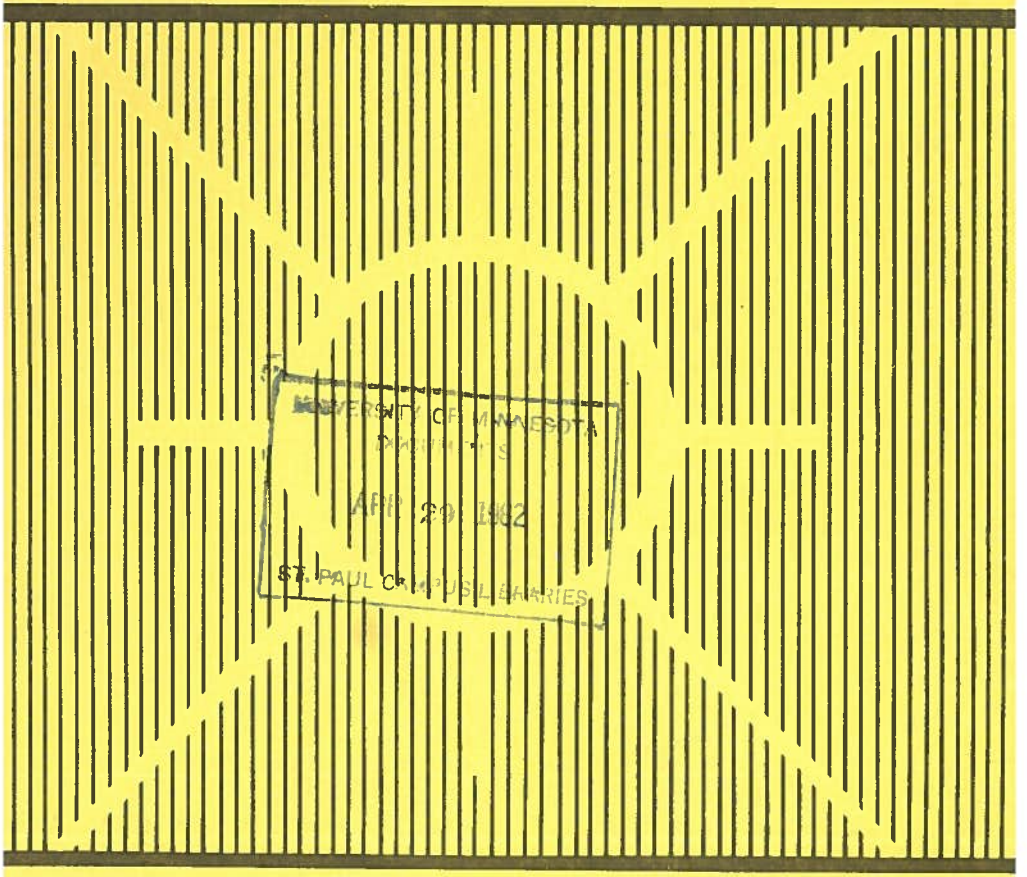
MARKET STRUCTURE AND TECHNOLOGICAL PERFORMANCE IN THE FOOD MANUFACTURING INDUSTRIES



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CHAPTER 5. SUMMARY OF STRUCTURE—R & D PERFORMANCE

The preceding chapters examined empirically the relationship between firm- and market-structure variables and firm research-and-development activity in the food-processing industries. It employed multivariate regression analysis using separate data sets for 1950-1956 and 1967-1974 to determine the independent effects of several structural and control variables in these two time periods. In the earlier period, the dependent variables were the number of firm R & D employees and the number of patents assigned to the firm, whereas in the latter period firm R & D expenditures was also used.

The firm data for the structural variables were exceptionally good. For the structural data centered at 1950, data at the 5-digit level were used for all observations. For the latter period, the structural data for most of the observations were at the 5-digit level.

A technological-opportunity variable was included to control for differences in the underlying technology of industries. The variable used an intercept dummy to allow for higher and lower technological-opportunity classes within the food industries. Since this variable is significant at the 5 percent level or higher in all but one of the best models, it appears significant differences in technological opportunity exist among various food industries.

OVERVIEW OF REGRESSION RESULTS

Various hypotheses relating firm- and market-structure variables to firm research-and-development activity were reviewed in Chapter 2. Starting first with firm size, there were theories hypothesizing both increasing and decreasing returns to scale. In order to test these hypotheses, both the log of firm assets and the squared log of firm assets were used as regressors in the regression models. In both time periods and for all dependent variables, the estimated relationship had a point of inflection at fairly modest firm size. This point of inflection is where the function changes from increasing at an increasing rate to increasing at a decreasing rate with firm size. For the best 1950-1956 models, this occurred at firm assets of $75 million in the patent model and $78 million in the employment model. With the best 1967-1974 models, the point of inflection occurred at $126 million in the R & D personnel model, $130 million in the R & D expenditures model, and $149 million in the patent model. The wholesale price index for industrial commodities rose by 28 percent[1] from 1950 to 1967 while the average inflection point increased by 78 percent; this suggests that there has been some increase over time in the "real" firm size at which the point of inflection occurs.

The estimated relationship between market concentration and firm research-and-development activity differed between the two periods. Economic theory suggested both positive and negative effects of increasing market concentration. Our specification of the regression model, with both linear and quadratic terms, allowed us to detect a maximum or minimum in the relationship. In the best 1950-1956 models neither linear nor quadratic CR4 was significant. In contrast, both linear and quadratic CR4 were significant in the best R & D employment and R & D expenditures models for 1967-1974, but not in the patent model. The estimated relationship was positive initially, then attained a maximum at CR4 equals 58 (employment) or 59 (expenditures), and then was negative for larger CR4s.

Thus, while in the earlier period four-firm concentration was not significant, in the later period it was significant and had a critical value where the function attained a maximum within the range of the data.

The relationship between firm relative market share and firm R & D activity, as with the relationship between market concentration and R & D, differed significantly between the 1950-1956 and 1967-1974 samples. In the best 1950-1956 patent model, linear and quadratic relative market shares were significant at the 20 percent level. With employment as the dependent variable, linear relative market share was significant at the 5 percent level and squared relative market share at the 10 percent level. These polynomials in relative market share (RMS) attained a maximum at RMS equals 31 and 36 in the patent and employment models, respectively. In the best 1967-1974 models, linear relative market share had a positive estimated coefficient that was significant at the 5 percent level in the R & D expenditures and patent models and only at the 20 percent level in the R & D employment model; squared relative market share was deleted in all best models. Thus, while there was a critical level of RMS, in the 1950-1956 sample beyond which firm R & D declined as RMS increased, no such critical value was seen in the 1967-1974 sample.

Industry advertising-to-sales (AS) was the third and last measure of market power. As with market concentration and relative market share, the estimated functional relationship between AS and firm research and development differed between 1950-1956 and 1967-1974. In the 1950-1956 regressions, both AS and SAS were included in the best models, but only AS was significant at the 10 percent level, and then only with R & D employment as the dependent variable. In the best 1967-1974 models, AS was significant at the 5 percent level or higher in R & D expenditures and patent models and was not significant in the R & D employment model. SAS was significant at the 5 percent level in the patent model and was not included in the other best models. Thus, while industry advertising-to-sales was not significant in 1950-1956, it was significant in 1967-1974 and the function relating R & D to AS displayed both linear and quadratic behavior.

Firm diversification was consistently a highly significant variable in both 1950-1956 and 1967-1974. Economic theory suggested that this variable, which is the number of 5-digit industries in which the firm has a substantial value-of-shipments, would have a positive estimated coefficient. With the 1950 structural data, diversification was positive and significant at the 5 percent level in the best patent model and at the 1 percent level in the best employment model. In the 1967-1974 models, firm diversification was positive and significant at the 1 percent level when patents and R & D employment were the dependent variables and at the 5 percent level when R & D expenditures was the dependent variable.[2]

Finally, the percent nonfood variable was significant in only one model and the percent foreign sales variables was never significant.[3] In the best R & D expenditures model the percent nonfood variable was positive at the 1 percent level.

THE INTERPRETATION OF FIRM STUDIES FOR INDUSTRY RESTRUCTURING

How are these regression results to be interpreted? Does it matter, for the purpose of interpretation, whether the unit of observation is the firm or the industry? While the hypotheses of economic theory relate firm R & D to firm and market structure, from the point of view of public policy it is the total research of

all firms in the industry, not the research of the individual firm, that is of interest. It has been implicitly assumed in previous studies of firm invention that the estimated coefficients are to be interpreted as representing the effect of firm and market structure on both firm and industry R & D. However, it is necessary to recognize that for a given industry size, it is not possible to change independently market concentration, relative market share, firm size, and the number of firms in the industry. These variables are interrelated; a change in the value of one may imply a change in the value of others. Because of this interdependence, the regression coefficients from a firm study must be carefully interpreted when they are applied to an industry.

By comparing expected *industry* R & D performance for several different industry structures, we will illustrate the complexity of determining the effect of changes in firm- and market-structure variables on industry R & D performance. Expected *industry* R & D performance is calculated by substituting into the *firm* R & D equation the values of the structural variables appropriate for that industry structure. Expected *industry* R & D performance is the sum of the expected R & D performance of all firms. Then, a direct comparison can be made of the expected industry R & D performances associated with different industry structures.

For this illustration we use the regression coefficients from firm models 4.3, 4.5, and 4.7 to calculate expected industry R & D for an industry whose initial structure is similar to that of the ready-to-eat breakfast-cereals industry in 1976. This structure is then modified to reduce concentration to 60. Restructuring to reduce market concentration reduces the size and market share of the leading firms and increases the number of firms in the industry. The firm data for the initial and restructured industry are presented in Table 5.1.

Table 5.2 presents expected industry R & D expenditures, R & D employment, and patents for each of the two industry configurations. Expected industry R & D, for all measures of R & D, is greater in the restructured industry. When market concentration declines from 90 to 60 expected industry R & D expenditures, R & D employment, and patents increase by 21 percent, 26 percent, and 199 percent, respectively.

Table 5.1. Initial and Final Industry Structures for Calculating Industry R & D, 1976

	Firm Market Share	Firm Relative Market Share	Firm Assets (millions)	Four-Firm Concentration Ratio
Initial Structure (1976)				
Kellogg	43%	48%	$430	90
General Mills	21	23	210	90
General Foods	17	19	170	90
Quaker Oats	9	10	90	90
Nabisco	4	4	40	90
Ralston Purina	3	3	30	90
Other	3	3	30	90
New Structure				
New firm	15%	25%	$150	60
New firm	14	23	140	60
New firm	14	23	140	60
New firm	11	18	110	60
New firm	10	17	100	60
General Foods	17	28	170	60
Quaker Oats	9	15	90	60
Nabisco	4	7	40	60
Ralston Purina	3	5	30	60
Other	3	5	30	60

Source: Firm market-share data for 1976 for the ready-to-eat breakfast-cereal industry were available from the September 4, 1978, issue of *Advertising Age* (page 67). We assumed that industry assets are equal to $1 billion and that firms' sales are equal to their assets. Firms' assets can then be derived from their market shares. All firms are assumed to be specialized. The 1972 industry advertising intensity of 13.5 was used for all firms, which assumed that the restructuring did not influence advertising intensity.

The estimated R & D performance of the restructured industries appears to offer a significant improvement. But given the tentative nature of our findings, this is hardly sufficient grounds for industrial restructuring. If it were, a similar case could be made for restructuring all food manufacturing industries whose CR4s were below 60.

Before a case can be made for restructuring solely on grounds of improving R & D performance, another question must be answered: How important is the R & D effort originating with food manufacturers compared to the R & D effort originating with firms and institutions located outside food manufacturing?[4] Only when this question is answered can we place in proper perspective any marginal changes in R & D performance resulting from structural changes in the food-manufacturing industries. Answering this question is the subject of the remainder of this study.

Table 5.2. Expected Industry R & D for 2 Different Industry Structures.

	Present and Expected Industry R & D Expenditures (Millions)	Expected Industry R & D Employment	Expected Industry Patents
Present Structure	$31.0	639	72
New Structure	37.6	808	215

FOOTNOTES

[1] *Economic Report of the President 1973,* (Washington, D.C.: United States Government Printing Office, 1973), p. 248.

[2] Several models were estimated with a quadratic firm-diversification term but none are reported since this term was never significant.

[3] Excluding equation 1.1 where NONFO was significantly negative.

[4] There are of course many other economic and noneconomic issues relevant to the decision to restructuring an industry. Our failure to discuss them does not imply that we are indifferent to them. Rather, such an examination is beyond the scope of this inquiry.