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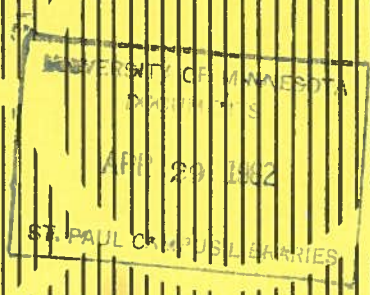
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# MARKET STRUCTURE AND TECHNOLOGICAL PERFORMANCE IN THE FOOD MANUFACTURING INDUSTRIES



Agriculture Experiment Stations of Alaska, California, Cornell, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, New Mexico, North Dakota, Ohio, South Dakota and Wisconsin.

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## PART IV

# CONCLUSION

### CHAPTER 9. SUMMARY AND CONCLUSIONS

This study has been an attempt to explain the sources of increased productivity of the food-manufacturing industries. It examined the relationship between the competitive structure of these industries and their R & D investments and outputs. It next identified the origins of the inventions and innovations influencing the productivity of these industries, finding that much of this technology originated with parties outside as well as within an industry. R & D effort by food manufacturers represents but a subset of the total R & D effort that ultimately determines their productivity.

This finding helps to explain the paradox that whereas food manufacturers spend very little on R & D they experience quite rapid increases in productivity. Indeed, some food industries (e.g., beer) that have spent trifling amounts on R & D have experienced much more rapid increases in productivity than the nation's most R & D-intensive industries.

Our analysis of the relationship between the competitive structure of industry and R & D inputs and outputs found that industry structure does indeed make a difference. The findings, which are summarized in detail in Chapter 5, do not support Schumpeterian and Galbraithian hypotheses that great market power and very large firm size best promote R & D effort. Rather, in food manufacturing industries decreasing returns to firm scale and market power occur beyond medium-firm size and moderate levels of concentration. Predicted industry R & D is maximized (over the constrained set of industry structure) at even lower levels of market concentration. Insofar as the estimated models can be used for making decisions regarding public policy, it appears that antitrust and other policies that promote competition or place restraints on the growth of large firms are not likely to affect adversely R & D inputs and outputs in food manufacturing. However, industrial restructuring that reduces concentration and the size of leading firms promises to increase only modestly R & D activity of food manufacturers. Moreover, industrial restructuring to achieve increased R & D inputs or outputs would be quite complex because of the interaction of concentration, firm size, and number of firms.

Parts II and III of our study further qualify the importance of competitive structures as determinants of R & D effort. The greater part of inventive and innovative activity that results in greater efficiency in food manufacturing originates outside these industries. This finding has important implications for public policy aimed at the competitive structure of industry. Examples best illustrate this point. Many of the inventions that contributed to the evolution of high fructose corn syrup came from laboratories of the Japanese government and from firms outside the corn wet-milling industry: Corning Glass Works; Miles Laboratories, Inc.; Novo Industri A/S. Moreover, as shown in Chapter 5, the estimated R & D output of a \$1 billion industry where four firms controlled 80 percent of sales might be increased by restructuring so that the top four firms held 60 percent of sales. (Estimated R & D expenditures would rise 20 percent, R & D employment would rise 65 percent, and industry patents would rise 198 percent.) These potential benefits of industry

restructuring shrink considerably, however, when they are placed in perspective by comparing them with *total* R & D outputs as measured by patents, i.e., patents originating outside as well as within an industry. For example, even if the patent output of beer companies were doubled, it would still be less than 15 percent of the total patents most closely identified with the beer industry. The total patents assigned to the top four firms within the industry patent classes examined represent modest shares of all patents originating within and outside all of the six industries studied.

Examination of the sources of innovations identified as making significant contributions to the efficiency of food manufacturing yielded the same general results as the study of patents. We studied 265 innovations that were cited with Putman Awards during 1969-1976 that showed promise of improving the efficiency and effectiveness of food manufacturers. Only a very small share (13 percent) of the innovations were made by food processors and food-ingredient manufacturers. The largest share (55 percent) was attributed to firms that manufactured food machinery, provided plant maintenance, sanitation and designs, and developed instrumentation and control systems. Paper and packaging companies (6 percent), chemical firms (4 percent), and miscellaneous corporations and government laboratories (21 percent) accounted for the remainder.

Smaller firms made a surprisingly large percentage of the innovations: 44 percent were by companies with annual sales under \$10 million and 63 percent by companies with sales under \$100 million.

About one-fourth of these innovators were acquired, either prior to or after receiving their awards. About 75 percent were acquired by corporations with sales exceeding \$100 million, suggesting that large firms used acquisitions to acquire innovations and outstanding researchers.

In sum, the evidence assembled here indicates that most inventions and innovations affecting efficiency originate outside the food-manufacturing industries. Another finding is the great diversity of the sources of inventive and innovative activity. Firms of all sizes within and outside the food-manufacturing industries, individual inventors, independent research laboratories, and government-sponsored research laboratories have all made meritorious inventions. Smaller enterprises have been especially productive in this regard. The case study in Part III shows that inventions relating to high-fructose corn syrup have resulted from the research investments of small firms (Baxter Laboratories, Miles Laboratories), large firms (Standard Brands, Corn Products Co.), foreign firms (Novo Industri A/S, Mitsubishi Chemical Industries), and government laboratories (Japanese Fermentation Research Institute).

These findings support the view that invention and innovation are best promoted by multiple sources of research effort, a conclusion consistent with the findings of Jewkes, Sawyers, and Stillerman's study of important inventions in all fields. They concluded:

It cannot be disputed that inventions and discoveries have had, and continue to have, many sources. It may be tempting to argue that one or another of these sources is more fruitful than the others and should be stimulated even at the expense of the rest. Our impressions are that, given the present state of knowledge, it is safer to strive to keep all the sources open since competition strengthens the flow of new ideas.<sup>1</sup>

The finding that most new production technology originates outside food manufacturing is not an indictment of these industries; rather it supports Rosenberg's theory of interindustry technological interdependence.<sup>2</sup> This theory posits

that the beneficiaries of increased productivity flowing from many innovations are located outside the industry in which the innovation originated. Although this theory has relevance for all industries, it is particularly important in food-manufacturing industries because of their large size, the common production processes shared by many food-manufacturing industries, and the relative simplicity of the technology employed in these industries. The first two factors create a large potential market for inventions and innovations, and the latter increases the supply of potential inventors and innovators. Food-machinery companies illustrate these points. Not only does the size of many individual food-manufacturing industries create a large market for food machinery, but this market is further enlarged because many food manufacturing industries employ common technical processes. This enables machinery makers to develop technology common to several industries. As a result, the technical know-how of food-machinery companies may be used to develop equipment for several industries. Thus, food-machinery companies have a larger potential market than do the individual food manufacturers whose primary concern is with their own industry. This difference in the size of markets for firms within and outside an industry encourages specialization in food-machinery manufacturing. The relative simplicity and small costs involved in most machinery and equipment innovations enlarges the potential supply of food-machinery inventors and innovators.

This was not always so. In the past, food manufacturers often built much of their own equipment, not by choice but of necessity. This was particularly true in small, new industries requiring specialized equipment not made for other industries. For example, during the infancy of the prepared-baby-food industry firms were forced to design and build much of their own equipment. But as the industry grew, its demand for machinery grew sufficiently to give machinery manufacturers an incentive to supply the necessary equipment. Today, prepared-baby-food makers can purchase practically all their machinery and equipment. The lessening need for baby-food manufacturers to develop technology of their own is illustrated by the changing mix of patents issued to Gerber Foods, the industry leader. During the 1950s, 71 percent of Gerber's patents covered mechanical inventions; this percentage fell to 35 percent during the 1960s and to 14 percent during the 1970s.<sup>3</sup> Although we have not examined the historical trends in the patent mix of food manufacturers, we believe that the baby-food industry typifies what has occurred in many other food industries.<sup>4</sup>

We reemphasize a caveat made earlier about the nature of this study and the interpretation of its findings. The great majority of inventions and innovations examined relate to mechanical equipment, production processes, control systems, plant designs, and related matters that are primarily important to the productive efficiency of food manufacturers. Where patents dealt with new products we were unable to determine their economic or social value. We did not address this question because it was beyond the scope of the data analyzed, not because we believe the question is unimportant.

Our findings are relevant to the interpretation of observed relationships between the competitive organization and technological performance of industries. They suggest that when there are significant relationships between industrial structure and technological performance, as have been found here and in most other cross-sectional studies, these findings must be placed in a broader context that includes the sources of all inventions and innovations affecting an industry. In many food-processing industries, and perhaps in many other types of industries as well, alternative industrial structures would have an insignificant impact on total inventive effort influencing technical efficiency.

This is not to denigrate cross-sectional studies or the public-policy questions that they seek to answer, particularly those relating to competition policy. But our findings suggest that considerable caution must be used in interpreting the public-policy significance of studies focusing solely on how an industry's competitive structure influences its technological performance. More competition may or may not be a good thing in food manufacturing, but public-policy decisions concerning this question must be based on concerns for other than technological development, concerns such as for the impact of market power on income distribution or allocative efficiency.

## FOOTNOTES

<sup>1</sup> J. Jewkes, D. Sawyers, R. Stillerman, *The Source of Invention*, 1968, p. 288.

<sup>2</sup> Nathan Rosenberg, "Technological Interdependence in the American Economy," *Technology and Culture*, January 1979, pp. 25-50.

<sup>3</sup> Not only did patents covering mechanical inventions represent a declining share of Gerber's total patents, but they declined in absolute terms as well.

<sup>4</sup> This finding is consistent with Stigler's theory of vertical disintegration. G. Stigler, "The Division of Labor is Limited by the Extent of the Market," *Journal of Political Economy*, June 1951.