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MARKET STRUCTURE AND TECHNOLOGICAL PERFORMANCE IN THE FOOD MANUFACTURING INDUSTRIES



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PART II

THE SOURCES OF INVENTIONS AND INNOVATIONS

CHAPTER 6. THE ORIGINS OF PATENTED INVENTIONS

The preceding chapters dealt only with R & D inputs and outputs originating with food-manufacturing firms. Inventions affecting an industry's productivity and product offerings may originate with firms in the industry or with firms, public institutions, or individual inventors located outside the industry. As Rosenberg has observed: ". . . many of the benefits of increased productivity flowing from an innovation are captured in industries *other* than the one in which the innovation is made. As a result, a full accounting of the benefits of innovation must include an examination of interindustry relationships."¹

In this view, technological interdependence among industries is a crucial determinant of technological progress. The pace of technical change in one industry is determined not only by the behavior of firms within the industry but also by those outside it. Such interdependence is maximized when some industries specialize in supplying capital goods to another. The extent of such specialization depends on the size of the market. We expect that in food manufacturing such specialization has been encouraged because many food manufacturers employ common technical processes, thereby creating a large potential demand for a wide variety of machinery and other inputs. This suggests that the major sources of technological progress in food-manufacturing industries originate outside rather than inside these industries. This hypothesis is consistent with food manufacturers' generally good record of rising productivity and modest spending on research-and-development.

This chapter examines inventions and the following chapter examines important innovations relevant to food manufacturing irrespective of their origins. Data are marshalled to test the hypothesis that inventions and innovations originating outside the food-manufacturing industry represent an important, and perhaps the major, source of new technology relevant to food manufacturers. Should this hypothesis be supported, it has important implications for the findings in previous chapters that examine the relationship between industrial organization and the inventive propensity of food-manufacturing firms. If substantial inventive activity originates outside food manufacturing, any relationship between industrial organization and inventive performance of food manufacturers explains only a small part of total R & D activity determining the ultimate performance of these industries.

The ideal test of this hypothesis would involve identifying and quantifying the relative importance of all inventions and innovations originating both within and outside food manufacturing. Such a test is not within the scope of this study or perhaps any other study. We are able, however, to identify the sources of patents relating to technology in several important food-manufacturing industries, as well

as the sources of a sizable number of innovations identified as being among the most important in recent years.

The remainder of this chapter deals with the origins of patents and the following chapter with the origins of important innovations.

Determining the origins of public inventions of a certain industry class requires a search program by which patents disclosing those inventions can be identified for subsequent examination. The cost of designing and executing such a program is largely a function of the objectives of the search and of the extent to which the relevant patents have been officially grouped into a U.S. Patent Office (USPTO) subclass that can be readily identified from a study of the *Manual of Classification*. Locating all public inventions of a certain class will usually be more costly to design and execute than one drawn up for a search with more modest objectives and a greater number of tolerable omissions. Moreover, the cost of a program will usually rise with the degree of dispersion of the relevant patents among the thousands of subclasses of the USPTO system. It is harder to find patents of very diverse classifications than it is to find patents assigned to only a few, closely related subclasses.

The complexity of modern technology is such that it is usually very difficult to identify all inventions important to a particular industry. Except in detailed case studies, investigators must be satisfied with search programs adequate to find *most* of the relevant patents in an industry. In addition, they usually must restrict the scope of their inquiry to permit concentration on those fields of invention that can be studied without the need for a laborious, complicated search of the patent literature. For some classes of food machinery and apparatus technology, highly satisfactory search programs can be designed and executed at relatively low cost because the corresponding patents are organized in only a few specialized subclasses. However, for other classes of technology, the relevant patents are dispersed throughout many subclasses, some of which hold inventions that, while functionally related, are used in a variety of industries. Thus, apparatus used in manufacture of dairy foods are found not only in the fairly well specialized subclasses 99-452+ but also in such general equipment classes as C1.62: Refrigeration; C1.100: Presses; C1.137: Fluid Handling; C1.138: Pipes and Tubular Conduits; C1.159: Concentrating Evaporators; C1.165: Heat Exchangers; and C1.210: Liquid Purification. A program intended to search all the patents in these several classes to find those relevant to dairy processing would be very costly and, in addition, might founder on the problems of classifying and interpreting those multi-purpose inventions having value in many industries.

For reasons of economy, the scope of the present study is restricted to an examination of the origins of many of the patents pertaining to machinery and other apparatus for the manufacture of beer, refined sugar, meat and poultry products; *some* of the patents pertaining to apparatus for the manufacture of dairy products; and a *very limited* number of the patents covering apparatus used in the manufacture of starch.

ORIGINS OF PATENTS IN SIX FOOD-MANUFACTURING INDUSTRIES

Patents provide both a convenient and meaningful index of inventive activity.² We therefore used the research procedure discussed above for identifying the origins of patents covering various types of apparatus and machinery used in six important food-manufacturing industries. Mechanical inventions were selected, in

part, because of their availability (comparable data cannot be developed for product patents). But more important, it is generally acknowledged that machinery and apparatus patents are the primary source of increased productivity in food manufacturing. Thus, the sources of such technology are also the sources of most productivity increases in food-manufacturing industries.

We reemphasize that the USPTO classification system for patents in a particular industry category cover only part of the total patents relevant to the industry because many patents and their corresponding innovations have applications for many industries. This is particularly true in food-manufacturing industries that use similar production techniques. Examples are fork lifts, conveyer systems, canning processes, and computerized control systems. Little of such multi-industry technology is likely to be included in the patent statistics examined here. *We emphasize, therefore, that the following analysis of the origins of inventions applicable to the food industries discussed below almost certainly understates by a substantial margin the relative importance of mechanical inventions originating outside the food-manufacturing industries.*

Our examination of the origins of patents in six food-manufacturing industries will proceed as follows:

- 1) Identify the nation where the patented innovations originated.
- 2) Identify patents as originating from corporations, individuals, and government.
- 3) Compare the market shares of the leading four firms in these industries with the total number of patents originating from all sources.
- 4) Examine briefly the leading sources of patents in individual food-manufacturing industries.

ORIGIN OF PATENTS: BY NATIONALITY OF INVENTORS

During 1963-1977, 73 percent of all patents in the six industries studied originated with corporations, individual inventors, and government research laboratories within the U.S. The share originating abroad increased over the period—from 20 percent during 1963-1965 to 37 percent during 1974-1977 (Table 6.1). The upward trend was most pronounced in poultry processing, where the share of patents originating abroad rose from 2 percent in 1963-1965 to 28 percent in 1974-1977. Patents for innovations developed outside the U.S. also rose for dairy, meat, and sugar, but fell in the beer industry.

Table 6.1. Granted Patents U.S. and Foreign Corporations, Individuals and Governments in Selected Patent Categories in Six Food-Manufacturing Industries, 1963-1977.

Industry	Origin	Percent of Patents				Total
		1963-1965	1966-1969	1970-1973	1974-1977	
Poultry	United States	98%	91%	88%	72%	87%
	Foreign	2	9	12	28	13
	Total	100%	100%	100%	100%	100%
Dairy	United States	64%	53%	54%	45%	53%
	Foreign	36	47	46	55	47
	Total	100%	100%	100%	100%	100%
Meat	United States	87	86	82	72	82
	Foreign	13	14	18	28	18
	Total	100%	100%	100%	100%	100%
Sugar	United States	48	45	49	30	42
	Foreign	52	55	51	70	58
	Total	100%	100%	100%	100%	100%
Beer	United States	33%	39%	45%	46%	42%
	Foreign	67	61	55	54	58
	Total	100%	100%	100%	100%	100%
Starch	United States	83%	44%	54%	80%	63%
	Foreign	17	56	46	20	37
	Total	100%	100%	100%	100%	100%
Total	United States	80%	75%	74%	63%	73%
	Foreign	20	25	26	37	27
	Total	100%	100%	100%	100%	100%

Source: Appendix Table 2

Four countries accounted for 62 percent of all patents granted foreign nationals (Table 6.2). These four countries also were among the foreign leaders in individual products, with Germany the leader in four products. The leaders in various products were: sugar—Germany and France; brewing—Germany, France, and Canada; poultry processing—the Netherlands; dairy processing—France, Germany, and the Netherlands; meat packing—Germany, France, and Canada; and starch—Germany and the Netherlands (Appendix Table 5).

ORIGINS OF PATENTS: CORPORATIONS, GOVERNMENT, INDIVIDUALS

The most striking feature of the origins of patents summarized in Table 6.3 is that U.S. firms within the six industries studied accounted for a minority share of all patents in their industries, ranging from a low of 5.9 percent for sugar to a high of 28.6 percent for starch. U.S. firms within the six industries accounted for only 10.2 percent of the total patents granted in these industries between 1969 and 1977.

Compared with firms in the industries studied, U.S. firms in different industries accounted for nearly four times as many patents on innovations relevant to the six food-manufacturing industries. Starch was the only industry in which the number

of patents that originated within the industry exceeded the number that originated with U.S. firms outside the industry.

Only a modest share of total patents originated with U.S. food manufacturers outside these industries—2.4 percent. Food-machinery manufacturers were the major U.S. corporate source of the out-of-industry patents. These companies accounted for 18.2 percent of all patents, which was nearly twice as many as the number originating with food manufacturers within these industries. The contribution of food-machinery companies varied greatly among industries, being greatest in meat, poultry, and dairy. In poultry, the machinery companies received over three times as many patents than did poultry processors. The leading food-machinery contributors were Gainsville Machine, which had five patents in meat and 21 in poultry, Townsend Engineering, which had 19 in meat and one in poultry, and Food Equipment Company which had two in meat and 14 in poultry.

Table 6.2. U.S. Patents Granted in Selected Patent Categories in Six Food-Manufacturing Industries by Country of Origin, 1963-1977.

	Percent			
	1963-1967	1968-1972	1973-1977	Total
Grand Total	100%	100%	100%	100%
U.S. Origin	78.1	73.9	65.3	72.5
Foreign Origin	21.9	26.1	34.7	27.5
Total Foreign Origin	100%	100%	100%	100%
Germany	32.3	23.8	33.9	30.0
France	9.5	17.6	11.4	13.1
Netherlands	3.8	9.0	13.9	9.6
Canada	10.1	12.9	5.3	9.1
United Kingdom	12.7	5.7	5.7	7.5
Sweden	7.0	4.8	4.5	5.2
Denmark	5.1	4.8	3.3	4.2
Australia	3.8	2.9	2.9	3.1
Japan	.6	3.3	4.1	2.9
Switzerland	3.8	3.3	2.0	2.9
Italy	2.5	1.0	2.9	2.1
Belgium	0	1.4	1.6	1.1
Czechoslovakia	1.9	1.9	0	1.1
Norway	1.3	1.0	.8	1.0
U.S.S.R.	0	1.0	1.6	1.0
Finland	0	.5	1.6	.8
Argentina	1.9	0	.4	.7
New Zealand	0	0	1.6	.7
Romania	0	1.9	0	.7
Other (13 Nations)	3.7	3.2	2.5	3.1

Note: The six industries are beer, meat, poultry, dairy, sugar, and starch. The patents for these industries are for the USPTO classes described in the text.

Source: Appendix Table 3.

Table 6.3. Origin of Patents by Industry, 1969-1977 (Percent).

Origins of Patents	INDUSTRY						Weighted average
	Beer	Meat	Poultry	Dairy	Sugar	Starch	
	100%	100%	100%	100%	100%	100%	100%
U.S. Firms within the Industry	6.7	10.6	12.6	7.9	5.9	28.6	10.2
U.S. Firms outside the Industry	17.3	42.9	46.4	28.1	20.9	14.3	37.0
a) other food manufacturing	3.8	2.9	.5	1.4	2.6	0	2.4
b) food machinery firms	2.9	18.2	39.9	20.1	3.3	7.1	18.2
c) other firms	10.6	21.8	6.0	6.5	15.0	7.1	16.3
Foreign Corporations	34.6	13.0	11.5	36.7	52.3	21.4	21.2
Individuals	40.4	32.4	27.9	25.9	20.9	32.1	30.5
U.S.	19.2	25.3	22.4	13.7	13.7	3.6	21.6
Foreign	21.2	7.2	5.5	12.2	7.2	28.6	8.9
Government	.1	1.0	1.6	1.4	0	3.6	1.1
U.S.	0	.5	1.6	1.4	0	3.6	.7
Foreign	.1	.5	0	.7	0	0	.4

Source: Appendix Table 4

¹ Sum of figures may not equal totals due to rounding

The remaining patents originated in a wide variety of industries. The most important of these was the chemical industry, where Union Carbide Corporation was the leader with 37 patents in meat packing and one in poultry processing. Its patents dealt mainly with apparatus for wrapping and packaging.

Individual inventors were also an important source of patents, with U.S. individuals receiving 21.6 percent of all patents in the six industries and individuals abroad 8.9 percent. Individual inventors were most important in the beer industry, where they received 41.3 percent of all patents; foreign individuals received over one-half of these.

Foreign corporations also were an important source of patents, receiving twice as many as companies within these industries. Foreign corporations were most important in sugar, where they received nearly nine times as many patents than did companies within the sugar industry. They were also very important in beer and dairy. Only in poultry and starch did foreign corporations receive fewer patents than U.S. corporations within these industries.

U.S. and foreign governments were a minor source of patents in these industries, although the U.S. government received patents in all industries except beer and starch. Between 1963 and 1977, the only foreign government receiving patents was the U.S.S.R., which received six U.S. patents in the industries studied. (Appendix Table 3).

TOP FOUR CORPORATIONS' SHARE OF INDUSTRY PATENTS

In earlier chapters we examined the relationships between firm size and R & D inputs and outputs. Although data do not enable us to subject this hypothesis to rigorous testing here, we were able to determine the share of total patents in these industries originating with the top four firms' in each. Table 6.4 shows for each industry the estimated share of shipments accounted for by the four leading firms in 1972 and these four firms' share of several universes of patents. Column 2 shows the four companies' share of all patents originating with firms within the industry. For example, the top four brewers made 51.0 percent of all beer shipments in 1972 and accounted for 57.1 percent of all beer patents during 1969-

1977. In all industries but sugar, the top four firms' share of industry shipments was smaller than their share of patents originating within their industry.

When the patent universe consists of all patents of each industry originating with all U.S. corporations, outside the industry as well as within, a dramatically different picture emerges. Whereas the four leading brewers made 51 percent of beer shipments in 1972, their share of beer-industry patents originating with all U.S. corporations was only 16.0 percent (Column 3). For all other industries except starch, the four leaders' shares are even smaller than for beer.

Finally, when the comparison is made with patents from all sources, including individuals, government, and foreign corporations, the four industry leaders' share fell to a mere 5.0 percent or less for all industries but starch. Again, we emphasize that the patent sample for the starch industry represents a very narrow USPTO category of patents.

Table 6.4. Top Four Companies' Share of Industry Shipments and Their Share of Patents Granted in Selected Patent Categories of Six Food-Manufacturing Industries, 1969-1977.

Industry	1972 Industry Shipments	Top Four Companies Share of:		
		Patents originating within the industry	Patents originating with U.S. corporations	Total Patents ²
	(1)	(2)	(3)	(4)
Beer	51.0%	57.1%	16.0%	3.8%
Meat	20.1	36.9	7.3	3.9
Dairy	22.0	63.6	14.0	5.0
Sugar	45.9	44.4	9.8	2.6
Poultry	14.7	30.4	6.5	3.8
Starch	67.6	87.5	58.3	25.0
Six Industries ¹				
Averages ³	25.5	46.8	10.7	8.3

¹ 1972 census of Manufacturers and Economic Information Systems. Weighted average of all 4-digit SIC industries in each of these industries.

² Organizations and individuals, U.S. and Foreign

³ Weighted by industry shipments

SOURCES OF PATENTS IN INDIVIDUAL INDUSTRIES

The Brewing Industry

Labor productivity for production workers in the beer industry rose 5.8 percent annually between 1972 and 1977, which was greater than all but five of 74 industries studied by the U.S. Bureau of Labor Statistics.³ The industry's productivity has been increasing at this rate since the late 1950s.⁴

Despite these impressive productivity gains, U.S. brewers' outlays for R & D were very low, even among food manufacturing firms. The industry's leader, Anheuser-Busch, has reported insignificant expenditures in recent years.⁵ Jos. Schlitz Brewing Co., the second largest brewer until 1976, reported R & D expenditures of \$1.8 million, or only 0.2 percent of sales in 1977.⁶ During

1967-1977, the Pabst Brewing Co. made even more modest R & D expenditures than Schlitz. The only brewer to make significant R & D expenditures in recent years has been Adolph Coors Co., the fifth largest brewer, which spent \$7.7 million on R & D, or 1.3 percent of its sales in 1977.⁷

The low R & D effort of this industry is reflected in its extremely low patent output. During 1969-1977, the four major brewers received only four patents in the USPTO categories reported in Table 6.3.⁸ This was less than the four leaders in any of the other five industries studied.

Foreign corporations were the major source of beer patents, followed by American and foreign individuals.

Improvements in productivity in the beer industry have been largely the result of technical improvements in the brewing process. Scherer reports that "during the 1950s and 1960s there were numerous cost-saving developments in the technology of brewing, with a notable spurt in the mid-1960s as highly automated brewhouse were introduced."⁹

These technical changes greatly increased labor productivity. For example, modern plants require only two brewhouse employees per shift to do the work which required 20 to 30 persons in older breweries. Corporations outside the beer industry provided practically all the apparatus and instrumentation used in these modern plants.¹⁰ Herein lies the explanation for the paradox of low R & D expenditures and high labor-productivity increases in the brewing industry.

This is not to say brewers have not made any significant inventions. A prominent example is the Adolph Coors Company, which pioneered in 1959 the technology leading to the sale of beer in aluminum cans.¹¹ Coors developed technology for such cans, but it also joined forces with Beatrice Foods to form Aluminum International, Inc., "to develop the techniques and equipment necessary to produce a 12 oz. extruded aluminum can."¹²

The Meat-Packing Industry

The USPTO classification system permits the identification of a broad group of patents pertaining to slaughter and related aspects of meat packing.¹³

Of the patents in these subclasses, the top four meat packers in 1972 received 37 percent of those received by all meat packers, but only 4 percent of those received by all sources (Table 6.4). The leading recipients were: Armour & Co. (Greyhound), with 21 patents; Iowa Beef, 10 patents; Swift, 9 patents; and Oscar Mayer, 8 patents.

U.S. food-machinery manufacturers received 18 percent and other U.S. firms 22 percent of all patents (Table 6.3). Thus, U.S. companies outside the industry received about four times as many patents in these subclasses than did all meat packers.

Foreign corporations were less important in meat packing than in the other industries studied, receiving 13 percent of all patents. American and foreign individuals received about 30 percent of all patents in meat processing. The U.S. government received about 0.5 percent of the patents and foreign governments 0.5 percent.

Poultry Processing

The poultry-processing industry is the major new food-processing industry of the 20th century. Developed largely after World War II, it has experienced remark-

able increases in productivity at all stages of processing and marketing, resulting in declining real prices and in an expansion in fresh-poultry consumption.¹⁴ Patents relating to poultry processing were found by search of USPTO subclasses 17-11+, which are specialized to inventions concerning machinery for the processing of food.

As in other industries studied during 1969-1977, the great majority of potential inventions originated with firms outside the industry for which they were designed. Although in many respects the technology for processing poultry is similar to meat packing, only one patent in the above subclasses investigated was assigned to a meat packer. The exception was Esmark (Swift until 1972) which in 1972 was one of the four leading poultry processors as well as one of the leading meat packers. Swift received all (7 patents) the patents received by the top four poultry producers. Its patents covered equipment for such tasks as poultry handling, cold treatment of poultry before slaughtering, and disjointing poultry.

Other poultry-processing companies that received more than one patent during 1969-1977 were Victor Weaver Company (five patents), Pillsbury Company (four), J.D. Sewell (two), and Campbell Soup (two). These patents covered a wide variety of highly specialized poultry-processing machinery and equipment, e.g., machines for removing skin from pieces of poultry, breast-sectioning machine, poultry cut-up machine, machine for de-boning chicken thighs, machine for opening the body cavity of poultry carcasses, and process and apparatus for eviscerating poultry.

U.S. food-machinery companies were the major sources of poultry-processing equipment inventions during 1969-1977. The four leading patent recipients were Gainsville Machinery Company (21 patents), International Agri-Systems (15), Gordon Johnson Company (14), and Ford Equipment, Inc. (14). Like those of poultry processors, these patents covered a variety of specialized poultry-processing machinery and equipment.

Compared with the other industries studied, the poultry-processing industry had the smallest percentage of patents that originated with foreign firms. This percentage, however, increased appreciably between 1963-1965 and 1974-1977 (Table 6.1.). Most (69 percent) of these patented innovations originated in the Netherlands (Appendix Table 5).

U.S. individuals received 22.4 percent and foreign individuals 5.5 percent of poultry-processing patents. Among the six industries studied, this represents the second largest share of patents received by U.S. individuals and the smallest share received by foreign individuals, which is consistent with the facts that the modern poultry-processing industry originated in the U.S. and that American firms continue to lead in this field.

The Dairy-Processing Industries

Dairy processing actually comprises several industries that use milk as a common raw material: fluid milk, ice cream, butter, cheese, condensed and evaporated milk. The largest dairy processors make most of these products.

In the USPTO subclasses examined,¹⁵ the seven patents received by two of the top four dairy processors between 1969 and 1974 accounted for 64 percent of all the patents received by dairy-processing firms (Table 6.4). Kraft received six patents and Borden one. All but one of Kraft's patents covered methods and apparatus for manufacturing cheese. The remaining four patents, also pertaining

to cheese manufacture, were assigned to the three firms ranked immediately behind the top four firms. In all, dairy-processors accounted for 7.9 percent of the patents in the subclasses examined.

Food-machinery makers received 20.1 percent and other U.S. firms outside the dairy industry received 6.5 percent of dairy-equipment patents examined (Table 6.3). Eighteen (13 percent) of these were received by four food machinery and equipment firms, Stoelting Brothers Company (five patents), American Machinery Corporation (four), and Grace Machinery Company (four). Practically all of these patents related to the manufacture of cheese.

The greatest single source of dairy-processing patents were foreign corporations, 36.7 percent. Individuals in the U.S. and abroad accounted for another 26 percent and the U.S. government 1.4 percent.

The Sugar-Refining Industry

Sugar-refining inventions covered by the patents summarized in Tables 6.1-6.4 relate to machinery and equipment in the USPTO subclasses 124+ 2 (Sugar, Starch, and Carbohydrates Apparatus; Treating Sacchariferous Material). Although some starch-industry patents are also included in these subclasses, the sugar-refining and starch industries produce distinct products manufactured for the most part by different firms.¹⁶

Labor productivity in sugar refining rose 3.7 percent annually between 1972 and 1977, which was above the average for all manufacturing industries.¹⁷ As in the beer industry, the industry leaders made insignificant investments in R & D. In 1977 the two industry leaders, Amstar Corp. and Great Western United Corp., spent 0.2 percent and 0.3 percent of sales on R & D.¹⁸

The top four sugar manufacturers accounted for only 2.6 percent of all patents in the above subclasses, the smallest share received by the four largest firms in any of the six industries studied (Table 6.4). Only two of the top four sugar companies, Amstar and Great Western, received patents, two each, during 1969-1977. Although not one of the top four sugar companies, CPC International received three patents.¹⁹

U.S. companies not engaged in sugar manufacturing received more sugar-machinery patents than did sugar companies (Table 6.3). However, foreign corporations were the major recipients of sugar-machinery patents, accounting for more patents (52.3 percent) than did all other recipients combined. While the proportion of patents received by foreign firms was the greatest in the sugar industry, the proportion attributed to individual inventors was less than in any of the other industries examined.

Table 6.5 summarizes the sources of patents in sugar refining over the 66-year period, 1912-1977. There are several notable trends over the period. First, the four leading sugar companies received a small share of all patents in all subperiods. Second, the contribution by foreign firms grew enormously at the end of the period, from 5 percent for 1912-1972 to 59 percent for 1971-1977. Third, the role of individual inventors declined substantially over the period, from 79 percent to 18 percent, but throughout the period individuals received more patents than did corporations engaged in sugar refining.

The Starch Industry

Our search of patents in the starch industry included subclasses 23 through 28 of Class 127 (Sugar, Starch, and Carbohydrates), which contain patents disclosing inventions relevant to apparatus used in the separation or purification of starch or the treatment of pure starch. Such apparatus includes bolters and shakers for preparing mill starch by removing hulls and germs (subclass 25), methods for removing gluten from mill starch (subclass 26), vessels for purifying starch liquors through sedimentation (subclass 27), and apparatus for cooking starch (subclass 28). There were relatively few patents in these classes, 54 for the period 1963-1977.

Starch is manufactured by the wet-corn-milling industry, which during 1972-1977 had the fourth highest annual increase (6.2 percent) in labor productivity of 75 industries studied by the U.S. Bureau of Labor Statistics. In 1977 leading companies spent relatively modest amounts on R & D as a percent of sales: CPC International, 0.9 percent; A.E. Staley, 0.4 percent; Archer-Daniels-Midland, 0.9 percent; and American Maize Products, 0.3 percent.

A relatively high percentage (28.6 percent) of all patents in the above subclasses were received by corn-refining companies (Table 6.3). This share was larger than the intraindustry shares attributed to the companies within any of the six industries studied. CPC International and A.E. Staley each received three patents during 1969-1977.

U.S. firms outside the corn-starch industry received only one-half as many starch patents as did starch companies. The largest class of patent recipients outside the starch industry was foreign individuals, who received the same number of patents as did corn-starch companies.

SUMMARY

Examination of the sources of inventions in six food-manufacturing industries shows that the great majority (90 percent) of mechanical inventions relevant to these industries originated outside the industries. Of the 10 percent originating within the industries, less than one-half originated with the four leading firms in each industry.

The reader should keep in mind that these percentages very probably are maximum estimates of the contribution (as measured by patented inventions) of firms within these industries. Our examination was limited to those inventions in USPTO classes that are most applicable to a single industry. Many mechanical inventions have multi-industry uses. Since the subclasses studied tend to be quite narrow, they encompass only a subset of all potential inventions relevant to these industries. Because firms within an industry are more likely to concentrate on industry-specific inventions, the greater part of their inventions are likely to fall within the subclasses we examined than are the inventions relevant to an industry but developed by parties outside that industry.

Our findings indicate that in all industries studied, the great majority of inventions influencing productivity, i.e., machinery and other mechanical inventions, originated outside these industries. The outside sources included corporations and individuals within and outside the U.S. Within the U.S., machinery corporations played an especially prominent role. However, U.S. individuals and foreign corporations, accounted for more patents than U.S. machinery companies. This evidence illustrates that there are many sources of inventive activity, both leading

Table 6.5. Patent Activity in the Sugar Industry, 1912-1977.

	1912-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1977	Total
U.S. Firms	15	28	32	22	29	36	27	189
a) Top Four Sugar	0	3	2	2	4	1	4	16
b) Other Sugar	0	1	1	1	3	6	4	16
c) Other	15	24	29	19	22	29	19	157
Foreign Firms	5	5	10	2	14	40	68	144
Individuals; U.S. and Foreign	75	55	43	22	32	26	21	274
U.S. Government	0	0	1	1	3	1	0	6
TOTAL	95	88	86	47	78	103	116	631

and smaller firms within an industry, U.S. firms that specialize in developing machinery for food processors, and numerous other firms and individuals within and outside the U.S. The share of patents attributed to foreign corporations and individuals has risen in recent years.

FOOTNOTES

- ¹ Nathan Rosenberg, "Technological Interdependence in the American Economy," *Technology and Culture*, January 1979, p. 41.
- ² M.I. Kamien and N.L. Schwartz, "Market Structure and Innovation: A Survey," *Journal of Economic Literature*, March 1975, pp. 4-5.
- ³ U. S. Department of Labor. Bureau of Labor Statistics, Productivity of Indexes for Selected Industries. 1978 Editions (1978), pp. 5-6.
- ⁴ *Ibid*, p.41.
- ⁵ Appendix Table 1.
- ⁶ *Ibid*.
- ⁷ *Ibid*.
- ⁸ These patents covered brewing equipment in two USPTO subclasses: (a) 99-275+ and 195-128 through 132 and (b) 195-138. The first group encompasses patents covering apparatus for the manufacture of beverages that has been further adapted to the carrying out of alcoholic fermentations, to treating the products of such fermentations, or to preparing materials for such fermentations. The second group encompasses subclasses defined to include improvements in apparatus designed to carry out diastatic mashing (i.e., reduction of cereal starch to simple sugars by the action of saccharogenic amylases).
- ⁹ F.M. Scherer, A. Beckenstein, E. Kafer, and R.D. Murphy, "Economy," Unpublished backup reports for their study: *The Economics of Multi-Plant Operation* (Cambridge: Harvard University Press, 1975).
- ¹⁰ F.W. Lawler and R.G. Wright, "All Out For Process Innovation," *Food Engineering*, November 1973, pp. 94-99.
- ¹¹ C.R. Havighorst, "Coors: The Story of an Innovator," *Food Engineering*, January 1977, p. 52.
- ¹² *Ibid*, p. 62.
- ¹³ Patents reported here for the following subclasses within Class 17, Butchering: 1R+ (miscellaneous equipment such as slaughtering enclosures and bone cleaners), 15 (hog scalders), 16+ (hop scapers), 20 (hog singers), 20 (skinners), 23 (carcass splitters), 24 (elevator and conveyors), 25+ (meat tenderers), 32 (meat briquetters), 33 (sausage stuffers and linkers), 34 (sausage linkers), 35+ (sausage stuffers), 42 (larding pins), 43 (intestine cleaners), and 44 (supports and shackles).
- ¹⁴ B.W. Marion and H. Arthur, *Dynamic Factors in Vertical Commodity Systems: A Case Study of the Broiler System*, Research Bulletin 1065 Ohio Extension Station, November 1973.
- ¹⁵ The patents pertaining to dairy processing are assigned to a large number of such scattered USPTO general equipment classes as C1.62: Refrigeration; C1.100: Presses; C1.13.7: Fluid Handling; C1.138: Pipes and Tubular Conduits; C1.159: Concentrating Evaporators; C1.165: Heating Exchangers; and C1.210: Liquid Purification. Since these classes cover multipurpose equipment, the examination was restricted to subclasses 99-452+: Apparatus, Mechanical, Fluid, or Heat Treatment of Dairy Food. According to the Current Class 99 *Classification Definitions* (August 1974), this class has 15 subclasses containing a variety of equipment adapted to pasteurizing, cooling, diluting, compacting, and otherwise treating fluid dairy products.
- ¹⁶ The top four sugar companies are Amstar, Great Western, C & H, and Savannah. The leading starch companies are CPC International, A.E. Staley, American Maize-Products, Cargill, Archer-Daniels-Midland Co. Products, and Standards Brands.
- ¹⁷ U.S. Department of Labor, *op. cit.*, p. 37.
- ¹⁸ Appendix Table 1.
- ¹⁹ These patents related to sugar not starch.