the results of these cases.[1] It then turns to the subject of innovative conduct by focusing on the introduction of the fluorescent lamp. The behavior of the various companies sheds insight into the problems of achieving optimal technological progress in a concentrated industry.

B. The 1911 General Electric Case

Although it is the least written about, the 1911 General Electric case may have had the most significant long-term impact on competition.[2] The Government's charges were numerous:

> The subsidiary relation of National to General Electric, notwithstanding which it was represented to the public as a competing organization, was impugned by the government. The price-fixing and market-sharing agreements with Westinghouse, with National, with the members of the Incandescent Lamp Manufacturers Association, and with other lamp producers were attacked as

---

1 See U.S. v General Electric Co., (1911) 1 D&J 267; U.S. v General Electric Co., U.S. 476 (1926); U.S. v General Electric Co., 82 F. Supp. 753 (1949); and U.S. v General Electric Co., 1973 Trade Cases 1974, (New York: Commerce Clearing House, Inc., 1974, p. 74942)

2 One authority stated that "the 1911 antitrust action did not significantly change the situation in the American lamp industry." A. A. Bright, op. cit., p. 159. This writer disagrees.

> tantalum, and tungsten lamps were rapidly replacing the ordinary carbon lamp, an open market for carbon lamps was not of much importance. . . .[1]

Consequently, General Electric was to continue its dominance of the industry through control of the tungsten lamp. But the provision that may have had the most important impact upon the future of the lamp industry was an order directing General Electric to incorporate the National Lamp Company into its lamp division. The decision was probably anticompetitive.

The Government contended that General Electric "had combined and conspired to restrain commerce by concealed stock ownership of bogus independent companies. . . ."[2] Although General Electric and National Lamp often conspired to fix prices and a spirit of cooperation existed between them, there is evidence that National Lamp would have been able to survive in open competition with General Electric.[3] The evidence can be

---

1 Ibid., p. 158.

2 Commerce Clearing House, Inc., The Federal Antitrust: With Summary of Cases Instituted by the United States, 1890-1951 (Commerce Clearing House, Inc., 1952,) p. 86.

3 By ordering the merger, the decree increased nominal concentration level in the lamp industry. The Herfindahl index was increased from 33.9 to 65.7. The table below shows the market shares of the leading firms before and after the decree.

Before		After	
Company	Market share	Company	Market share
General Electric	43%	General Electric	80%
National Lamp	37	Westinghouse	13
Westinghouse	13	All Others	7
All Others	7		

> restraining trade. The pyramiding of patents on improvements in machinery and production processes as well as on detail improvements in lamp design and on improvements in filament materials was alleged to maintain for General Electric and its group a substantial monopoly of the carbon-filament lamp after the basic patent on it had expired. It was also charged that the acquisition of patents by General Electric and National was illegally suppressing competition in tantalum and tungsten lamps. In addition, the dealer contracts tying the distribution of carbon lamps to the new metallic-filament lamps were attacked. The practice of requiring prices fixed by General Electric to be maintained to the retail level for both carbon and metal-filament lamps was also complained of as a restraint of trade, as were the preferential agreements which had been made with the glass, base, and machinery manufacturers.[1]

Even though the Government had a strong case, the companies decided to litigate. Later, however, the companies entered into a consent decree enjoining General Electric and the other firms from the following practices: exclusive dealing arrangements with machinery makers, fixing retail and wholesale prices, allowing price differences not based on quality, tying agreements for different types of lamps, tying agreements on discounts and patents, predatory price discrimination, and resale price maintenance.

The decree did little to lessen General Electric's patent control of the metal filament lamps. A. A. Bright states:

> . . . Moreover, the decree expressly stated that patent licenses might specify any prices, terms, and conditions of sale desired, although they could not fix resale prices. That permission left an enormous opening for continued control over the incandescent-lamp industry by General Electric, and the industry leader took full advantage of it in later years. Since the GEM,

---

1 _Ibid._, pp. 156, 157.

divided into two categories: evidence from events before the 1911 decree and evidence from the resources held by National Lamp in 1911.

As noted earlier, National Lamp was founded by a group of small firms in order to pool overhead costs such as research, engineering, and marketing. Events before 1911 seem to demonstrate that National Lamp could have survived without General Electric support or cooperation. Even though General Electric had majority control and National Lamp did cooperate with the larger firm, National Lamp was run independently.

From 1901 to 1911, entry barriers to the industry were low because the manufacturing process was essentially characterized by handicrafts and no important patents were in effect on carbon filament lamps. Therefore, several small firms were able to exist. While General Electric held onto the largest market share, it still had to contend with the smaller firms. The marketing, engineering, and research facilities at National Lamp were of considerable help to the firms affiliated with National.

Apparently, General Electric considered an investment in National Lamp more profitable than an investment in expanding its own lamp facilities to obtain a larger market share. The expected investment return would have been predicated to some extent on a degree of cooperation between General Electric and National Lamp on prices and product development. Nevertheless, this cooperation certainly would have been open to National Lamp had someone else financed them because it was in General Electric's interest to mitigate competition. The fact that General Electric itself financed National Lamp is alone evidence of National's viability under pre-decree conditions because no one understood better than General Electric the requirements of success in the lamp business.

National Lamp Company's resources in 1911 were such that it is apparent the firm could have survived in competition with General Electric and the other lamp manufacturers. These resources were three types: management personnel, physical plants, and claims on patent and research assets.

That the management personnel at National Lamp were good can be seen from their subsequent careers within General Electric. General Electric ran National Lamp as a separate division until 1926, and they kept the same management. The founders of National Lamp, F. S. Terry and B. G. Termaine, remained more or less in control of the National Lamp Division under General Electric tutelage until its consolidation into the other lamp division. Terry closed his career as General Electric vice president, and Termaine, as a member of the Board of Directors. After 1925, when one consolidated lamp division was established, the first two managers of that division, T. W. French (1926-34) and Joseph E. Kernley (1934-45), were former National Lamp personnel. Apparently, rather than being a "bogus" firm, National Lamp had such good management that General Electric ran it as a unit until 1926, and even when it was consolidated into the General Electric Lamp Division, its managers continued to be very influential.

The major physical resources held by National Lamp in 1911 were the Nela Park Headquarters and Laboratory, its lamp plants, and the Providence Gas Burner Company. Since the latter was the principal (if not the only) maker of lamp bases in the country, the control that National had on the supply of bases certainly would have provided it with substantial bargaining power in negotiations for licenses on General Electric patents. And the lamp plants were important assets as well. General Electric continued to use many of the National Lamp plants for years after the consolidation, two of them still being in operation. And in 1926, the General Electric Lamp Division chose the Nela Park site orginally built by National Lamp as the location for its own headquarters.

National Lamp's research and patent position in 1911 was not weak. National Lamp had a 40 percent interest in the Just and Hanaman patent on tungsten filament lamps. And while Coolidge was developing a method of extruding ductile tungsten in the General Electric laboratory, T. W. French and others at National Lamp were also working on drawn wire tungsten.[1] In fact, many of the personnel who subsequently developed the General

---

[1] See P. W. Keating, Lamps for a Brighter America, (New York: McGraw Hill Book Company, Inc., 1954), p. 81.

Electric research and patent position were originally National employees. Notable among them was Aladar Pacz, the inventor of non-sag tungsten filaments. While at National Lamp in 1906, he developed a tungsten filament suitable for use in physically small miniature lamps. With the Nela Park Laboratory, National Lamp would have been in a good bargaining position for General Electric patents.

Even if General Electric's patent position were superior to that of National Lamp, it still might have been in General Electric's interest to license National Lamp for those patents. Because other firms often have lower production costs,[1] a patentee may choose to license other firms as a means of maximizing its own income. The fact that General Electric licensed its lamp patents to Westinghouse and a number of other firms lends credence to the assertion that it would have licensed National Lamp.

The contention of the previous paragraphs is that National Lamp could have been a viable competitor to General Electric and Westinghouse, and that the Court could have lessened concentration by having General Electric divest its interests in National Lamp. Whether that would actually have increased competition cannot be known, but it is possible that after the various patents had expired, four, rather than three, large, wide-line,

---

1 See R. A. Posner, Antitrust Cases, Economic Notes, and Other Material (St. Paul: West Publishing Company, 1974), p. 286-288.

lamp competitors would have emerged. In any case, it is ironic that in the year 1911 when the judicial system broke up the Standard Oil and tobacco trusts, it not only sanctioned, but also ordered the merger of the two largest firms in the lamp industry.

C. The 1926 General Electric Case

The 1926 antitrust case evolved out of an investigation initiated at the request of General Electric to clarify the legality of its consignment and licensing systems. The Justice Department charged that General Electric's distribution system was an illegal form of resale price maintenance and that the lamp patent license granted by General Electric to Westinghouse was an illegal form of price fixing. General Electric, which retained title to its lamps until they were in the hands of the final consumer replied that "it had the legal right to market its lamps and pass them directly to the consumer by such agents."[1] General Electric also stated that it had the right to restrict its patent licenses. The District Court ruled in favor of General Electric, and the Government's appeal to the Supreme Court failed.

For two reasons, this is the most frequently cited antitrust case involving lamps. First, it set a precedent for other cases involving antitrust and patents. Second, the existence of resale price maintenance has puzzled many economists because it seems to

---

[1] United States vs General Electric Company, 272 U.S. 476 (1926), p. 193.

run counter to economic theory. Both of these issues created controversy among antitrust economists and lawyers.

Two questions have arisen surrounding General Electric's patent licensing agreements with Westinghouse. First, why did General Electric license Westinghouse (and for that matter the smaller firms) rather than manufacture the Nation's whole tungsten lamp output? Second, what was the purpose of the pricing restriction on the Westinghouse license?

Two not necessarily conflicting explanations have been given for General Electric's licensing of patents. The first one, given by R. A. Posner, is that Westinghouse was a lower cost producer than General Electric in some given segments of the market. Thus, General Electric could extract a higher rent for its patent rights by licensing Westinghouse to produce a given number of lamps than it could extract by manufacturing the lamps itself.[1] The second reason given for patent licensing in this case is that the patents were so weak that a challenge to them had a high probability of success. Therefore, General Electric may have decided to license the firm most likely to challenge its patents successfully.[2] Evidence for both of these hypotheses exists, but it is not conclusive.

---

1 See R. A. Posner, op. cit., p. 282.

2 Posner mentions this possibility in the above reference, but it is more fully developed in L. G. Telser, "Why Should Manufacturers Want Fair Trade?", Journal of Law and Economics, vol. III (October 1960), p. 86.

Starting with the Posner theory, the period under question was from 1912, when the ductile tungsten lamp came on the market, until 1926 when this antitrust case was adjudicated. In this period, great changes occurred in the lamp industry on both the supply and demand sides of the market. The total volume of the industry increased by 527 percent, from 90.8 million lamps in 1912, to 478.9 million lamps in 1926. And these years were years of substantial technological change. Machinery was being improved, and the group system was developed. The growing demand and technological progress led to a high level of uncertainty in the industry.

Even though General Electric was the technological leader, its future profitability was not certain. At the time it may have seemed possible that a continued hold on the entire tungsten lamp market could lead to significant diseconomies of scale. Because the company was a multiplant firm, some problems of communication and coordination must have existed. The company leaders could not foresee how these problems might increase with future growth. Two facts point to these problems. First, when National Lamp was merged with General Electric, it continued to operate as a separate division until 1926. Second, much emphasis was put on developing management personnel and management systems during this period.

General Electric may have felt that the returns from its patent would be more certain if it licensed smaller firms such as Westinghouse to make lamps. Since General Electric was already larger than Westinghouse, it would have had a clear idea of the smaller firm's cost situation. Therefore, even if General Electric patents had been legally invulnerable, licensing other firms to manufacture lamps may have been a rational policy given the situation of the industry during that period.

The patents, however, were not invulnerable. A number of firms challenged the General Electric patents, and many firms infringed on them. The three basic General Electric patents were the 1912 Just and Hanaman patent on tungsten lamps, the 1913 Coolidge patent on ductile tungsten, and the 1916 Langmuir patent on gas-filled lamps. General Electric pursued a large number of infringement cases.[1]

Besides these three basic patents, General Electric had a number of lesser patents which also involved the company in litigation. While no documentary evidence can be presented, it can be inferred that General Electric managers were aware of the weaknesses in their patents. For instance, they did know that T. W. French at National Lamp was working on ductile tungsten at the same time as Coolidge at General Electric.[2] At the time, it

---

1 In A. A. Bright, op. cit., pp. 264-280, some of this litigation is described.

2 T. W. French was, then, actually one of General Electric's managers.

may have seemed likely that someone else was working on it.[1] Therefore, a sound strategy might have been to forestall potential patent infringement suits by granting licenses. Also, the licensees may have had valuable patents or other assets to sell. As Telser says:

> Certainly with regard to the Westinghouse Electric Company there is little doubt that General Electric had a formidable rival. In its own right Westinghouse owned valuable and important patents and had an active research laboratory.[2]

Westinghouse also had access to legal resources comparable to those of General Electric. For smaller firms, such as Hygrade Sylvania Corporation and Consolidated Electric Lamp Company, this analysis would apply with less force because they did not have as many resources with which to bargain. And, in fact, the smaller firms received less favorable licensing terms than those of Westinghouse. In summary, it probably was uncertainty concerning, first, its own future production costs and, second, the viability of its patent position that led General Electric to license other firms to manufacture tungsten lamps.

The second question about the patent licensing agreements involved the price restrictions on the class A licensee. Westinghouse was constrained by its license to sell lamps at General Electric designated prices and to distribute them through

---

1 Subsequently, in 1929, the Coolidge patent was invalidated by the Supreme Court. Moreover, judicial interpretation of patent law was (and is) often hard to predict.

2 L. G. Telser, _op. cit._, p. 100.

the same type of consignment system as General Electric.[1] Westinghouse was also allocated a certain percentage of the market. Why did General Electric choose to regulate Westinghouse's prices and set its terms of sale instead of merely setting patent royalties that mandated certain given prices? This question is so intertwined with the problem of the General Electric consignment system that it is analyzed with the consignment system below.

The purpose and effect of the consignment system, the second aspect of the 1926 General Electric case, has been discussed by many writers. Before going into the various possible explanations for this behavior, a short historical review is in order.

The 1911 antitrust suit against General Electric enjoined the firm from the practice of resale price maintenance on lamps. In 1912, General Electric developed a consignment system whereby its sales were segmented into three classes. The first class involved sales to large lamp consumers such as industrial or commercial firms and governments with which General Electric negotiated directly. The second class involved sales by the company to other large consumers through distributors called class B agents. The lamps were actually owned by the company until sold by the class B agents. The company designated the

---

1 The class B licensees, on the other hand, were allowed to set their own prices and terms of sale, but they were allocated a certain percentage of the market, and they had to pay General Electric higher license fees on lamp sales over their quotas.

price and terms of the sales. In some cases it negotiated directly with the large consumer, ordering a class B agent to deliver the lamps from its inventory.

The third class involved sales through class A agents to the small consumers. These agents were retail outlets, and the lamps were owned by the manufacturer until they were sold to the consumer. Class B agents were sometimes required to supply the class A agents, the former agents being compensated for their services to the company. The result was similar to distributing lamps through agents under resale price maintenance contracts.

In most circumstances retail price maintenance seems perverse from a profit maximizing viewpoint. If one assumes that a firm has some ability to price monopolistically at one stage of integration, it does not benefit from monopolistic pricing at a stage of integration closer to the consumer. If the distributors had the power to price monopolistically, then the manufacturer's output would be further restricted. It would seem in the manufacturer's interest "that these middlemen . . . should sell as cheaply as possible, and advertise as much as possible their cheap sales."[1] Therefore, it seems odd that the manufacturer would advocate resale price maintenance or set up a consignment system whereby prices at the retail level would be set by the manufacturer.

---

[1] F. W. Taussig, "Price Maintenance," <u>6 American Economic Review Suppl.</u>, p. 170 (1916).

The explanations given for this behavior fall under three different, but not contradictory, categories: the service argument, the cartel argument, and the price discrimination argument. The service argument postulates that under certain conditions, a manufacturer's profits are maximized when the distributors or retailers provide a certain level of service. In order to assure the level of service, the manufacturer specifies to the retailer the price at which the item will be sold in the store, thereby setting the retailer's margin. The result can be brought about through either a resale price maintenance scheme or a consignment system.

The scheme or system could be desirable under certain circumstances. When a manufacturer introduces a new product or sells a product that is bought only occasionally, it would be useful for the retailers to educate the consumers on the uses and advantages of the product. Therefore, the manufacturer may desire distributors to obtain on their sales a margin large enough to support the provision of these services. Once the consumers are educated, it is also necessary to prevent low-margin, low price retailers from luring business away from the high service firms. Because, except in the early history of the industry, household lamps were items familiar to consumers, this explanation does not seem applicable to the lamp industry.

Similarly, the consignment scheme can be used to assure a proper level of retailing service for a given product. Since the manufacturer may know best how to merchandise a given product, it may use devices such as a consignment system to maintain control over a product until it is sold. The control may involve such areas as advertising and shelf displays. Often the manufacturer desires to operate a coordinated national advertising campaign. It is plausible that this problem at least partially motivated General Electric.[1]

The second argument set forth to explain the consignment system or other forms of resale price maintenance is the cartel argument.[2] In all cartels, each member has mixed incentives. On the one hand, if the other firms maintain the going price, it is in the interest of each member to shave prices to some customers. On the other hand, if all firms lower prices to entice customers, the profits of all members decline. If the process continues, the result is a competitive equilibrium. Consequently, the major problem faced by a cartel is the prevention of price shaving. In order for a cartel to survive, a method must be developed to enforce the cartel price. Enforcement has to involve two activities: detection and retaliation. If price shaving is to be prevented, it must be detected, and then, sanctions must be taken against violators.

---

1 These ideas are most clearly set forth in Ward S. Bowman, Jr., Patent and Antitrust Law: A Legal and Economic Appraisal, (Chicago: University of Chicago Press, 1973), pp. 131-139.

2 The major advocate of this position is L. G. Telser. See L. G. Telser, op. cit., p. 86.

Telser argues that the combination of the patent licensing and consignment systems adhered to by General Electric and Westinghouse provided a means of solving both of these problems. First, the agreement certainly lessened the problem of detecting Westinghouse cheating. Under the patent licensing agreement, Westinghouse had to reveal to General Electric its prices and market share, the former being set by the agreement. The consignment system made it difficult for General Electric to cheat without being detected by Westinghouse. Under the consignment agreement, no distributor or retailer could be a consignee of both firms. Therefore, if General Electric attempted to gain extra business from a Westinghouse consignee, the consignee would have to switch his total lamp business from one firm to the other. Any price shaving by either firm would become obvious to the other. Also, the fact that retail prices were set by the manufacturer somewhat attentuated the incentive of retailers to cooperate with a price shaving firm. With retail price already set, the retailer could enjoy an increased return only on his original volume and could not increase his sales by lowering prices.

Other features of the licensing agreement provided a means to enforce a cartel agreement through the consignment system. The penalty system for producing over the quota decreased the incentive for Westinghouse to increase its market share. The license itself provided an enforcement device since General Electric had the option of suing Westinghouse or withdrawing its license if Westinghouse did not behave as specified. Nonetheless, the relatively strong patent position and legal resources of Westinghouse acted to restrain General Electric's behavior. With the consignment system, Westinghouse could monitor General Electric lamp prices. In fact, Telser stated, ". . . the entire system of distribution is a confession of weakness on the part of General Electric."[1] Before accepting the Telser theory, however, one should consider the possibility that other motives for the consignment system existed.

A third and probably more convincing theory concerning the consignment system involves price discrimination. The lamp manufacturers sell lamps to a variety of customers, and it is possible that the elasticities of demand among classes of users vary widely. If a system of market segmentation could be developed, a firm could increase its return significantly by charging different customers different prices.

That the demand elasticities of the lamp customers do vary can be inferred from certain facts. At the present time, the lamp companies give substantial discounts to large users, and it seems likely that the practice of discounting large quantities has a long history. Early in its history, General Electric developed an intensive advertising campaign for its lamps. The Mazda trademark was adopted and licensed to Westinghouse. Whereas the household consumer may have been favorably disposed

---

[1] Ibid., p. 101.

to purchase General Electric or Westinghouse Mazda lamps, the large buyer could make his own quality tests and buy the lamps that fitted his needs. Consequently, the large buyer might have been more likely to buy lamps from the small licensed or unlicensed manufacturers.[1]

If demand elasticities do differ, it would have been to the advantage of General Electric and Westinghouse to find a means by which to segment the markets. Certain features of the General Electric consignment system seem designed to have brought about such segmentation. The company dealt with large users either through its own employees or through class B agents. Therefore, it was able to monitor closely the lamps going to large customers.

The large customers and class B agents could not sell or distribute lamps to other distributors or users without the manufacturer's consent. Consequently, the class A agents, the retail outlets, had to obtain their supply of lamps from General Electric and its class B agents. With the household segment of the market segregated from the large user segment, General Electric and Westinghouse could charge different prices for their products to different buyers and obtain the additional profit this system entails. The Supreme Court seems to have accepted

---

[1] In fact, the class B patent licenses to small lamp firms allowed them to set their own prices and terms of trade. These firms undoubtedly dealt mainly with large customers, and they were not a large factor in the household customer market.

the price discrimination theory. Chief Justice William Howard Taft stated:

> ... The plan was, of course, devised for the purpose of enabling the company to deal directly with consumers and purchasers, and doubtless was intended to avoid selling the lamps owned by the company to jobbers or dealers and prevent sale by these middlemen to consumers at different and competing prices.[1]

The plan prevented middlemen from brokering the lamps, thereby allowing General Electric and its licensee to price discriminate.

Although elements of all three explanations of resale price maintenance and the consignment system may have had some relevance in this case, it seems that price discrimination might have provided the strongest motivation. In the end, the Court dismissed the Government's case, stating that both the Westinghouse licensing agreements and the consignment system were legal mechanisms for General Electric to obtain the maximum revenue from its patents.

> The owner of an article patented or otherwise is not violating the common law or the Anti-Trust Act by seeking to dispose of his articles directly to the consumer and fixing the price by which his agents transfer the title from him directly to such consumer.[2]

D. The Antitrust Cases in the 1940's

In the 1940's, the Government brought two lamp antitrust suits: one involving incandescent lamps and one involving

---

[1] United States vs General Electric Company, 272 U.S. 476 (1926), p. 194.

[2] Ibid., p. 196.

fluorescent lamps.[1] The former was easily the most complex and comprehensive case brought in the history of the lamp industry. In this section, the substance of these cases is described, and their long run impact is analyzed.

In the first case, the Department of Justice filed suit against General Electric and eight other firms with which General Electric had allegedly anticompetitive agreements. The other firms included International General Electric Company, Inc.,[2] N. V. Philips,[3] Westinghouse, Sylvania, Consolidated Electric Lamp Company, Chicago Miniature Lamp Works, Tung-Sol Electric Lamp Works, Inc.,[4] and Corning Glassworks. The Government's complaint can be subdivided into six allegations: input monopolies, patent licensing and pooling, the agency consignment system, foreign agreements, trademarks, and quality control.[5]

The Government claimed that General Electric used patents and licensing agreements to monopolize the following inputs:

---

1 United States vs General Electric Company, 82 F. Supp. 753; and United States vs General Electric Company, No. 2590 (D.N.J.), June 30, 1954.

2 The international arm of General Electric.

3 N. V. Philips is a Dutch firm manufacturing lamps and other electrical equipment; it is the largest lamp manufacturer in Europe.

4 Tung-Sol Electric is the predecessor firm to Studebaker Worthington in auto lamps.

5 See United States vs General Electric Company, 82 F Suppl. 753, p. 779-799.

lamp machinery, glass machinery and products, lamp bases and base machinery, filaments, lead-in wires, and lamp patents. Stating that a dominant position was not necessarily monopoly, the Court dismissed all of the charges under this heading except those related to glass products and lamp base parts.

In lamp glass products the Court held that General Electric and Corning Glassworks had illegally attained complete market control by pooling patents and knowledge between themselves and N.V. Philips and the American Blank Company, a dummy corporation.[1] Similarly, the Court held that General Electric had monopolized the lamp base market through illegal patent pooling.

The last General Electric input monopoly posited by the Government was in lamp patents. The Government claimed that General Electric perpetuated its dominance of the industry through patent pooling with its licensees. The Court upheld the Government's contentions and developed a remedy described below.

The second group of Government assertions concerned the patent licensing system set up by General Electric. The Justice Department claimed that these agreements eliminated competition between General Electric and the other firms. Although the Supreme Court had upheld a General Electric Westinghouse licensing agreement in 1926, the Government contended and the Court agreed that the decision applied only to patents in effect

---

1 The American Blank Company was essentially a patent licensing firm.

at that time. The Government found most reprehensible the part of the agreement that provided that Westinghouse use the same distribution system as General Electric. Given similar distribution practices, it seemed apparent to the Government that this system could further facilitate collusion. The Court found the evidence for this assertion compelling and declared the agreement illegal.

Class B licenses were also attacked.[1] The major provisions of the class B patent licensing agreements were: (1) that the companies pool their patents, (2) that the licensees' production be restricted to quotas (usually percentages of General Electric sales), (3) that the licensees not sell the lamp parts or machinery used under license from General Electric, and (4) that the licensees not use the GE and Mazda labels.

The five type B licensees were also restricted to a particular type of lamp: Sylvania, Ken Rad (formerly Kentucky Electric Lamp Company), and Consolidated were licensed to make large incandescent lamps, and Tung-Sol and Chicago Miniature Lamp were licensed to make miniature incandescent lamps. It was also specified that the lamps made under these licenses could not be exported.[2] While the licensing agreements did not specify

---

1 The license arrangement for Westinghouse was referred to as class A. The arrangement for other companies was designated class B.

2 This provision had considerable relevance to the Government's allegations with respect to the international lamp market.

any price rules, General Electric had some control over prices through production quotas. At the same time, the licensing system solved both the perpetual cartel problems. General Electric could not only detect price cutting, it could also impose penalties upon the licensees who exceeded their quotas. Moreover, General Electric had the right to withdraw the license. Therefore, as with the Westinghouse agreement, the class B licensing agreements served to facilitate the working of a cartel.[1] The evidence presented by the Government convinced the Court that class B licenses were in violation of the Sherman Act.

The Government further asserted that General Electric violated the Sherman Antitrust Act in its relationship with foreign lamp firms. Specifically, the Justice Department contention consisted of two allegations: first, that General Electric tried to prevent the importation of lamps and the purchase by domestic firms of foreign lamp parts; and second, that the firm tried to acquire important foreign patents for the patent pool.

From the beginning of the lamp industry, General Electric and the major foreign companies had participated in licensing agreements. These agreements often included provisions that would restrict commerce. In 1924, International General Electric and the other major European manufacturers organized Phoebus S. A. Phoebus was a Swiss firm whose functions included the ". . . exchange of patents and technical information, and the

---

1 See page 115 above.

division of markets."[1,2] Although the overseas subsidiaries of General Electric participated in this cartel, the American General Electric remained aloof. Nevertheless, Phoebus member firms did not sell lamps in the United States and Canada where the American General Electric Company dominated. Therefore, through the sanctions of Phoebus and the various licensing agreements, this cartel controlled the bulk of the world's lamp output. The Court found that the cartel and General Electric's patent agreements with the cartel had restricted competition in the United States.

The Government also claimed that General Electric used the trademark, Mazda, to restrict competition. First, General Electric allowed only itself and Westinghouse to use the trademark; and second, the firm persuaded large lamp purchasers such as local governments and public utilities[3] to specify in their bid invitations that the lamps must be "Mazda types." The General Electric attorneys stated that the Mazda lamps were lamps made to certain quality specifications and that these specifications were the result of a program of research and development

---

1 G. W. Stocking and M. W. Watkins, Cartels in Action (New York: Twentieth Century Fund), p. 335.

2 The world was divided into three territories: the home territories, where only the native firm could sell lamps; the British Overseas Territories, where the British firms shared the markets with International General Electric and some other European firms; and common territories, where all firms were allowed to sell, usually on a quota basis.

3 Until recently, many electrical utilities provided lamps to their household customers upon demand.

generating information on the art of incandescent lamp manufacture. Only lamps meeting certain standards were eligible to bear the "Mazda" mark. General Electric further contended that it had the right to sell or not to sell the results of its research to anyone. The Court, while agreeing that the company expended much money on research and development, maintained that General Electric attempts to persuade lamp buyers to specify "Mazda" lamps restricted competition.

On the agency or consignment system, the Government presented essentially the same arguments in this case as in 1926, and the Court upheld the 1926 decision.

Because so many practicies were involved, it took a long time to resolve the case. In fact, some firms came to separate settlements with the Government. In 1942, Westinghouse settled with the Government and eventually severed its licensing relationship with General Electric. In 1946, Corning Glassworks entered a consent decree with the Government. Sylvania, while still defending its case, entered a counterclaim against General Electric and Corning Glassworks concerning the sale of glass parts.[1]

In 1953, a final settlement was reached with the defendants. First, the defendants were required to dedicate to the public existing patents on lamps and lamp parts and to license present

---

1 United States v General Electric Co., Civil Action No. 1364, District Court of New Jersey, Answer and crossclaims of the defendant, Hygrade Sylvania Corporation, 1941.

patents on lamp machinery. Second, General Electric was required to license its new patents on lamps, lamp parts, or lamp machinery for the next five years for a "fair" fee. Third, General Electric was required to provide technological information, including blueprints, on its production machinery. Fourth, General Electric was enjoined from using the Mazda trademark on more than one percent of its lamp sales and from licensing any trademarks. Fifth, the defendant was enjoined against anticompetitive practices such as allocating markets and fixing prices. Sixth, Philips was enjoined from entering into agreements which restricted the import and export of lamps into or from the United States. Seventh General Electric was enjoined from using its stock ownership in foreign firms either to restrict patent licensing in the United States or to prevent firms from competing in the United States.

In 1942, a case was brought against General Electric, Claude Neon, Consolidated Electric Lamp, and others in the area of fluorescent lamps.[1] This case was complicated by a patent infringement suit brought by General Electric against Sylvania.[2] The Court ruled in favor of General Electric in the patent case, but Sylvania continued to manufacture flourescent lamps. In 1954, a consent decree was agreed upon. The

---

1 United States v General Electric Co., 82 F. Suppl. 753.

2 General Electric v Hygrade Sylvania Corp., 61 Fed Supp. 531, 539, 476.

decree had most of the provisions of the 1953 incandescent lamp decree, including compulsory licensing of patents for lamps, lamp parts, and lamp machinery parts.[1]

The two antitrust cases above were among the most complex in antitrust history. Basically, the Government maintained that General Electric and its licensees were able to control the lamp industry through a number of separate, but perhaps coordinated, actions and agreements. The provisions of the final settlement seem to indicate that the Court thought the cartel was held together by certain actions and that their prohibition would lead to a more competitive market.

That many of these actions restricted competition seems obvious, but there has been no radical change in the structure of the industry since the decree. Between 1954 and 1972, the four-firm concentration ratio declined only from .93 to .87 whereas the eight-firm ratio fell from .97 to .93. These ratios include more than the fluorescent and incandescent lamp sectors, but they reflect accurately those market segments.

It might be argued that while the structure of the industry has not changed, the elimination of the various practices and agreements has led to a more competitive industry. Indeed, N. V. Philips (North American Philips) has entered into the market as

---

1 See Talbot S. Lindstrom and Kevin P. Tighs, Fluorescent Lamps, Lamp Parts and Lamp Machinery: United States vs Electric Company et al, Civil No. 2590 (D. New Jersey, June 30, 1954) [filed December 6, 1942], in Antitrust Consent Decrees, volume I, (Rochester, N.Y.: The Lawyers Co-Operative Publishing Co.), p. 723-728.

has Tungsram of Hungary. Such entry would not have taken place under the Phoebus cartel.[1] Yet, the relatively small decline in concentration suggests that the effects of the decree may not have been substantial.

There are three possible reasons why the decree did little to change the structure of the industry. First, by the mid-1940's, the General Electric licensing system was already in abeyance. The original patents on which it was based either had expired or had been invalidated. New patents led to improvement in the quality of lamps, but as time elapsed, the value of each new patent became more marginal. Also, the legal validity of some of the newer patents was questionable. Consequently, the value of General Electric licenses declined. The antitrust case probably accelerated this decline, but it was inevitable in any case. Events in the late 1930's and early 1940's made this situation evident. Throughout the 1930's the market share of the unlicensed firms increased (from 2.3 percent in 1928 to 14.3 percent in 1941). In 1938, Sylvania was willing to risk the benefits of its class B license for the prospect of higher returns in the fluorescent lamp field. When the antitrust case was brought in 1942, Westinghouse entered into a consent decree, and its class A license from General Electric was canceled in

---

[1] Whether a Communist Hungary would abide by a cartel agreement is an open question.

1945. The class B licenses were abandoned in 1944. Consequently, the license structure, one of the focal points of the Government's case, was defunct before the case was decided.

A second reason that the case had little effect on structure was that the mere decontrolling of patents was not enough to attract substantial new entry except by firms already established in other countries. The established firms had advantages other than the patents.

Knowledge and experience were both decided advantages. Whereas a new entrant could obtain blueprints of the various machines after the 1953 decree, it is doubtful that any could actually operate the lamp machinery economically enough to compete. Moreover, in some parts of the industry, scale economies, rather than patents or secret technology, seem to explain the fewness of sellers. An obvious example of this is the manufacture of glass bulbs. Although General Electric and Corning Glassworks have been obligated to supply anyone with the plans for a ribbon machine, from 1953 to this day, no firms have entered this glass sector. As for lamp bases, the other sector the Court called "monopolized," only Sylvania has entered.

The third reason that the 1949 decree failed to alter the structure of the industry was the superior consumer acceptance of General Electric lamps. Although the Court objected to the use of the Mazda trademark primarily because of alleged abuses in dealing with large buyers, there was the possibility that the loss of the trademark could reduce General Electric's superior position in the household market. But the post-decree evidence is consistent with the General Electric attorneys' contention that the symbol, GE, not Mazda, was the source of the company's consumer goodwill.

While the 1949 and 1954 decisions may well have made the behavior of the industry more competitive, they did little to alter the structure. The Court could not deal effectively with scale economies and product differentiation.

E. The 1973 General Electric Lamp Case: The Fall of the Consignment System

In 1973, the latest lamp antitrust case was brought by the Justice Department. Again, the General Electric consignment plan for large incandescent lamps was attacked as a per se violation of Sections 1, 2, and 3 of the Sherman Act.[1]

Most of the arguments presented were of a legal nature. The controversy centered on whether recent decisions in the area of consignment systems overturned the 1926 and 1953 decisions for General Electric.[2] This time the Court decided against General Electric, and the consignment system was finally dismantled. After the 1973 decision was handed down, there were reports of lower retail prices.[3] But according to a retailer

---

1 United States vs General Electric Co., 358 F Suppl. 731 (1973), p. 731-743.

2 The arguments involved Simpson vs Union Oil Co., 377 U.S. 13, 24-25 (1964), and the United States vs Arnold Schwinn & Co., 388 U.S. 365 (1967).

3 See "General Electric Ends Court Plea, And Agency System of Lighting Bulb Sales," Wall Street Journal, April 22, 1974, p. 22.

survey made in 1974, most firms still charged more for General Electric lamps than for other lamps.[1] Moreover, retailers had to pay a higher wholesale price for General Electric lamps. Such evidence is consistent with the hypothesis that product differentration, not the consignment system, was the source of General Electric's higher prices.

Generally speaking, the Courts have applied antitrust remedies to the lamp industry on the assumption that the alteration of conduct would change the structure. Although some of the remedies may have led to greater competition, changes in the basic structure of the industry have not occurred.

F. Introduction of the Fluorescent Lamp

The early history of the fluorescent lamp provides some insight into the general innovative process in the lamp industry. General Electric, with the help of Westinghouse, developed the fluorescent lamp in the 1930's. Nonetheless, once the fluorescent lamp was introduced commercially, it was Sylvania that aggressively marketed the lamp.[2] In order to understand this behavior, it is necessary to understand the incentives of, first,

---

1 See p. 91, above.

2 See A. A. Bright and W. R. MacLaurin, "Economic Factors Influencing the Development and Introduction of the Fluorescent Lamp," Journal of Political Economy, LI (October 1943), p. 429-449; and A. A. Bright, The Electric Lamp Industry: Technological Change and Economic Development From 1800 to 1947, (New York: MacMillan Company, 1949), p. 368-439. Much of what follows is based on these sources. In analyzing the record of innovation in the lamp industry, Bright and MacLaurin focused on two facets, the ability of a firm to innovate and the incentives for the firm to innovate.

the dominant firm, General Electric, and second, the sizable challengers, Westinghouse and Sylvania.

General Electric's posture toward the fluorescent lamp was essentially defensive.[1] General Electric realized that research on new lighting and lamp production techniques was necessary to prevent a new or a smaller firm's upsetting its dominant position.[2] In fact, it was from such research and development that the large company derived its strong position. General Electric, therefore, had incentives for carrying on technical research and development, and it is not surprising that the company undertook the development of the fluorescent lamp.

Once the new lamp was developed, however, General Electric did not promote its rapid adoption. First, General Electric's dominant position in incandescent lamps seems to have made the firm conservative in the introduction of the fluorescent, and many General Electric executives seemed skeptical of the fluorescent's advantages.

Second, the electric utility companies, large customers of General Electric's other products, feared that the increased efficiency of the fluorescent lamps would lead to a decrease in

---

1 A. A. Bright and W. R. MacLaurin, op. cit., p. 441.

2 The most clearcut example of such a technological revolution in American history was the dieselization of the railroad locomotive. The old locomotive makers, Alco, Lima, and Baldwin, were either oblivious to the advantage of the diesel or slow to move, and, consequently, a new entrant, General Motors, came to dominate the field. See Thomas G. Marx, "Economic Theory and Judicial Process: A Case Study," Antitrust Bulletin, Vol. XX, No. 4 (Winter 1975), p. 775.

the demand for their product. This fear proved to be unfounded; the total demand for power subsequently increased. Even though the worst fears of General Electric proved unimportant, it can be argued that a gradual introduction of the fluorescent lamp would have appeared to be a rational course for the firm. But the actions of Sylvania took the matter out of General Electric's hands.

The licensing agreement between General Electric and Westinghouse helps to explain the innovative abilities and incentives of the two challenger firms, Westinghouse and Sylvania. In the 1930's, the former firm had the ability to innovate in the lamp area. Westinghouse had a steady stream of profit, a large parent organization, and a regular lamp research program. But the licensing arrangement with General Electric dampened its incentives.

In exchange for the license to use General Electric patents, Westinghouse not only had to pay a fee but also had to license General Electric on its own patents. Therefore, the benefits of Westinghouse research would automatically be shared with General Electric. The largest disincentive facing Westinghouse was the quota whereby it could produce only a given percentage of the number of lamps produced by General Electric. The quota included not only incandescent but also electric discharge (and therefore fluorescent) lamps. The quota alone could explain Westinghouse's inactivity in fluorescent lamp research. Since its sales were limited to a fraction of General Electric's, the expected earnings from a given project would be limited.

But Westinghouse's position did not totally discourage innovative activity. With its class A license, Westinghouse enjoyed an advantage over the smaller firms. In order to retain its position vis-a-vis General Electric, the class A licensee had to offer some quid pro quo. Part of this was in the form of special Westinghouse research projects which would benefit both firms. Another incentive for lamp research activity by Westinghouse was the need to maintain some ability to sever relations with General Electric. Without some form of research staff, the smaller firm would be totally at the mercy of the industry leader. Consequently, Westinghouse did play a minor role in the development of fluorescent lamps and slowly started to manufacture them under a license from General Electric on a quota basis.

Licensing agreements also help to explain Sylvania's innovative activity. First, the protection of the license system allowed Sylvania to earn a return on its investment sufficient to maintain a research and engineering laboratory. But, like Westinghouse, Sylvania had to share with General Electric any important inventions. Second, Sylvania's class B license allowed it to sell only a fixed fraction of General Electric's sales. Consequently, like Westinghouse, its incentive to engage in innovative activity was somewhat subdued, and Sylvania was devoting a substantial part of its innovative effort to other industries such as radio tubes.

There was, however, one important difference between the class A and B licenses; the class B license did not cover electric discharge lamps. In fluorescents, therefore, Sylvania found an opportunity to "grow up" in the industry.

When it discovered that General Electric had developed a fluorescent lamp, Sylvania decided to enter the market segment. Apparently, the Sylvania management thought the prospective gains were large enough to risk the high profits derived from its General Electric license. Thus, Sylvania acquired what it thought was a defensible patent position and started to manufacture and sell fluorescent lamps. It gained 20 percent of the fluorescent market segment (as opposed to its 5.5 percent share of the incandescent market segment) and upset the larger firm's plans for a gradual introduction of the fluorescent lamp.

As the fluorescent lamp episode shows, the threat of innovation by an outsider or a small firm can upset the market leader's comfortable position, and this threat gives an industry leader a strong incentive to engage in research and development. For the challenger, the prospect of high returns from an increased market share provides an incentive to invest in innovation.

If a new innovation such as the fluorescent lamp were to be developed today, there are smaller lamp firms that could use the innovation to challenge the position of the three leaders, General Electric, GTE Sylvania, and Westinghouse. North American Philips, Durotest, General Motors, and Studebaker Worthington probably have this capability. The presence of such firms benefits the consumer in two ways. First, these smaller firms may themselves develop a superior lamp and succeed in challenging the large firms. Second, to preclude this possibility, the large firms must remain active in R&D and introduce superior lighting as it is developed. The importance of the fluorescent episode to antitrust policy is the desirability of these smaller, profitable, "challenger" type firms.

G. Summary

In summary, the various antitrust cases did little to change the structure of the industry, but they may have increased competition by hastening the demise of the licensing system. The largest change in the structure of the lamp industry was the rise of Sylvania in the late 1930's and early 1940's. Sylvania's success was the result of a smaller firm's taking advantage of a major innovation (essentially developed by someone else) to increase its market share of the total lamp industry. The existence of such firms probably has contributed as much to the competitiveness of the industry as the antitrust cases.

CHAPTER V

Performance

A. Introduction

In this chapter, two aspects of performance, profitability and innovation are examined.

B. Profits

Profit data in the lamp industry are scarce because lamps are manufactured by large corporations with many product lines. The major companies manufacturing lamps do not publish profits by product line. Since lamps constitute only a small part of these firms' activities, it is impossible to cull lamp profits from the company statements.

The best available data are for the smaller firms. In 1966, discussions at International Telephone and Telegraph Corporation concerning the possible acquisition of Consolidated Electric Lamp Company showed that the lamp company had after tax returns for 1965 of 5.30 percent on assets and 6.27 percent on stockholders' equity.[1] Consolidated Electric Lamp Company, with 1965 lamp sales of $12.3 million, was bought by I.T.T. in 1967 and was sold to North American Philips in 1973. The only publicly-held corporation dealing mainly in lamps is the Durotest Corporation. For 1975 and 1974, Durotest had after tax returns on equity of

---

1 U.S. House of Representatives, Hearings Before the Antitrust Subcommittee of the Committee on the Judiciary, House of Representatives, 91st Congress, on International Telephone and Telegraph Corporation, November 20, 21, 26, and December 3, 1969 (Washington, D.C.: U.S. Government Printing Office, 1970), pp. 1,343 and 1,345.

12.9 and 12.4 percent, respectively. In the periods discussed, however, Durotest and Consolidated Lamp were small firms that did not enjoy the production cost or product differentiation advantage of the three largest firms.

Historically, the lamp divisions of General Electric and Westinghouse have been very profitable.

> In incandescent lamps alone from 1935 to 1939 General Electric made average net profits of between $16,000,000 and $21,000,000 on net sales which averaged around $45,000,000. . . These figures represented profits of 64 to 88 percent on costs, 39 to 47 per cent on net sales, and 20 to 30 percent on invested capital. . . . The profit rate of Westinghouse on its average lamp sales of about $15,000,000 from 1935 to 1939 was also high although not quite so high as that of General Electric, and the earnings of the B licensees were above average.[1]

In recent years, profit figures have not been available for the larger firms, but what little information we do have indicates that the profits of the largest firms are substantial. During a discussion of the Consolidated Lamp acquisition in 1966, an official of International Telephone and Telegraph Corporation, stated:

> In looking at the U.S. Market, we have been interested in certain indirect consumer products which experience high profit margins, are consumable, and are often characterized by one or two industry leaders with considerable fragmentation of the balance. The lamp business is a perfect example of such an industry. We understand that General Electric carries down a pretax net of 27% on its lamp business and that Sylvania's

---

[1] A. A. Bright, op. cit., p. 270.

most profitable division is its fully integrated lamp operation.[1]

Although industry profit data are not directly available from the Bureau of the Census, some meaningful measures can be constructed. The most common measure based upon Census data is the price-cost margin, an approximation of the ratio of (Price - Cost)/(Price). The primary defect of the Census price-cost margin is that certain components of cost, most notably depreciation and advertising, are not collected by Census and hence are included in the numerator of the ratio. Thus, a Census price-cost margin might be unusually high either because an industry was very profitable or because the industry incurred very high depreciation or advertising expenses.

The 1967 price-cost margin for SIC Industry 3641 was 45.7 percent, a margin 82 percent above the average for all manufacturing industries.[2] That the high margin is probably not due to high depreciation expenses is suggested by looking at gross capital output ratios. Whereas the 1967 gross capital-output ratio for all manufacturing industries was .4002, the ratio for SIC 3641 was only .3484. Advertising, which accounted for only .83 percent of value of shipment in 1967, does not explain the

---

1 U.S. House of Representatives, Hearings Before the Antitrust Subcommittee of the Committee on the Judiciary, House of Representatives, 91st Congress, on International Telephone and Telegraph Corporation, op. cit., p. 1,327.

2 The price-cost margin data are taken from U.S. Dept. of Commerce, Bureau of the Census, Census of Manufactures, vol. 1, 1971.

high price-cost margin.[2] It would only represent 1.8 percent of that margin. The Census data suggest that the electric lamp industry may be much more profitable than the average of all manufacturing industries.

C. Innovation

From the time of its invention until the 1930's, the incandescent lamp was rapidly improved through the efforts of the established firms, especially General Electric. Since the 1930's, its quality, if measured in light output and bulb life, has improved only gradually.

It is not appropriate, however, to judge the industry performance by developments in incandescent lamps alone. There is a high probability that the limits of improvement on the incandescent lamp were reached in the 1930's. Also, a higher payoff in investment may have existed in research on other types of lamps. Table V-1 shows the improvement in light efficiency of the various types of lamps from their invention to the present time. It is obvious that over time the industry not only has found more and more efficient lamps but also has greatly improved the older lamps. Also, the industry has increased the number of applications of the various types of lamps. The specifications and configurations of already-developed lamps, such as photoflash, fluorescent, and incandescent lamps, have been altered to fit

---

[1] Federal Trade Commission, Brand Advertising Expenditures by SIC Code, unpublished data set, 1975.

TABLE V-1

Improvements in the Efficiency of Various Lamp Types

Type of Lamp	Year invented	Initial lumens per watt	Typical present lumens per watt
Incandescent	1879	2	17
Mercury-Vapor	1934	40	50-60
Flourescent	1938	40	80
Lucalox (Ceramic Tube Sodium-Vapor)	1958	100	125
MultiVapor	1965	70	80-90

Source: General Electric Company.

many new situations. Table II-6 (in chapter II) illustrates this phenomenon by showing some of the innovations of General Electric. With the exception of the sodium and MultiVapor lamps, these innovations have been alterations of older types of lamps either to fulfill their functions better or to fit new situations better. Other firms have made similar innovations. The smaller lamp firms, especially Durotest, focus on specialty lamps for unusual situations such as decoration and special color effects.

The industry has encountered criticism, however, primarily because it may not have provided the household consumer a wide enough selection of incandescent lamps. There is an inverse relationship between incandescent lamp life and the amount of light given off by a bulb. Until recently, for any given wattage, only bulbs at one point on the light-life trade-off were available from regular household consumer outlets. Some consumers might prefer a longer life bulb that gives less light output per watt. For example, since one does not need much light from a high hallway ceiling fixture, and since it may be difficult to replace the bulb, a long-life lamp may be desirable. Unless a great deal of time was spent checking with distributors, however, such lamps were generally unavailable to household consumers until recently.

In the early 1960's, smaller firms started selling long-life incandescent bulbs through unconventional consumer outlets such as telephone salesmen. They would often guarantee the length of the bulb life, but in many cases, they did not explain the life-lumens trade-off. Furthermore, when the lamp did not live up to the guarantee, the consumer did not always get proper recompense. The situation resulted in complaints that came to the attention of the Federal Trade Commission and the Government Activities Subcommittee of the Committee on Government Operations, U.S. House of Representatives (the Brooks Committee). Hearings and studies followed.[1] These bodies focused not only on the small, long-life lamp sellers but also on the question of the proper bulb life for the standard lamp. The House Committee report shows that on some lamp wattages the life of the incandescent lamps sold in ordinary consumer outlets was not as long as many consumers would prefer. The outcome of this controversy was the FTC Trade Rule instituted in 1971 relating to Incandescent Lamps (light bulbs). In essence, this rule requires lamp manufacturers to reveal on their bulb packages light output (in lumens), wattage, and average bulb life. In 1973, General Electric introduced a line of long-life bulbs for the household consumer.

Thus, although the industry has been generally innovative, certain criticisms about the slow introduction of long-life lamps to the household consumer may be valid.

---

1 U. S. House of Representatives, The Short Life of the Electric Light Bulb, Report Prepared by the Government Activities Subcommittee of Committe on Government Operations (Washington: U.S. Government Printing Office, 1966).

CHAPTER VI

Conclusions and Policy Implications

Five generalizations can be made safely about the lamp industry. First, the cost structure at the plant level would preclude an atomistic industry. A minimum efficient high volume plant would produce from 7 to over 60 percent of the total output, depending upon the type of lamp produced. Therefore, one would have to expect four-firm concentration levels ranging from 28 to 100 percent at the product level at least for the products in the widest use.

The second definite conclusion is that General Electric, due to its product differentiation advantage among small household buyers and also due probably to its mutually comfortable relationship with the large food and other retailers, dominates the consumer sector of the industry.[1] Evidence from experts, retailers, price surveys, and literature on retailing confirm this assertion.

Third, the five Justice Department cases relating to this industry have left the structure of the lamp industry essentially unchanged. Changes in the industry's structure have occurred through other means. The basic philosophy of the court decisions in these cases was that by changing conduct one could increase competition in the industry. Whether competition was increased or not, structure has changed little due to these cases.

---

1 See Steiner, op. cit.

Fourth, although the optimal rate of innovation for the lamp industry is not known, the rate of innovation over the years has been considerable. Not only has the lamp industry developed and introduced several types of new and different lamps, but it has also greatly improved the efficiency and widened the application of the older lamps.

Lastly, it is safe to say that the large lamp firms have enjoyed very high profits over time, but present profitability can be estimated only imperfectly from publicly available data.

Before drawing policy conclusions, it is appropriate to discuss the areas where our knowledge is inadequate. First, the extent of multiplant economies is unknown. While the spreading of some overhead costs over more than one plant probably leads to some lowering of costs, we currently do not know the size of the cost advantage enjoyed by large multiplant firms.

Second, due partly to the multiplant economies question, it is difficult to ascertain the source of the large firms' profitability. Profitability could be due to tacit collusion and scale economies, or it could arise from the absolute cost differences among established large firms as well as potential entrants and marginal producers. The cost differences could be caused by either scale economies or absolute cost advantage of the large producers. In different market segments, either or both of these conditions may hold. The identity of the sources of the profits has an important bearing on the desirability of an antitrust case.

The third major subject on which knowledge is imperfect is the effect of the various antitrust cases upon conduct and profitability. The conduct remedies may have increased competitive behavior, but it is also possible that they have had little effect. Even with the antitrust decrees, the differences in cost between the large, established firms and possible entrants may be so great that the large, established firms can price at the monopoly level.

The last subject, on which this research effort sheds little insight, is the relationship between the firms in the industry. There is no evidence of price conspiracy; in fact, the lamp firms seem to take precautions not to involve themselves in such activity.[1] This avoidance of overt price fixing activity, however, does not preclude the possibility that the firms can keep prices above the competitive level by conscious parallelism. In most segments of the lamp industry, there are only two or

---

[1] Two anecdotes can illustrate this policy. First, across the street from General Electric's Pitney Glassworks in Cleveland is an electronics plant recently bought by GTE Sylvania. When GTE Sylvania purchased this plant, it was found that some employees of the company and some General Electric lamp division employees were close friends and belonged to the same country club. Both firms went to considerable trouble to assure the Justice Department that these relationships would not lead to discussions of product prices. Second, according to the testimony on the famous electrical equipment price conspiracies, one General Electric employee, George Burens, had been in the lamp division. He was reluctant to involve himself in the price-fixing conspiracy because it was so different from his experience in the lamp division where no contacts between companies on prices had been allowed. (See U.S. Senate, Hearings held before Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary in the Electrical Antitrust Cases, April 25, 1961, p. 808.)

three major competitors, and probably five or six significant competitors are the most one could find in any given segment of the industry. Therefore, because the pricing actions of only a few competitors need to be watched, a policy of conscious parallelism is possible.

Both the areas where our knowledge is certain and the subjects on which our knowledge is inadequate have a bearing upon future antitrust policy in the lamp industry. First, the importance of plant scale economies preclude the possibility of breaking up the industry into an atomistically competitive market. To produce at minimum cost, only a few firms could operate in each market segment. Nonetheless, the multiplant nature of the largest firms suggests that it is possible for more firms to operate in some segments. Some evidence, though it is by no means conclusive, suggests that reductions in the market shares of the first and second largest firms can improve industry performance.[1]

Second, the product differentiation advantage of General Electric would have to be addressed. Even if divestiture were ordered, for example, the firm retaining the GE name would probably retain a strong position in the household consumer area. With this advantage, it might be able to reestablish the traditional relationship with the retailer where the combination of

---

[1] John E. Kwoka Jr., <u>Market Shares, Concentration, and Competition in Manufacturing Industries</u>, Staff Report to the Federal Trade Commission, August 1978.

high retail margins and exclusive brand merchandizing seem to lead to a mutually profitable position. If the old situation is reestablished for this sector, little will have been accomplished. On the other hand, breakup of the manufacturer-retailer relationship may result in lower prices even without major structural changes in the industry. This may be a promising area for public policy action.

The impact of antitrust policy upon innovation must also be considered. A disproportionate share of the research and development has been done by the larger firms, especially General Electric. Smaller firms may not have the ability to carry out proportionately as much research as the larger firms. Finally, the issue of multiplant economies of scale must be considered. If such economies are important, the potential for divestiture, for example, may be limited to a very few market segments. Otherwise, antitrust action could actually increase costs to the consumer.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1980 623-711 1479