VERTICAL INTEGRATION IN THE FOOD MANUFACTURING INDUSTRY,

1967-1992

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# VERTICAL INTEGRATION IN THE FOOD MANUFACTURING INDUSTRY,

# 1967-1992

Youssouf Diabate

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VERTICAL INTEGRATION IN THE FOOD MANUFACTURING INDUSTRY,

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# VITA

Youssouf Diabate, the son of Mamoutou Diabate and Haoua Kone, was born and raised in Bamako, Mali. He graduated from Bouillagui Fadiga High School in 1977 and from the Polytechnic Institute of Katibougou in 1986 with a degree of Engineer in Animal Sciences. He worked as consultant for Carl Bros International in Mali on a study on the "Integration of Agriculture and Animal Sciences in the Sahel". He obtained the degree of Master of Science in Agricultural Economics at Tuskegee University, Tuskegee, Alabama in 1995. From 1995 to the present, he worked in the Rural Business and Economic Development Program at Tuskegee University as a business development specialist, with a focus on business planning, economic development, and entrepreneurship development in the Alabama Black Belt counties.

DISSERTATION ABSTRACT

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This study uses Ordinary Least Squares (OLS), fixed effects, and random effects models to test the relationship between vertical integration and concentration ratios, demand growth, average firm size, and total factor productivity. The data set contained forty-one different food industries. Data at the four-digit industry level were from 1967 to 1992. The industries are those defined in the Standard Industrial Classification (SIC) and cover virtually the entire food manufacturing sector with the exception of a few excluded industries because of the unavailability of particular variables due to changes in industry classification. The objective of this study was to replicate the Levy (1984) model for the food manufacturing industry. The model presented in this study examines the quantitative relationship of concentration, industry growth, firm size, and total factor productivity on vertical integration in forty-one food manufacturing industries with data from 1967 through 1992. The fixed effects model was found to be a better prediction of vertical integration than the random effects model according to the Hausman test, whereas Levy's study favors the random effects model. The results indicate that only total factor productivity is significant in both the fixed effects and the random effects models. Selected subsets of the food manufacturing industry also produced different results. While the vertical integration model of Levy (1984) should be applicable to all manufacturing industries, the present results suggest that it is not. The empirical results found here in the analysis of vertical integration in food manufacturing industries do not follow a common path. This finding calls into question Levy's pooled data results. Levy's results cannot be replicated with newer data and different industries. Finally, industry by industry analysis shows that there is considerably greater diversity in results than is even suggested by the fixed effects model. These results were not consistent with Stigler's assertion that "the division of labor is limited by the extent of the market".

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# I. INTRODUCTION

The issues involved in the introduction of industrialization into agricultural production have created a demand for studies on production agriculture. The industrialization of agriculture refers to both the integration of agriculture into factory farming and the industrial economy itself. Although the study of industrialization in other industries was initiated by Coase (1937) it took decades for agriculturalists to realize that industrialization can also be applied to the food production and marketing industry. According to Boehlje and Schrader (1998) the industrialization of agriculture has been characterized by the changing nature of the linkages between stages and the consolidation of firms in the food production and distribution system. The introduction of industrialization in farming has increased the size of farms and made them more capital intensive and specialized in production, marketing, and labor use. With industrialization comes a closer integration between production, marketing, and the adoption of factory-like production systems.

The U.S. agricultural industry has had the characteristics of pure competition, in which large numbers of buyers and sellers traded homogeneous commodities in open markets, with spot prices coordinating product flows from sellers to buyers. However, these characteristics are changing with increased market concentration due to a smaller number of firms accounting for a greater portion of sales or purchases in all sectors of agriculture. Examples of these changes include contractual arrangements between growers and processors, consolidation and increasing concentration in the meatpacking industry, mergers in the grain processing, agri-chemical, and seed industries, railroad mergers, and increases in the overall scale of individual production. Now that consumers are under more time pressure and more health conscious and more ethnically diverse, the nature of food demand has changed. These changes, in turn, have affected how food is produced and marketed.

Industrialization of food processing has had an impact on buyers and sellers in many areas, including the average size of operations, degree of horizontal and vertical integration, diversification or specialization, market concentration, product differentiation, legal organization, contractual marketing arrangements, and barriers to entry. One of the more important elements in food processing industrialization is that vertical integration has resulted in greater concentration in the food industry. MacDonald (2000) emphasized three main concerns connected with this increased concentration in agribusiness: the declining numbers of buyers purchasing from farmers in such key commodity processing industries as meatpacking, grain and oilseed processing; the replacement of cash transactions by contracts organizing the marketing of farm products; and the introduction and expansion of biotechnology in input markets whereby the exchange of intellectual property can lead to increased concentration in input markets.

**Problem Statement**

Vertical integration/coordination in the U.S. food industry has raised concerns about processor market power and marketing methods, changes in the size of food processing industries, production methods, and business organization. The markets have been affected by decreasing numbers of buyers and sellers of raw and processed intermediate agricultural commodities, changes in the methods of exchange between growers and buyers, particularly in input markets, and the emerging influence of biotechnology. Vertical integration can be implemented either through direct ownership or by contracts between two firms at adjacent stages in the marketing channel. This integration often leads to a decrease in the amount of market price information available, rendering price discovery a major issue. In a similar manner, market entry becomes more of a problem as the market structure tends toward fewer larger firms. Small producers/firms also have some concerns. Larger buyers and sellers restrict their market outlets, and trading on the open spot market generally becomes more volatile when spot market prices are based on fewer trades. There is fear of price discrimination if quality premiums in contractual arrangements are not made publicly available (MacDonald, 2000).

Vertical integration limits competition and promote monopoly power, putting small farmers out of farming and eliminating a major source of income from farm communities (MacDonald, 2000). It is important to study how vertical integration is achieved by food industries, and the factors influencing the establishment of such organizations.

**Purpose and Objectives**

The purpose of this study was to assess vertical integration in the food manufacturing industry using Levy's (1984) model. Attempts were made to systematically collect, review, and interpret available data to provide a meaningful framework for understanding vertical integration in the food manufacturing industry. Specific objectives were to:

(1) describe vertical integration in the food manufacturing industry; (2) determine

(2) the variables influencing vertical integration in the food manufacturing industry; and

(3) replicate Levy's model of vertical integration using forty-one food manufacturing industries, and some selected variables and determine the influence of these variables on vertical integration in the food processing industry.

**Justification and Relevance of the Study**

The food manufacturing industry is important to the US economy due to its contribution to the GNP, and to producers and consumers. The food manufacturing industry is one of the largest business in the United States, and the largest such industry in the world (Connor, 1988). Food manufacturing is changing and becoming highly integrated. Some business information is available on the food processing industry but there is almost no literature or relevant statistical analysis on its vertical integration. Another reason for the food industry's importance is the effect of its industrial structure on the shift from small firms to large corporations. Vertical integration is considered a barrier to competition in the food industry but it is also believed that vertical integration results in lower food costs and hence savings to consumers. Koch (1980) stated that vertical integration enables a firm to reduce costs and increase efficiency, and may also reduce and restrict competition in the market in which the firm operates. It also can, in some cases, create market power and increase the barriers to the entry of new competitors. According to Carlton and Perloff (1994) vertical integration is beneficial to the economy and increases the welfare of consumers if firms were allowed to vertically integrated to reduce the cost of production.

The full implications of vertical integration in the food industry are not yet completely understood. This study examines vertical integration in the food manufacturing industry using Levy's model. Particular attention is paid to a number of important indicators of vertical integration: concentration in the food processing industry, demand growth, average size of firms, productivity factors, and the changes that they have brought that affect the evolution of vertical integration. Specifically, this study focuses on how these variables impact vertical integration in the food manufacturing industry.

# II. LITERATURE REVIEW

Transactional economies are the most important determinants of vertical integration. Transaction costs are different from production costs in that they are associated with the process of exchange itself. Asset specificity is the primary determinant of vertical integration in transaction cost economies. With asset specificity, an upstream or downstream firm makes investments such that the value of an exchange is greatest when it occurs between these two branches, rather than with other firms. Thus, transaction-specific assets create a bilateral monopoly. According to Kaserman (1978), there are no incentives for vertical integration in markets where: (1) transaction costs are absent; (2) all relevant costs and prices are known; and (3) output and input prices are given. The relaxation of any of these assumptions can result in the creation of such incentives, but the structure and performance consequences that are generated vary with the particular assumption dropped. Market structure, or industry structure, refers in part to the number, size, and location of firms in an industry. Consumer demand for products and economies of scale for firms in a particular industry determine the industry structure.

Anderson (1998) studied the potential effects of increased non-price vertical coordination in the feed cattle market. A non-price vertical coordination is a form of contracts, business arrangements, etc., between packers and cattle feeders. Anderson (1998) was trying to determine the value in terms of increased industry level profits of coordinated marketing/purchasing of fed cattle by feedlots and packing plants. He found that the potential gains in industry-level profit due to the adoption of non-price coordination strategies are significant in the fed cattle market. This profit increase was due not only to cost reductions from coordinated production and/or marketing but also to boxed beef price increases.

The beef and lamb industries both experienced rapid structural changes in the 1970s and 1980s. According to Ward (1995), the low number and cost of processing plants were the results of economies of size in slaughtering, combined with a declining demand for beef and lamb. He emphasized that "takeovers and acquisitions, spinoffs and divestitures combined to result in consolidation among firms, leaving relatively few, large, highly concentrated processing firms." The pork industry experienced similar changes in the 1980s and 1990s; declining demand and economies of scale were again the main driving forces.

The retail distribution stage of the beef, pork, and lamb industries has also changed due to the reduction in the number of firms, and the increase in the size of the firms that remain. Ward (1995) argued that the broiler and turkey industries experienced some of the same changes, but to a lesser degree and over a different time period because the structural changes occurred in the 1950s and 1960s. The driving forces for changes during the last two decades have thus not been the same for the poultry industries as for the red meat industries. Ward (1995) argued that the driving forces for changes for the red meat were economies of size in slaughtering and processing, combined with declining demand for red meat, resulted in a sharp trend toward fewer, larger, and more cost-competitive plants. Whereas, the broiler and turkey industries experienced some of the same changes, but to a lesser degree and in different time period. First, many structural changes in broilers and turkeys arose in the 1950s and 1960s, well ahead of similar changes in beef, pork, and lamb. Second, the driving forces for changes during the last two decades were not the same for the poultry industries as for the red meat industries. Declining consumer demand was not a problem. In sharp contrast, the quantity of broiler and turkey products demanded by consumers has continued increasing the past two decades. Economies of size in processing were not as important to recent consolidation among firms as other factors, perhaps economies of scope and distribution.

Market behavior, or market conduct, deals with pricing behavior and product marketing. According to Pierce (1997), the cattle industry has economic and production facets that do not favor a transition to the level of vertical integration seen in the pork and poultry industries, and will likely not follow that path of industry development. According to Pierce (1997) the modern housing arrangements for pork and poultry allow and even favor identical genotypes and phenotypes in all areas of the country. In contrast, the environment, forage type, and pest exposure in different areas of the North American continent dictate that cattle breeds and genetics be chosen that will enable the animal to excel biologically and economically in each of these areas and will differ depending on location. A particular breed and type of cow that is best suited for the Midwest is much different than that required in the Southwest, etc. Whereas, poultry and pork production environments are tailored to the production systems, beef production systems are tailored to the local environments. Further, the type and consumer appeal of beef products differs greatly by region. In other words, the land requirements for cattle production are extremely extensive. In contrast, both the pork and poultry industries use confinement production. There is basically no land required for raising either hogs or broilers, except that required indirectly to raise corn. For the beef industry to ever be fully vertically integrated would require control of huge landholdings by a single entity. However, non-integrated coordination may improve long-term productivity and efficiency in beef production and marketing. Pierce (1997) suggested that there may be opportunities to capture many of the efficiencies of vertical integration for cattle production by capitalizing on coordination (vertical and horizontal) among beef producers, processors, marketers, and suppliers. However, he argued that vertical integration, including strict production contracts and ownership of multiple stages of production by only a few firms, is not beneficial from a production science point of view for the beef sector. Whereas, coordinating activities that reduce transaction costs and increase the transfer of supply and demand information through the system has the greatest potential to increase beef system profit.

MacDonald (2000) analyzed data on the procurement market for animals and found that the share of all hogs slaughtered by the four largest hog packers was 54%, while the share of all steers and heifers slaughtered by the four largest steer and heifer packers was 80%. He indicated that the average across all U.S. manufacturing industries is close to 40%, and 80% is generally considered to be highly concentrated. Economies of scale in meatpacking firms represent the most striking example of increased concentration in agribusiness, but the pattern of concentration may also be explained by the use of contracts. The advantage of contracts for farmers is the reduction in their price risks by transferring risks to processors, who are often better positioned to bear such risks. In some cases, holding a contract may make it easier for a farmer to acquire debt financing. Contracts can provide incentives to produce higher and more consistent levels of product quality, and increase consumer demand. However, a disadvantage of contracts is resulting price discrimination by buyers, who exploit the potential market power created by concentration.

Stumo (1998) maintained that the bulk of the livestock produced in the U.S. now originates from factory farms under contract to IBP, Monfort (a ConAgra subsidiary), and Excel (a Cargill subsidiary) as a result of secret undisclosed negotiations. He stated that the Big Three plus National Beef (a subsidiary of Farmland Industries) controlled 82% of the national steer and heifer slaughter in 1997. In hogs, the Big Three plus Smithfield Foods (which recently became the nation's largest pork packer after acquiring John Morrell & Company's plants), and Hormel control 63% of pork slaughter. Firms not engaged in contract or ownership integration may find themselves unable to market products or purchase products from firms that are vertically integrated. This may become increasingly evident as attempts are made to move closer to value-based marketing. Value-based marketing refers to a system in which animals are priced individually based on carcass merits, typically quality grade, yield grade, and carcass weight.

Producers who do not produce the quality of products those prices indicate, or that integrated firms demand, may find their market access severely limited. Spot prices have been the coordinating mechanism in the beef industry for decades. However, the percentage of trade coordinated by market prices decreases as one moves from feeder cattle marketing, to fed cattle marketing, to wholesale beef marketing. Up until the past few years, spot prices have also been the primary coordinating mechanism in the pork industry. Integrated farrow-to-finish operations are common in the pork industry.

However, with the increase in larger contract production units, the volume of independent feeder pig production has declined. Ward (1995) stated that less than 5% of hogs were being marketed under contract or ownership integration, but this percentage has since increased sharply, and will continue to increase during the next few years. He suggested that the percentage of slaughter hogs produced or marketed under contract was about 15% in 1991 and may have been over 20% in 1995, probably heading toward 30% in the near future. For feeder lambs, market prices are the primary coordinating mechanism, while spot prices are still the primary coordinating mechanisms for slaughter lambs 30 percent or more of slaughter lambs are marketed under some type of vertically integrated arrangement. Ward (1995) found that a smaller percentage of lamb was marketed by vertical integration from packers to retail and food service distributors than for either beef or pork. Nearly all poultry production is coordinated by contract or ownership integration. In essence, there is no spot market for live poultry. Prior to the disappearance of the live poultry market, price discovery for live broilers and turkeys was a problem (Ward, 1995).

Market performance measures such indices as the profitability of firms in an industry and their returns on investment. Increasingly, there is less and less information about the market performance of livestock and poultry industries as the trend is toward more consolidated and concentrated industries. Privately-owned firms do not report performance information publicly, and some publicly-owned firms only report consolidated financial reports rather than reports by commodity or product groups. Therefore, it is difficult to monitor or track the performance of firms in the livestock and poultry industries. Most would argue that consumers are winners in the case of poultry, receiving abundant supplies of a variety of products at reasonable prices. Ward (1995) argued that consumers are also benefiting, or will soon benefit, from structural and behavioral changes in the red meat industries.

Demand growth is a proxy here for stages in the industry life cycle. According to Stigler (1968), the life cycle of a firm is characterized by changes in the age of the industry. In relatively new industries with smaller scale, there is no incentive for specialized suppliers to develop. Each firm produces all the successive steps of the production process, so that the industry initially does not branch out horizontally or vertically. Eventually, though, all firms become vertically integrated. So that as the industry matures and increases scale, there is a greater opportunity for specialization, because the per-unit transaction costs decrease. Therefore, firms "farm out" increasing numbers of their sub-processes to more specialized firms. In declining industries, suppliers exit the industry.

Stigler (1968, p. 171) stated that "when a firm supplies only a part of its needs for some process, the rising costs of internal coordination are in fact the basis of explanation for partial recourse to purchase" . This will happen if the increase in internal costs with firm size, and the costs of managing nonsimilar activities increase more than for an uniform activity. Therefore, vertical integration will be inversely related to the scale of the firm economic activities.

The number of firms in an industry is another important and measurable aspect of the extent of the market that might be expected to affect vertical integration. According to Williamson (1975) vertical integration may be a result of some small numbers bargaining problems. Small numbers situations occur when economies of scale arising with experience, location or production of a specialized component confer cost advantages on a producing firm. Because of the lack of alternative buyers and sellers, firms are able to take advantage of their bargaining position. To internalize the associated costs firms vertically integrate. Levy (1984) added that small number situations occur when economies of scale arising as a result of experience, location, or production of a specialized component confer cost advantages on the producing firm. The lack of alternative buyers and sellers enables firms to take advantage of their bargaining position, internalize the associated costs and thus vertically integrate. Williamson (1979, p. 260) stated that "as generic demand grows and the number of supply sources increases, exchange that was once transaction-specific loses this characteristic and greater reliance on market-mediated governance is feasible. Thus vertical integration may give way to obligational market contracting, which in turn may give way to markets." Hence, vertical integration is expected to be positively related to the concentration ratio of firms.

**1. Food Industry Structure**

This section focuses on the industrial structure of the food processing industries. In particular, the focus is on the numbers and sizes of establishments and companies, sales concentration, technological change, and industry growth. The terms food manufacturing industry and food processing industry are often used interchangeably. Industries are defined as groups of establishments or companies that sell the same products according to the U.S government Standard Industrial Classification (SIC) system. In the SIC system, food and beverage processing is one of 20 major industry groups that make up the manufacturing sector. Food processing is officially entitled

“Food and Kindred Products.” A four digit industry code represents establishments that use similar production technologies to transform a given raw material into higher value products and that the end uses of the products made are generally given little weight in deciding on the definition of an industry (Connor and Schieck, 1997). For example, cottonseed oil and soybean oil crushing plants are classified in different industries, even though both oils are quite interchangeable in many consumer oil products.

The ratio of value-added over value of shipments is used as proxy of vertical integration in this study. According to Connor (1988), high-value added industries are characterized by consumer-goods industries, and product differentiation.

## 2. Food Industry Size

Table 1 lists forty one food manufacturing industries in 1992, ranked by industry value added. The values of shipments and employment totals are also shown for each industry. According to Conner (1988) value added and value of the shipments are measures of industry size. Shipments basically correspond to receipts for products as they leave the plant; generally, taxes and transportation costs are not included. According to the U.S Census (1992):

> the “measure of manufacturing activity is derived by subtracting the cost of materials, supplies, containers, fuel, purchased electricity, and contract work from the value of shipments. The result of this calculation is adjusted by the addition of value added by merchandising operations plus the net change in finished goods and work-in-process between the beginning-and end-of-year inventories. Value added avoids the duplication in the figure for value of shipments that results from the use of products of some establishments as materials by others.” Therefore,

value added includes wages, salaries, fringe benefits, gross operating profits, and the many other overhead expenses.

**Table 1. The Size of the Food Processing Industries, Ranked by Value Added, 1992**

| Rank | Industry | Value Added | Value of Shipments | Plant Employment |
|---|---|---|---|---|
| | | Measure of Industry Size | | |
| | | $ Million | $ Million | Thousands |
| 1 | Bread, cakes, and related products | 11,462 | 18,124 | 155.1 |
| 2 | Malt beverages | 10,189 | 20,430 | 102.4 |
| 3 | Bottled & canned soft drinks | 9,586 | 17,340 | 34.5 |
| 4 | Breakfast cereals | 7,338 | 9,799 | 16.1 |
| 5 | Canned fruit and vegetables | 6,959 | 15,066 | 63.7 |
| 6 | Meat packing | 6,928 | 50,434 | 122.4 |
| 7 | Fluid milk | 5,966 | 21,927 | 63.4 |
| 8 | Food preparations, n.e.c. | 5,883 | 11,776 | 27.9 |
| 9 | Cookies and crackers | 5,523 | 8,688 | 47.2 |
| 10 | Sausages & other prepared meat | 5,491 | 19,972 | 85.5 |
| 11 | Sweet and confectionery products | 5,442 | 19,074 | 10.7 |
| 12 | Flavorings extracts & syrups | 5,269 | 6,911 | 10.3 |
| 13 | Cheese, natural & processed | 4,472 | 18,352 | 36.1 |
| 14 | Pickles, sauces and salad dressings | 3,749 | 6,398 | 21.4 |
| 15 | Canned specialties | 3,618 | 6,663 | 21.0 |
| 16 | Dry, condensed & evaporated dairy | 3,380 | 7,541 | 15.2 |
| 17 | Wet corn milling | 3,258 | 7,045 | 9.2 |
| 18 | Frozen fruit and vegetables | 2,910 | 7,535 | 48.0 |
| 19 | Roasted Coffee | 2,753 | 5,293 | 10.5 |
| 20 | Prepared fresh/frozen fish/seafood | 2,325 | 6,996 | 41.3 |
| 21 | Ice cream &frozen desserts | 2,097 | 5,291 | 20.9 |
| 22 | Wine and brandy spirits | 2,089 | 4,301 | 14.0 |
| 23 | Distilled & blended liquors | 1,946 | 3,394 | 7.1 |
| 24 | Prepared flour mixes & doughs | 1,822 | 3,866 | 15.8 |
| 25 | Flour & other grain mill products | 1,625 | 6,294 | 13.1 |
| 26 | Dehydrated fruits, vegetables and soups | 1,515 | 2,853 | 13.5 |
| 27 | Chocolate & cocoa products | 1,476 | 7,534 | 12.0 |
| 28 | Edible oils and fats, n.e.c. | 1,385 | 13,120 | 6.2 |
| 29 | Soybean oil | 1,274 | 10,651 | 7.4 |
| 30 | Chewing gum | 907 | 7,755 | 5.2 |
| 31 | Macaroni & spaghetti | 831 | 1,390 | 5.9 |
| 32 | Beet sugar | 800 | 2,282 | 7.6 |
| 33 | Animal & marine fat oils | 755 | 6,490 | 12.3 |
| 34 | Raw sugar cane | 562 | 4,334 | 10.2 |
| 35 | Rice milling | 437 | 1,651 | 3.9 |
| 36 | Canned and cured fish and seafood | 362 | 968 | 7.9 |
| 37 | Manufacturing ice | 255 | 16,280 | 0.2 |
| 38 | Cottonseed oil mills | 211 | 738 | 2.4 |
| 39 | Malt | 176 | 8,983 | 13.8 |
| 40 | Creamery butter | 148 | 1,034 | 1.5 |
| 41 | Vegetable oil mills | 134 | 666 | 0.9 |
| | Total | 133,306 | 395,239 | 1,123.7 |

Source: National Bureau of Economic Research. Manufacturing Industry Database, 1958-96.

Table 2 shows the intensity of value added in 1992. In the United States, the top ten food processing industries had a combined value added of over $75 billion in 1992. These ten industries created over 56 percent of the value added of the forty one food processing industries. According to Connor and Schiek (1997) high-value-added food industries are those that produce consumer products. Table 1 shows that the highest-ranking food processing industry specializing in producer goods was wet corn milling, which is ranked seventeenth. The other food processing industries that primarily sell ingredients to industrial customers are flour (twenty-five), cane sugar (thirty four), soybean oil (twenty nine), other fats and oils (thirty-three), beet sugar (thirty-two), and cottonseed oil (thirty-eight). In the aggregate, these eight predominantly producer goods industries accounted for 7.77 percent of the total value added by the food processing industries.

Industries with high value added generally also have large shipments, but this does not necessarily apply in reverse. For example, the breakfast foods industry ranks fourth in value added, but it is relatively low in ranking by shipments (fourteen). On the other hand, the soybean oil processing ranked thirteenth in shipments, but a lowly twenty-ninth in terms of value added.

According to Connor and Schiek (1997) most of the less processed, less differentiated products have dropped in rank, for example fluid milk, flour, and sugar, several highly processed foods for which physical and brand differentiation are important have risen in rank, soft drinks, beer, frozen specialties, and breakfast cereals are all examples of the latter trend.

**Table 2. The Food Processing Industries, Ranked by Intensity of Value Added, 1992**

| Rank | Industry | Value Added per $ of Shipments 1967 | 1992 |
|---|---|---|---|
| | | Percent | |
| 1 | Flavoring extracts & syrups | 57.9 | 76.2 |
| 2 | Breakfast cereals | 59.7 | 74.9 |
| 3. | Chewing gum | 62.7 | 73.0 |
| 4 | Manufacturing ice | 76.1 | 71.1 |
| 5 | Cookies and crackers | 54.4 | 63.6 |
| 6 | Bread, rolls, and cakes | 53.4 | 63.2 |
| 7 | Sweet & confectionery products | 46.1 | 60.7 |
| 8 | Macaroni and spaghetti | 45.0 | 59.8 |
| 9 | Malt beverages | 52.7 | 58.8 |
| 10 | Sauces, pickles, and dressings | 36.1 | 58.6 |
| 11 | Distilled & blended liquors | 54.0 | 57.3 |
| 12 | Canned specialties | 42.2 | 54.3 |
| 13 | Dehydrated fruit, vegetables and soups | 39.8 | 53.1 |
| 14 | Roasted coffee | 34.7 | 52.0 |
| 15 | Wine and brandy spirits | 48.0 | 48.6 |
| 16 | Food preparations, n.e.c. | 45.9 | 48.3 |
| 17 | Chocolate & cocoa products | 37.7 | 47.5 |
| 18 | Prepared flour mixes and doughs | 42.6 | 47.1 |
| 19 | Wet corn milling | 47.1 | 46.3 |
| 20 | Canned fruit and vegetables | 40.8 | 46.2 |
| 21 | Dry, condensed & evaporated dairy | 29.5 | 44.8 |
| 22 | Animal & marine fat oils | 36.9 | 40.7 |
| 23 | Ice cream & frozen desserts | 38.0 | 39.6 |
| 24 | Frozen fruit and vegetables | 36.7 | 38.6 |
| 25 | Raw sugar cane | 36.3 | 38.5 |
| 26 | Bottled & canned soft drinks | 52.9 | 37.7 |
| 27 | Canned and cured fish and seafood | 34.6 | 37.4 |
| 28 | Beet sugar | 37.4 | 35.0 |
| 29 | Prepared fresh/frozen fish/seafood | 29.6 | 33.2 |
| 30 | Malt | 21.9 | 30.5 |
| 31 | Cooking oils and margarine | 22.6 | 28.7 |
| 32 | Cottonseed oil mills | 16.1 | 28.6 |
| 33 | Sausage & other prepared meat | 24.4 | 27.5 |
| 34 | Fluid milk | 30.0 | 27.2 |
| 35 | Rice milling | 18.9 | 26.5 |
| 36 | Flour & other grain mill products | 20.0 | 25.8 |
| 37 | Cheese, natural & processed | 13.3 | 24.4 |
| 38 | Vegetables oil mills | 17.7 | 20.1 |
| 39 | Creamy butter | 11.8 | 14.3 |
| 40 | Meat packing | 14.3 | 13.7 |
| 41 | Soybean oil mills | 10.0 | 12.0 |
| | Average | 38.2 | 43.5 |
| | Total | 1,526.8 | 1,785.4 |

Source: National Bureau of Economic Research. Manufacturing Industry Database, 1958-96.

## 2. Food Industry Growth

Table 3 shows the rate of food manufacturing industry growth in 1992. Conner (1988) stated" A high" growth is a rate that is at least twice the average of all the food processing product classes." Only sausage and other prepared meat reported high growth in both the periods included in the study, while around ten product classes experienced low growth. What is surprising is that a few of the high-growth classes in one period appear as low growth classes in the other (manufacturing ice, beet sugar and malt.) In some cases, this may be due to price changes rather than quantity changes (Connor and Schieck, 1997).

Except for ice cream and frozen desserts, the growth of most dairy products was well above the average growth of processed foods. According to Connor (1988 although government storage programs explain some of the growth of the natural cheese market, much of the explanation appears to lie in the greater variety available, improved packaging, an image of convenience, and possibly the product's high calcium content.

Most processed foods based on fruits, vegetables, and grains grew quite slowly. Canned and dried fruits and vegetables suffered from intense competition from frozen preparations and, to a lesser extent, from a shift toward fresh produce. High rates of output growth have occurred among nearly half of the food processors since 1967, but it is rare for such extraordinary growth to persist for more than five to ten years. Indeed, it is not unusual for a product class to experience a sudden reversal in its growth pattern. Many growth patterns are consistent with consumer desires for healthier and more convenient foods (Connor, 1988).

Three categories of processed foods (frozen foods, beverages, and highly prepared, convenience- type foods) displayed above average growth between 1967 and 1992. Frozen type foods grew at above average paces in all periods, though the novelty of the products and the possibilities of substitution for canned versions (canned fruits, vegetables, stews, ethnic foods, and the like) was clearly becoming exhausted after 1972 (Conner, 1988).

The beverage product classes have in general experienced rapid real growth from 1967 to 1992. Health concerns about coffee and drinks high in alcohol were factors in declining consumption

**Table 3. The Food Manufacturing Industries Ranked by Industry Growth, 1992**

| Rank | Industry | Industry Growth Rate 1967 | 1992 |
|---|---|---|---|
| | | Present | |
| 1 | Food preparations, n.e.c. | 0.217016 | 0.381794 |
| 2 | Wet corn milling | 0.191416 | 0.367123 |
| 3 | Sausage & other prepared meat | 0.364918 | 0.337067 |
| 4 | Flour & other grains mill products | 0.160141 | 0.328812 |
| 5 | Manufactured ice | -0.129041 | 0.327777 |
| 6 | Flavorings extracts & syrups | 0.186235 | 0.315178 |
| 7 | Canned fish and cured fish and seafood | 0.288803 | 0.309583 |
| 8 | Meat packing | 0.277363 | 0.288803 |
| 9 | Beet sugar | 0.018462 | 0.284426 |
| 10 | Sauces, pickles, and salad dressings | 0.253016 | 0.278105 |
| 11 | Bread, cakes and related products | 0.177470 | 0.277363 |
| 12 | Wine, brandy and brandy spirits | 0.089252 | 0.267021 |
| 13 | Cookies and crackers | 0.191582 | 0.253016 |
| 14 | Sweet & confectionery products | 0.175118 | 0.244493 |
| 15 | Malt | 0.077922 | 0.217016 |
| 16 | Distilled & blended liquors | 0.165605 | 0.214857 |
| 17 | Chewing gum | 0.174452 | 0.199005 |
| 18 | Raw cane sugar | 0.160291 | 0.194871 |
| 19 | Fluid milk | 0.148682 | 0.191582 |
| 20 | Cottonseed oil mills | -0.137315 | 0.191416 |
| 21 | Cheese, natural & processed | 0.404058 | 0.191182 |
| 22 | Dry, condensed & evaporated dairy | 0.337067 | 0.186235 |
| 23 | Creamy butter | 0.012576 | 0.177470 |
| 24 | Malt beverages | 0.177226 | 0.177226 |
| 25 | Vegetable oil mills | -0.040527 | 0.175118 |
| 26 | Edible oils and fats, n.e.c. | 0.327777 | 0.174452 |
| 27 | Macaroni & spaghetti | 0.214857 | 0.165605 |
| 28 | Canned fruit and vegetables | 0.199005 | 0.160291 |
| 29 | Frozen fruits and vegetables | -0.016551 | 0.160141 |
| 30 | Rice milling | 0.191182 | 0.148682 |
| 31 | Bottled & canned soft drinks | 0.284426 | 0.144296 |
| 32 | Dehydrated fruits, vegetables and soups | 0.309583 | 0.077922 |
| 33 | Canned specialties | 0.165916 | 0.051620 |
| 34 | Ice cream and frozen desserts | 0.051620 | 0.018462 |
| 35 | Animal and marine fat oils | -0.123435 | -0.016551 |
| 36 | Breakfast cereals | 0.244493 | -0.040527 |
| 37 | Chocolate & cocoa products | 0.144296 | -0.114873 |
| 38 | Prepared flour mixes and doughs | 0.088636 | -0.123435 |
| 39 | Roasted coffee | -0.114873 | -0.129041 |
| 40 | Soybean oil mills | 0.315178 | -0.137315 |
| 41 | Prepared fresh/frozen fish/seafood | 0.367123 | -1.020190 |
| | Average | 0.160757 | 0.143807 |

Source: National Bureau of Economic Research. Manufacturing Industry Database, 1958-96.

## 4. Food Industry Average Size

Table 4 shows the average firm size average in the food manufacturing industry in 1992 ranked by value added. Companies are legal entities that own one or more establishments. While each establishment usually pursues only one line of business, larger companies usually have a principal activity and several secondary ones. According to Connor and Schieck (1997) only nine food processing industries had more companies in 1992 than in 1967: wet corn milling (310 percent) breakfast cereals (305 percent), soybean oil mills (about 236 percent), chewing gum (about 200 percent) beet sugar (172 percent), malt beverages (108 percent), distilled and blended liquors (about 91 percent), edilible oils and fats, n.e.c. (64 percent), and dry, condensed and evaporated dairy (60 percent). In all cases, these industries experienced above-average growth in demand. This allowed some companies to exploit small but stable segments of product demand. In other cases, new companies were founded to serve fast-growing specialty markets (Connor, 1988). Industries with especially least gain in average firm size were manufactured ice (0.8 percent increase from 1967 to 1992), canned fish and cured fish and seafood (about 0.8 percent), food preparations, n.e.c. (8 percent), macaroni and spaghetti (about 9 percent), wine, brandy and brandy spirits (about 9 percent), bread, cakes and related products (10 percent), animal and marine fat oils (11 percent), prepared fresh/frozen fish/seafood (about 13 percent), and ice cream and frozen desserts (about 14 percent). In most cases, low growth rates contributed to the disappearance of many of the firms in those industries. As economies of scale and geographic scope increase, fewer plants are needed to serve the market (even a growing one), and as most food processing firms operate only a single plant, firm numbers also decline.

**Table 4. The Food Manufacturing Industries Ranked by Average Firm Size, 1992**

| Rank | Industry | 1967 | 1992 | 67-92 |
|---|---|---|---|---|
| | | Average Firm Size Change | | |
| | | Percent | | |
| 1 | Wet corn milling | 10.072 | 320.808 | 310.736 |
| 2 | Cereal breakfast foods | 7.375 | 312.389 | 305.014 |
| 3 | Soybean oil mills | 19.371 | 255.107 | 235.736 |
| 4 | Chewing gum | 3.900 | 203.830 | 199.929 |
| 5 | Beet sugar | 13.456 | 185.720 | 172.263 |
| 6 | Malt beverages | 10.734 | 119.214 | 108.479 |
| 7 | Distilled & blended liquors | 9.861 | 100.797 | 90.935 |
| 8 | Edible oils and fats, n.e.c. | 11.175 | 75.542 | 64.366 |
| 9 | Dry, condensed & evaporated dairy | 1.961 | 62.201 | 60.239 |
| 10 | Cheese, natural & processed | 0.655 | 51.235 | 50.579 |
| 11 | Rice milling | 6.650 | 50.984 | 44.334 |
| 12 | Fluid milk | 1.178 | 49.325 | 48.146 |
| 13 | Frozen fruits and vegetables | 0.635 | 45.624 | 44.988 |
| 14 | Bottled & canned soft drinks | 0.289 | 45.247 | 44.958 |
| 15 | Meat packing | 2.374 | 42.262 | 39.888 |
| 16 | Malt | 3.491 | 40.306 | 36.814 |
| 17 | Raw cane sugar | 1.993 | 40.283 | 38.289 |
| 18 | Vegetable oil mills | 4.065 | 39.639 | 35.573 |
| 19 | Canned specialties | 3.068 | 38.777 | 35.708 |
| 20 | Roasted coffee | 2.640 | 35.351 | 32.710 |
| 21 | Cottonseed oil mills | 2.386 | 34.073 | 31.686 |
| 22 | Canned fruit and vegetables | 1.290 | 33.582 | 32.292 |
| 23 | Flour & other grains mill products | 3.237 | 32.758 | 29.520 |
| 24 | Flavorings extracts & syrups | 1.054 | 30.839 | 29.785 |
| 25 | Cookies and crackers | 1.259 | 29.245 | 27.986 |
| 26 | Dehydrated fruits, vegetables and soups | 0.826 | 27.565 | 26.738 |
| 27 | Creamy butter | 0.729 | 27.418 | 26.688 |
| 28 | Prepared flour mixes and doughs | 1.782 | 27.010 | 25.228 |
| 29 | Sauces, pickles, and salad dressings | 0.585 | 23.857 | 23.272 |
| 30 | Chocolate & cocoa products | 6.375 | 21.106 | 14.731 |
| 31 | Sausage & other prepared meat | 0.895 | 18.166 | 17.272 |
| 32 | Sweet & confectionery products | 0.412 | 14.525 | 14.113 |
| 33 | Ice cream and frozen desserts | 0.569 | 14.468 | 13.899 |
| 34 | Prepared fresh/frozen fish/seafood | 0.232 | 13.198 | 12.966 |
| 35 | Animal and marine fat oils | 0.447 | 11.710 | 11.263 |
| 36 | Bread, cakes and related products | 0.471 | 10.819 | 10.347 |
| 37 | Wine, brandy and brandy spirits | 0.862 | 9.689 | 8.827 |
| 38 | Macaroni & spaghetti | 0.426 | 8.947 | 8.521 |
| 39 | Food preparations, n.e.c. | 0.296 | 8.417 | 8.120 |
| 40 | Canned fish and cured fish and seafood | 0.538 | 8.177 | 7.638 |
| 41 | Manufactured ice | 0.037 | 8.386 | 0.801 |
| | Average | 3.406 | 61.489 | 58.083 |

Source: National Bureau of Economic Research. Manufacturing Industry Database, 1958-96.

## 5. Industry Four-Firm Concentration

Table 5 presents the concentration ratios for each food processing industry in 1967 and 1992. Industry concentration ratio rises when the market shares of the leading firms increase. Sales concentration is an important piece of information for business people and public officials alike. A high concentration normally represents a source of high profit for firms doing business in an industry; on the other hand, a high concentration also typically signals the presence of problems for firms that are outside the industry but would like to enter it. Concentration ratios are used by government agencies when making antitrust enforcement decisions, particularly in the case of mergers. A high concentration before or subsequent to a merger is likely to lead the antitrust agencies to mount a legal challenge against the acquiring firm (Connor, 1988).

In 1992, the most concentrated industries were chewing gum, malt beverages, vegetable oil mill products, breakfast cereals, macaroni and spaghetti, chocolate and cocoa products, wet corn milling, soybean oil mills, and beet sugar. The least concentrated were prepared fresh/frozen fish/seafood, food preparations, fluid milk, manufactured ice, ice cream and frozen desserts, sausage and prepared meats, canned fruit and vegetables, frozen fruits and vegetables, and canned fish and cured fish and seafood (all below 30 percent). The four-firm concentration ratio is the most conventional measure of concentration, but the Hirshman-Herfmdahl index is also used for comparative purposes. The Hirshman-Herfmdahl index is currently being used by the Justice Department to decide whether to prosecute or enjoin mergers.

According to Conner (1988) concentration ratios are relatively stable over the years, but in the food processing industries several changes have recurred (Table 5).

Three-fourths of the food industries rose in concentration. Some of them showed extraordinary increases: malt beverages (+50 percent), macaroni spaghetti (+47 percent), butter (+34 percent), vegetable mill products (+33 percent), flour and other mill products (+ 26 percent), malt (+26 percent), and meat packing plant products (+24 percent). Only prepared flour mixes and refrigerated doughs declined by as much as 29 percent, followed by canned and cured seafood (-15 percent). According to Connor (1988), the major factor affecting concentration change in the food manufacturing industries is advertising intensity. When advertising as a percentage of sales is high, concentration rises twice as fast as the average, but when it is absent, as in the case of industrial products, concentration is stable. Market concentration ratios are higher and increasing in industries that produce highly differentiated foods. From 1967 to 1992, the largest increase was in the brewing industry, which saw concentration rise by 50 percent.

**Table 5. The Food Manufacturing Industries Ranked by the Four-firm Concentration Ratio, 1992**

| Rank | Industry | Concentration 1967 | Concentration 1992 | Change 67-92 |
|---|---|---|---|---|
| | | Percent | | |
| 1 | Chewing gum | 86 | 97 | 11 |
| 2 | Malt beverages | 40 | 90 | 50 |
| 3 | Vegetable oil mills | 56 | 89 | 33 |
| 4 | Breakfast cereals | 88 | 85 | -03 |
| 5 | Macaroni & spaghetti | 31 | 78 | 47 |
| 6 | Chocolate & cocoa products | 77 | 75 | -02 |
| 7 | Wet corn milling | 68 | 73 | 05 |
| 8 | Soybean oil mills | 55 | 71 | 16 |
| 9 | Beet sugar | 66 | 71 | 05 |
| 10 | Flavoring extracts & syrups | 67 | 69 | 02 |
| 11 | Canned specialties | 69 | 69 | 00 |
| 12 | Roasted coffee | 53 | 66 | 13 |
| 13 | Malt | 39 | 65 | 26 |
| 14 | Cottonseed oil mills | 42 | 62 | 20 |
| 15 | Distilled & blended liquors | 54 | 62 | 08 |
| 16 | Flour & other grains mill products | 30 | 56 | 26 |
| 17 | Cookies and crackers | 59 | 56 | -03 |
| 18 | Wine, brandy and brandy spirits | 48 | 54 | 06 |
| 19 | Rice milling | 46 | 50 | 04 |
| 20 | Meat packing | 26 | 50 | 24 |
| 21 | Creamy butter | 15 | 49 | 34 |
| 22 | Sweet & confectionery products | 25 | 45 | 20 |
| 23 | Raw cane sugar | 43 | 45 | 02 |
| 24 | Dry, condensed & evaporated dairy | 41 | 43 | 02 |
| 25 | Cheese, natural & processed | 44 | 42 | -02 |
| 26 | Sauces, pickles, and salad dressings | 33 | 41 | 08 |
| 27 | Dehydrated fruits, vegetables and soups | 32 | 39 | 07 |
| 28 | Prepared flour mixes and doughs | 68 | 39 | -29 |
| 29 | Animal and marine fat oils | 28 | 37 | 09 |
| 30 | Bottled & canned soft drinks | 13 | 37 | 24 |
| 31 | Edible oils and fats, n.e.c. | 43 | 35 | -08 |
| 32 | Bread, cakes and related products | 26 | 34 | 08 |
| 33 | Canned fish and cured fish and seafood | 44 | 29 | -15 |
| 34 | Frozen fruits and vegetables | 24 | 28 | 04 |
| 35 | Canned fruit and vegetables | 22 | 27 | 05 |
| 36 | Sausage & other prepared meat | 15 | 25 | 10 |
| 37 | Ice cream and frozen desserts | 33 | 24 | -09 |
| 38 | Manufactured ice | 33 | 24 | -09 |
| 39 | Fluid milk | 22 | 22 | 00 |
| 40 | Food preparations, n.e.c. | 24 | 22 | -02 |
| 41 | Prepared fresh/frozen fish/seafood | 26 | 19 | -07 |
| | Average | 42.78 | 51.07 | |

Source: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures, Various issues. Special Report Series: Concentration Ratios in Manufacturing.

## 6. Technological Change

Tables 6 shows the total factor productivity growth in the food processing industries for 1967-1992. When indicators of technological change in the food processing industries were assessed for this study, the total factor productivity was used because of easy the availability of the data, although research and development (R&D) in the industries data might have been better. According to Connor (1988), R&D expenditures by food processors totaled $834 million in 1984, and had increased at a rate of more than 9 percent per year since 1963 (Connor, 1988). However, obtaining data on R&D or other evidence of technological progress in individual industries is a daunting task. No government data series exist, which is why Total Factor Productivity (TP) was used for this study. TP is a measure of total factor productivity growth based on a five-factor production function: capital, production worker hours, non-production workers, non-energy materials, and energy. A Divisia index of TP growth is calculated as the growth rate of output (real shipments) minus the revenue-share-weighted average of the growth rates of each or the five inputs (NBER, 1996). See appendix C for calculation. There are substantial differences in technological progress among industries, and in general all five input indexes tell the same story (see appendix C). The industries with the highest total factor productivity growth in 1992 were prepared fresh/frozen fish/seafood ( about 1.38 percent), meat packing (about 1.26 percent), canned fish and cured fish and seafood (1.24 percent), frozen fruits and vegetables (about 1.22 percent), cookies and crackers ( 1.21 percent), flavoring extracts and syrups (1.14 percent), flour and other grains mill products (about 1.14 percent), wine, brandy and brandy spirits (about 1.13 percent), malt beverages ( about (1.11 percent), cheese, natural and processed (about 1.11 percent), and wet corn milling (1.10 percent). The industries with the lowest growth in TP in 1992 were rice milling (0.8 percent), bread, cakes and related products (about 0.83 percent), fluid milk (0.84 percent), edilible oils and fats, n.e.c. (about 0.86 percent), macaroni and spaghetti ( about 0.87 percent), prepared flour mixes and doughs (about 9 percent), food preparations, n.e.c. (about 0.9 percent), animal and marine fat oils (0.9 percent), and dry, condensed and evaporated dairy (0.9 percent). The meat packing, sausages and other prepared meat industries, display an average productivity growth. The dairy industries were not high in TP except for cheese, natural and processed. The grain-based industries increased a relatively average level in terms of TP. The baking industries showed high technological effort with cookies and crackers slightly above bread. The sugar industries had high TP growth, whereas miscellaneous food and kindred products were generally low. Lee (1986) calculated multifactor productivity rates for nine food industry groups for the years 1958 to 1982 and found that each of the industry groups except miscellaneous foods had positive, if low, rates of productivity growth. Meats, dairy, and fruits and vegetables had the highest rates of change. However, all the industry groups experienced some periods of negative productivity change. The rate of innovation is represented by the rate of growth in total factor productivity (TP). Growth in TP embodies technological innovations. Armour and Teece (1980), in their study on vertical integration and technological in the U.S petroleum industry found a positive, strong and statistically significant relationship between vertical integration and technological innovation (TP).

**Table 6. The Food Manufacturing Industries Ranked by Total Factor Productivity Growth, 1992.**

| Rank | Industry | Total Factor Productivity Growth 1967 | 1992 |
|---|---|---|---|
| | | Percent | |
| 1 | Prepared fresh/frozen fish/seafood | 1.70194 | 1.37705 |
| 2 | Meat packing | 0.95105 | 1.25851 |
| 3 | Canned fish and cured fish and seafood | 1.64510 | 1.24300 |
| 4 | Frozen fruits and vegetables | 0.96438 | 1.21944 |
| 5 | Cookies and crackers | 1.13080 | 1.21232 |
| 6 | Flavorings extracts & syrups | 0.71402 | 1.14294 |
| 7 | Flour & other grains mill products | 0.72780 | 1.13925 |
| 8 | Wine, brandy and brandy spirits | 0.78905 | 1.12956 |
| 9 | Malt beverages | 0.57509 | 1.10948 |
| 10 | Cheese, natural & processed | 0.98241 | 1.10477 |
| 11 | Wet corn milling | 0.83341 | 1.10048 |
| 12 | Raw cane sugar | 1.07834 | 1.07355 |
| 13 | Sauces, pickles, and salad dressings | 0.77534 | 1.06127 |
| 14 | Sweet & confectionery products | 0.93759 | 1.05388 |
| 15 | Beet sugar | 1.03307 | 1.05320 |
| 16 | Chocolate & cocoa products | 0.96792 | 1.05039 |
| 17 | Breakfast cereals | 0.89830 | 1.04301 |
| 18 | Malt | 0.77653 | 1.03842 |
| 19 | Cottonseed oil mills | 1.12902 | 1.03086 |
| 20 | Canned specialties | 0.88467 | 1.02001 |
| 21 | Roasted coffee | 1.03108 | 1.01893 |
| 22 | Sausage & other prepared meat | 0.89857 | 1.00909 |
| 23 | Vegetable oil mills | 0.74062 | 0.99816 |
| 24 | Bottled & canned soft drinks | 1.02549 | 0.99751 |
| 25 | Ice cream and frozen desserts | 0.92907 | 0.98677 |
| 26 | Chewing gum | 1.40955 | 0.98378 |
| 27 | Manufactured ice | 1.45671 | 0.98305 |
| 28 | Soybean oil mills | 0.83165 | 0.96634 |
| 29 | Dehydrated fruits, vegetables and soups | 0.94970 | 0.96350 |
| 30 | Canned fruit and vegetables | 0.85775 | 0.94274 |
| 31 | Creamy butter | 1.07070 | 0.94069 |
| 32 | Distilled & blended liquors | 0.69410 | 0.92355 |
| 33 | Dry, condensed & evaporated dairy | 1.20141 | 0.91767 |
| 34 | Animal and marine fat oils | 0.76170 | 0.90403 |
| 35 | Food preparations, n.e.c. | 0.91184 | 0.89983 |
| 36 | Prepared flour mixes and doughs | 1.03845 | 0.89627 |
| 37 | Macaroni & spaghetti | 0.92592 | 0.87640 |
| 38 | Edible oils and fats, n.e.c. | 1.02434 | 0.86498 |
| 39 | Fluid milk | 0.82824 | 0.84432 |
| 40 | Bread, cakes and related products | 0.89054 | 0.83771 |
| 41 | Rice milling | 0.71399 | 0.80934 |
| | Average | 0.96798 | 1.02503 |

Source: National Bureau of Economic Research. Manufacturing Industry Database, 1958-96.

## III. THEORETICAL CONSIDERATIONS AND METHOD

The theoretical considerations relevant to this study are divided into the theoretical framework discussed in this chapter and model specification covered in the next. Method deals with data collection and analysis. The research method used for this study combines traditional economic theory, industrial organization theory, consumer theory, and applied econometric and statistical methods using secondary data. A model framework was developed to examine the effects of selected variables (concentration, industry growth, firm size, and total factor productivity) on vertical integration in the food manufacturing industry. Three sets of regressions were estimated to test the empirical implications: ordinary least squares (OLS), and a fixed and random effects model.

### 1. Theoretical Considerations

Several variables are known to influence vertical integration in the U.S manufacturing industry (Tucker and Wilder, 1977). The model presented in this study examines the quantitative relationship of concentration, industry growth, firm size, and total factor productivity on vertical integration in the food manufacturing industry using data from 1967 through 1992.

The concentration measure used is the share of the total sales revenues for the US food manufacturing industry of the four largest firms. This concentration ratio measure has been used previously in the literature on the determinants of market structure. It was pointed out by Hannah and Kay (1977) that the concentration ratio is not very sensitive to the number of small firms, although it affects both the degree of inequality of firm size and the overall number of firms.

Technological change has been dramatic in the food industries, with capital-intensive technologies substituting for land and labor. These new technologies exhibit greater economies of scale and have created opportunities for larger, more efficient production units. Growth and development have continued in industries as farm specialization and concentration of production intensify (Connor, 1988).

Vertical integration is a kind of business coordination that occurs when a firm combines activities or stages of production related to the sequence of production and marketing activities. Integration can be either forward or backward. A meat packer who operates a meat wholesaling or retailing firm is an example of forward integration, while a meat packer who operates a livestock buying station or cattle feed lot is an example of backward integration. Alternative means of coordination include the market-price system, vertical integration, contracting, cooperation, and combinations of these (Perry, 1989). A firm can be described as vertically integrated if it engages two single-output production processes in which the entire output of the "upstream" process is employed as part or all of the quantity of one intermediate input into the "downstream" process source (Perry, 1989).

Table 7 shows the food manufacturing industry ranked by the vertical integration ratio in 1992. The most vertically integrated food manufacturing industries in 1992 were animal and marine fat oils (76 percent), sweet and confectionery products (75 percent), malt beverages (about 73 percent), roasted coffee (71 percent), fluid milk (about 64 percent), raw cane sugar (63 percent), dry, condensed and evaporated dairy (about 61 percent), soybean oil mills (abut 60 percent), rice milling (about 59 percent), and bread, cakes and related products (about 59 percent). The least vertically integrated were edible oil and fats, n.e.c. (about 12 percent), food preparations, n.e.c (about 14 percent), sausage and other prepared meat (14 percent), macaroni and spaghetti (20 percent), flour and other grains mill products (24 percent), cookies and crackers (about 26 percent), malt (26 percent) and canned and cured fish and seafood (27 percent).

Vertical integration may arise from technological economies of integration if fewer of the other intermediate inputs are required in order to obtain the same output in the downstream process when the firm has integrated one of the upstream processes. Vertical integration not only replaces some intermediate inputs with primary inputs but also reduces the requirements of other intermediate inputs. This is the sense in which technological economies of integration give rise to vertical integration.

Adelman (1955, p. 319) commenting on Stigler's analysis of industry age and vertical integration stated that "as firms and their industry grow, they do so under the forced draft of demand chronically in excess of supply at prevailing prices, and a sluggish response by input suppliers will often force the growing firm to provide its own supplies and/or marketing outlets." Adelman pointed out that those young industries experiencing rapid growth face supply reliability problems due to an inability to transfer information about quantity demanded, or product specification. Levy (1984) added that this argument depends on the unstated assumption that information can be more efficiently transferred within the firm than between firms. An expanding industry is likely to be more highly integrated than the stable one and, in our model vertical integration is expected to be positively related to industry demand growth.

According to Levy (1984) the relationship between vertical integration and concentration can also be justified by extending Stigler's discussion of the decreasing cost activity. According to Stigler, the firm’s functions are purchasing and storing materials; transforming materials into semifinished and semifinished products into finished products, storing and selling the output as well as extending credit to buyers. The execution of each of the mentioned function engenders a cost which may depend upon the location of the preceding function. Therefore one may expect to find many different patterns of average costs of functions some falling continuously some rising continuously some conventionally U-shaped. It is also possible that the average cost of some operations first rises and then falls. Stigler (1968) argued that vertical integration (disintegration) is subject to decreasing (increasing) costs in the production functions. The firm starts out vertically integrated and as demand increases (decreasing cost functions), firms vertically disintegrate. The integrated firms buy from new firms entering to meet the demand for the increasing cost activities products because of the demand increases and vis versa when demand declines. In other words, everything starts when the quantity demanded increases (decreasing cost function) which leads eventually to vertical disintegration with new firms entering the market (decreasing cost activity products).

According to Levy (1984) the specialized firm can produce at lower costs than the integrated firm, and the integrated firm spins off the decreasing cost activity and buys from the specialized firm at a price lower than the average cost. Analyzing the full life of industries, Stigler states that industries started vertically integrated and that "young industries" are often strangers to the established economic system and require new kinds or qualities of materials and hence make their own. These young industries must design their specialized equipment and often manufacture it. When the industry has matured (old industries), many of these functions of the firms (decreasing cost functions for the integrated firms and increasing cost activities for the specialized firms) are sufficiently important to be turned over to specialists. Vertical integration leads to specialization. It becomes profitable for other firms to undertake the functions previously done by vertically integrated firms. Finally, when the industry begins to decline, that also leads specialized industries to decline, and therefore, the surviving firms must begin to take over functions which are no longer carried on at a sufficient rate to support independent firms. Specialization leads to concentration. Vertical integration is expected to be positively related to the concentration ratio.

According to Henderson and Frank (1998) the ratio of value added to sales is subject to both profits bias and primary-industry bias. Vertical integration is subject to both profits bias and primary-industry bias. Profits bias results from cyclical variation in profits (accounting biasness) that influence the ratio of value-added to sales over time within the same firm, thus distorting time-series measurements. This is the case when using forward and backward integration. Primary-industry biasness is when the high vertical integration ratio depends on the position at the primary compared to the other stages of production, thus distorting cross-sectional comparisons.

A negative relationship is expected between vertical integration and average firm size that creates a disincentive to integrate due to rising costs of internal control. Since the scarcity of firms at each stage leads to an increased likelihood of bargaining disadvantages among nonintegrated firms and less incentives for specialized firms to take advantage of scale economies (Levy, 1984), the concentration ratio is expected to be positively related to vertical integration. Stigler (1968, p. 143) explains how there are less incentives for specialized firms to take advantage of scale economies "The sales of the product may be too small to support a specialized merchant; the output of a by-product may be too small to support a specialized fabricator; the demand for market information may be too small to support a trade journal. The firm must then perform these functions itself. But, with the expansion of the industry, the magnitude of the function subject to increasing returns may become sufficient to permit a firm to specialize in performing it." Levy (1984) added that there must be a specification in order to know whether the increasing cost function will be performed in a specialized firm or in an integrated firm. Levy (1984) added that the advantages of vertical integration and specification are not clearly specified.

**Table 7. The Food Manufacturing Industries Ranked by Vertical Integration Ratio, 1992.**

| Rank | Industry | Total Factor Productivity Growth 1967 | 1992 |
|---|---|---|---|
| | | Percent | |
| 1 | Animal and marine fat oils | 0.369242 | 0.762465 |
| 2 | Sweet & confectionery products | 0.493055 | 0.748893 |
| 3 | Malt beverages | 0.527597 | 0.726268 |
| 4 | Roasted coffee | 0.347194 | 0.710981 |
| 5 | Fluid milk | 0.300440 | 0.635787 |
| 6 | Raw cane sugar | 0.363094 | 0.631776 |
| 7 | Dry, condensed & evaporated dairy | 0.295408 | 0.607481 |
| 8 | Soybean oil mills | 0.100265 | 0.597913 |
| 9 | Rice milling | 0.189303 | 0.587611 |
| 10 | Bread, cakes and related products | 0.539529 | 0.585996 |
| 11 | Canned specialties | 0.442103 | 0.573230 |
| 12 | Meat packing | 0.142918 | 0.542948 |
| 13 | Sauces, pickles, and salad dressings | 0.360850 | 0.531001 |
| 14 | Prepared flour mixes and doughs | 0.422605 | 0.520046 |
| 15 | Dehydrated fruits, vegetables and soups | 0.399682 | 0.485631 |
| 16 | Prepared fresh/frozen fish/seafood | 0.295838 | 0.483435 |
| 17 | Creamy butter | 0.118064 | 0.474923 |
| 18 | Distilled & blended liquors | 0.540023 | 0.471247 |
| 19 | Chewing gum | 0.626605 | 0.462372 |
| 20 | Beet sugar | 0.373997 | 0.461943 |
| 21 | Manufactured ice | 0.760804 | 0.448150 |
| 22 | Canned fruit and vegetables | 0.407549 | 0.406522 |
| 23 | Flavorings extracts & syrups | 0.578734 | 0.396269 |
| 24 | Wine, brandy and brandy spirits | 0.479766 | 0.386251 |
| 25 | Cottonseed oil mills | 0.161123 | 0.384916 |
| 26 | Ice cream and frozen desserts | 0.380404 | 0.377166 |
| 27 | Breakfast cereals | 0.596847 | 0.373812 |
| 28 | Cheese, natural & processed | 0.132627 | 0.350438 |
| 29 | Chocolate & cocoa products | 0.370849 | 0.332361 |
| 30 | Bottled & canned soft drinks | 0.529245 | 0.305488 |
| 31 | Frozen fruits and vegetables | 0.367443 | 0.286664 |
| 32 | Vegetable oil mills | 0.176595 | 0.286528 |
| 33 | Wet corn milling | 0.470651 | 0.274944 |
| 34 | Canned and cured fish and seafood | 0.346014 | 0.272068 |
| 35 | Malt | 0.219400 | 0.264736 |
| 36 | Cookies and crackers | 0.543775 | 0.258087 |
| 37 | Flour & other grains mill products | 0.199927 | 0.243705 |
| 38 | Macaroni & spaghetti | 0.466289 | 0.200841 |
| 39 | Sausage & other prepared meat | 0.244233 | 0.143520 |
| 40 | Food preparations, n.e.c. | 0.420063 | 0.137367 |
| 41 | Edible oils and fats, n.e.c. | 0.226414 | 0.119599 |
| | Average | 0.373818 | 0.435399 |

Source: National Bureau of Economic Research. Manufacturing Industry Database, 1958-96.

# IV. MODEL SPECIFICATION

## 1. The Economic Model

The economic model used in this study was adapted from that originally developed by Levy (1984) in his paper "Testing Stigler's Interpretation of 'The Division of Labor is Limited by the Extent of the Market'." The economic model has four exogenous variables: concentration ratio, demand growth of the industry, firm size, and productivity growth (one more than Levy). The following ordinary least squares (OLS) model was developed in order to quantify the effect of the exogenous variables on vertical integration. The general model can be written as:

$$VI_{it} = f(CN_{it}, DG_{it}, AS_{it}, TP_{it}),$$

where

$VI_{it}$ = level of vertical integration in industry *i* at time *t*

$CN_{it}$ = concentration in industry *i* at time *t*

$DG_{it}$ = demand growth in industry *i* between time $t_{-1}$ and *t*

$AS_{it}$ = average firm size in industry *i* at time *t*

$TP_{it}$ = growth of total factor productivity in industry *i* between time $t_{-1}$ and *t*

The explicit model for the vertical integration model is expressed as:

$$VI_{it} = \beta_0 + \beta_1 CN_{it} + \beta_2 DG_{it} + \beta_3 AS_i + \beta_4 TP_{it} + \varepsilon_{it} \quad (1)$$

Where

$\varepsilon_{it}$ = Error term

*i* is the industry index,

and *t* is time

A more detailed description of the variables, along with their expected signs, is in Table 8. For specialized firms with zero scale economies in the production of specific products, costs decrease as demand increases because of efficient information exchange between successive stages of production (Stigler, 1968). Concentration of firms in an industry is thought to create buying (or selling) problems of inputs (or outputs) for non-integrated firms due to their lack of bargaining power. Stigler (1968) stated that a decreasing cost activity creates an incentive for firms to integrate vertically and to take advantage of their bargaining power (lower transaction costs). According to Williamson (1978) vertical integration creates a unified structure where the transaction is removed from the market and organized within the firm, subject to an authority relation with a flow of efficient information. Vertical integration is expected to be positively related to the concentration of firms in an industry, hence it is expected that $\beta_1 > 0$.

Adelman (1955) stated that young industries grow faster and face a supply reliability problem due to their inability to rapidly transfer information about quantity demanded or about product specification. Since data on industry age is not readily available, as an alternative, Polli and Cook (1969) used industry demand growth to classify stages in the life cycle. Whereas "old" industries grow slowly and cautiously, drawing on studies by Levy (1984) and Stigler (1968) it is assumed that firms are expected to be more likely to integrate vertically in faster growing industries in order to reduce information costs, implying $\beta_2 > 0$.

Larger average firm sizes create disincentives to integrate due to the rising costs of internal control (Levy, 1984). It is expected that $\beta_3 < 0$, the relation found by Levy (1984) and Tucker and Wilder (1977). The rate of innovation is represented by the rate of growth in total factor productivity (TP). Armour and Teece (1980) in their study on vertical integration and technological change in the U.S petroleum industry, found a positive, strong and statistically significant relationship between vertical integration and technological innovation. The relationship between the growth in total factor productivity and vertical integration generates coefficient $\beta_4$ which is expected to be positive.

Ordinary least squares (OLS) and the random effects model (REM) were used by Levy (1984) Tucker and Wilder (1977) used only OLS that is unable to capture a complete picture of the industry and temporal effects. Therefore, the fixed-effects models (FEM) and random-effects models (REM) were used in this study in an attempt to capture the industry and temporal effects with the intention of increasing the efficiency of the estimates (Greene, 2000).

A panel data set is used in the analysis. This increases the degrees of freedom and reduces the collinearity problem, improving the efficiency of the estimates. According to Hsiao (2003, p. 5) “The use of panel data also provides a means of resolving or reducing the magnitude of a key econometric problem that often arises in empirical studies, namely, the often heard assertion that the real reason one finds (or does not find) certain effects is the presence of omitted (mismeasured or unobserved) variables that are correlated with explanatory variables…By utilizing information on both the intertemporal dynamics and the individuality of the entities being investigated, one is better able to control in a more natural way for the effects of missing or unobserved variables."

The fixed-effects models were made more specific by analyzing a number of important economic questions that could not be addressed using cross-sectional or time-series data sets. The advantage of using fixed-effects and random-effects models is that they capture both the time-specific effects and industry-specific effects. These different effects could be captured by the intercept term alone, or by slope coefficients. The commonly used methods for incorporating industry-specific and time-specific effects are to either include separate dummy variables for each cross sectional unit and each time period, or to use a REM. Both, fixed and random effects models were used in this study.

In an REM, the error term $\varepsilon_{it}$ is composed of an error component due to industry effects and a temporal component that is due to time effects. In the models, the variables were all estimated at the food industry level and the cross sectional data were pooled for six census years.

## 2. Data Sources

### 2.1. NBER/Census Data

Data on the rate of growth in total factor productivity were taken directly from the Manufacturing Industry Database, 1958-96 of the National Bureau of Economic Research (NBER). Data from the same source were used for value added, value of shipments, and number of companies in order to estimate a ratio for vertical integration, firm size, and demand growth variables, as described in Table 8. Data on the concentration ratio (the four largest companies in each industry) and the number of companies were taken from the U.S. Department of Commerce, Census Publications, at the four-digit industry level. Complete data were only available at five year intervals.

**Table 8. Variable Definitions and Data Sources**

| Variable Name | Definition | Expected Signs | Data Source |
|---|---|---|---|
| VI | Level of vertical integration in industry<br>$VI = \frac{\text{Value Added}}{\text{Value of Shipments}}$ | | NBER Manufacturing Industry Database, 1958-96 |
| CN | Percentage of the total value of shipments accounted for by the four largest companies | $\beta_1 > 0$ | U.S. Department of Commerce |
| DG | Demand growth in industry<br>$DG = \frac{\text{Value of Shipments at } t_1 - \text{Value of Shipments at } t_{-1}}{\text{Value of Shipments at } t_{-1}}$ | $\beta_2 > 0$ | NBER Manufacturing Industry Database, 1958-96 |
| AS | Average firm size in industry<br>$AS = \frac{\text{Value of Shipments (adjusted by PPI for 1987)}}{\text{Number of Companies}}$ | $\beta_3 < 0$ | NBER Manufacturing Industry Database, 1958-96 and U.S. Department of Commerce |
| TP | Growth of total factor productivity in industry<br>= % increase in gross output − % increase in (weight) capital, labor, and material inputs | $\beta_4 > 0$ | NBER Manufacturing Industry Database, 1958-96 |

## 2.2. Standard Industrial Classification Codes (SIC)

The major industrial group of food and kindred products (SIC 2000-2099) consists of "…establishments manufacturing or processing foods and beverages for human consumption, and certain related products, such as manufactured ice, chewing gum, vegetable and animal fats and oils, and prepared feeds for animals and fowls. Products described as dietetic are classified in the same manner as nondietetic products (e.g., as candy, canned fruits, cookies)." (Office of Management and Budget, 1987. p.69)

The industries defined in the Standard Industrial Classification (SIC) cover the entire food manufacturing sector (see Table 9 and Appendix A). Some industries (2015, 2038, 2047, 2048, 2053, 2068, and 2096) were excluded from the present study because of the unavailability of particular variables, and also because of changes in industry classification. Four-firm concentration ratios for the four-digit industries were available in the Census of Manufactures (U.S Department of Commerce). One problem in obtaining any consistent long-term industry data set is that industrial classifications have changed over time to reflect changes in the importance of these industries in the economy. These changes have occurred to a small degree in every Census of Manufactures, and to a much greater extent every few Censuses, with major redefinitions in 1972 and 1987 (U.S Census, 1992). The final data set contains 41 industries for each of the six years and the final industries are listed in Table 9. The means of the variables for particular years are listed in Table 10, in the next chapter.

The use of the four-digit industry scale was selected because its definition is close to the standard definition of an industry (U.S Census, 1992) and past studies have pointed to the four-digit SIC industry as the preferred means of differentiating between categories of industry (Meehan and Duchesneau, 1973). The selection of specific industries was based on the following general criteria: (1) data on all the variables were available for the period studied, and (2) industry definitions were basically unchanged during the period covered by the OMB and U.S Census. After 1992, the North American Industry Classification System (NAICS) has replaced the U.S. Standard Industrial Classification (SIC) system. NAICS was developed jointly by the U.S., Canada, and Mexico to provide new comparability in statistics about business activity across North America. The SIC coding system groups establishments by their primary type of activity, whereas, the NAICS coding system groups establishments according to similar production processes. There is not direct link between the SIC and the NAICS.

**Table 9. Four-digit Food Industry Codes Used in the Study**

| SIC Code | Industry Name |
|---|---|
| | ***Meat Products*** |
| **2011** | Meat packing |
| **2013** | Sausages & other prepared meat |
| | ***Dairy Products*** |
| **2021** | Creamery butter |
| **2022** | Cheese, natural & processed |
| **2023** | Dry, condensed & evaporated dairy |
| **2024** | Ice cream & frozen desserts |
| **2026** | Fluid milk |
| | **Preserved Fruits and Vegetables** |
| **2032** | Canned specialties |
| **2033** | Canned fruits & vegetables |
| **2034** | Dehydrated fruits, vegetables and soups |
| **2035** | Pickles, sauces & salad dressings |
| **2037** | Frozen fruits & vegetables |
| | ***Grain Mill Products*** |
| **2041** | Flour & other grain mill products |
| **2043** | Cereal breakfast foods |
| **2044** | Rice milling |
| **2045** | Prepared flour mixes & doughs |
| **2046** | Wet corn milling |
| | ***Bakery Products*** |
| **2051** | Bread, cake, and related products |
| **2052** | Cookies and crackers |
| | ***Sugar and Confectionery Products*** |
| **2061** | Raw cane sugar |
| **2063** | Beet sugar |
| **2065** | Sweet & confectionery products |
| **2066** | Chocolate & cocoa products |
| **2067** | Chewing gum |

**Table 9: (continued)**

| | |
|---|---|
| | ***Fats and Oils*** |
| **2074** | Cottonseed oil mills |
| **2075** | Soybean oil mills |
| **2076** | Vegetable oil mills |
| **2077** | Animal & marine fat oils |
| **2079** | Edible oils and fats, n.e.c. |
| | ***Beverages*** |
| **2082** | Malt beverages |
| **2083** | Malt |
| **2084** | Wine, brandy and brandy spirits |
| **2085** | Distilled & blended liquors |
| **2086** | Bottled & canned soft drinks |
| **2087** | Flavoring extracts & syrups |
| | ***Miscellaneous Food and Kindred Products*** |
| **2091** | Canned and cured fish and seafood |
| **2092** | Prepared fresh/frozen fish/seafood |
| **2095** | Roasted coffee |
| **2097** | Manufactured ice |
| **2098** | Macaroni & spaghetti |
| **2099** | Food preparations, n.e.c. |

Source: U.S. Department of Commerce, Census of Manufactures, 1997.

### 2.3. Variable Measurement

The ratio of value added to value of shipments was calculated and used as the vertical integration variable. This is the same variable used by Levy (1984), Tucker and Wilder (1977), and Aldeman (1955). The concentration ratio was the four-firm concentration ratio, i.e., the share of the value of shipments accounted for by the four largest firms in each industry. Average firm size was measured as value of shipments (adjusted by the producer price index for 1987) divided by the number of companies in the industry. Demand growth was calculated as the difference in sales over the time periods. The rate of innovation was assumed to be the rate of growth in total factor productivity (TP). The measure of total factor productivity growth was based on a five-factor production function indexing capital, production worker hours, non-production workers, non-energy materials, and energy (NBER, 1996).

# V. EMPIRICAL RESULTS

## A. Descriptive Statistics

Table 10 lists the variable means for the period 1967-1992. As the table shows, vertical integration declined from 37 % in 1967 to a low of 35 % in 1977, and then increased to a high of 44 % in 1992. The four-firm concentration ratio rose steadily over time, from 42.8 % in 1967 to 51.1 % in 1992. Demand growth decreased at a rate of 3% from 1967 to 1992. Average firm size increased substantially, from 3.4 % 1967 to 61.5 % in 1992. Over the 1967-1992 period, the total factor productivity rose from 97 % in 1967 to 103 % in 1992, although with a dip to 93% in 1977.

### 1. Examination of SIC industry growth

Among these industries, there were differences in the growth rates experienced by different categories, as expressed by their SICs. The following SICs had the highest vertical integration ratios, 70% and more in manufactured ice (2097), and 60% and more for cereal breakfast foods (2043), chewing gum (2067), and flavoring extracts and syrups (2087) and the lowest, at 10%, in meat packing (2011), creamery butter (2021), cheese, natural and processed (2022), and vegetable oil mills (2076). For the concentration ratio, chewing gum (2067) had the highest, with 92.3%, followed by chocolate and cocoa products (2066) with 73.8 %; the lowest was 4% in cheese, natural and processed (2022).

Gopinath and Yonghai (2003) stated that persistent negative growth rates of TP are likely whenever output growth is low relative to input growth, which can occur in highly protected industries such as dairy processing (2022, 2023) and cane-sugar processing (2062). Industries such as canned fruits and vegetables (2033), wet corn milling (2046), distilled and blended liquors (2085), and flavoring extracts and syrups (2087) showed higher TP growth in conjunction with higher growth in concentration, with 2051 and 2074 as exceptions. The average firm size was the highest for beet sugar (2063), and chewing gum (2067), with the lowest in manufactured ice (2097), food preparations, n.e.c (2099) and wine, brandy and brandy spirits (2084). Total factor productivity showed little variation among the SICs, with prepared fresh/frozen fish/seafood (2092) the highest, and malt beverages (2082) the lowest. The highest demand growth was soybean oil mills (2075), but cottonseed oil mills (2074) was negative.

**Table 10. Means of Selected Variables Used in Regression Analysis Explaining Vertical Integration in Food Industries, 1967-1992**

| Variable | 1967 | 1972 | 1977 | 1982 | 1987 | 1992 |
|---|---|---|---|---|---|---|
| VI | 0.374 | 0.371 | 0.348 | 0.364 | 0.420 | 0.435 |
| | (0.156) | (0.156) | (0.1534) | (0.159) | (0.169) | (0.171) |
| CN | 42.780 | 44.585 | 44.761 | 46.512 | 48.536 | 51.073 |
| | (19.453) | (19.269) | (19.315) | (20.246) | (20.332) | (21.314) |
| DG | 0.167 | 0.313 | 0.478 | 0.389 | 0.039 | 0.135 |
| | (0.141) | (0.169) | (0.180) | (0.197) | (0.391) | (0.282) |
| AS | 3.406 | 6.750 | 18.005 | 35.387 | 43.439 | 61.489 |
| | (4.367) | (11.867) | (26.900) | (43.782) | (51.630) | (79.311) |
| TP | 0.968 | 0.985 | 0.929 | 0.970 | 1.000 | 1.025 |
| | (0.239) | (0.167) | (0.137) | (0.078) | (0.000) | (0.124) |

Numbers in parentheses are the standard deviation

Source: NBER Manufacturing Industry Database, 1958-96, and U.S. Department of Commerce, Census of Manufacture.

## B. LEVY'S EMPIRICAL FINDINGS

This chapter outlines findings of the empirical research of Levy's model in the food manufacturing industry. The objective of this chapter is to present and discuss a framework for comparing the Levy (1984) model and results to its replication and results in the food manufacturing industry. This chapter is divided into five sections. The first section presents the methodology and results of Levy (1984). Section two presents the application of Levy's model of the food industry. The third section outlines the results of Levy's model estimated with data from the food manufacturing industry. The fourth section shows the regression results in selected food industries. The fifth section summarizes this study's findings and provides concluding remarks.

The original model used by Levy (1984) is replicated for the food manufacturing industry and modified by adding the total factor productivity growth. According to Levy (1984) the "extent of the market" can be decomposed into several determining factors: the concentration ratio, average firm size and industry demand growth; each variable is hypothesized to have an independent effect on vertical integration. Levy (1984) states that his study of manufacturing industry supports Stigler's original implications and are consistent with those of an earlier study by Tucker and Wilder (1977). Levy's (1984) study omitted a potentially important variable --the technology-- factor which is included here, and represented by the total factor productivity (TP). For the food manufacturing industry, a fixed effects model was found to be a better specification than the random effects model according to the Hausman test. The fixed effects model did not perform well, however, because there is heterogeneity in the food manufacturing industry. Therefore, an industry by industry analysis was conducted on some selected industries

(Meat Packing, Fluid Milk, Cereal Breakfast Foods, Chewing Gum, Malt Beverages, and Prepared Fresh/Frozen Fish/Seafood industries) with and without total factor productivity growth.

## 1. Levy's Model and Results

In his study "Testing Stigler's Interpretation of The Division of Labor is Limited by the Extent of the Market." Levy (1984) examined Stigler's hypotheses that vertical integration is positively related to concentration ratio and demand growth, and is negatively related to firm size. His objective was to provide a clearer relationship between the theory and empirical testing by pooling Census data for 38 manufacturing industries for three census years, 1963, 1967, and 1972.

### Testing Stigler's Interpretation of "The Division of Labor is Limited by the Extent of the Market"

Stigler (1968, page 145) stated that "If one considers the full life of industries, the dominance of vertical disintegration is surely to be expected. Young industries are often strangers to the established economic system. They require new kinds or qualities of materials and hence make their own; they must overcome technical problems in the use of their products and cannot wait for potential users to overcome them; they must persuade customers to abandon other commodities and find no specialized merchants to undertake this task. These young industries must design their specialized equipment and often manufacture it, and they must undertake to recruit (historically, often to import) skilled labor. When the industry has attained a certain size and prospects, many of these tasks are sufficiently important to be turned over to specialists. It becomes profitable for other firms to supply equipment and raw materials, to undertake the marketing of the product and the utilization of by-products, and even to train skilled labor. And, finally, when the industry begins to decline, these specialized industries begin also to decline, and eventually the surviving firms must begin to reappropriate functions which are no longer carried on at a sufficient rate to support independent firms."

### 2. Levy's Model and Variables

In his attempt to empirically specify Stigler's theoretical model, Levy (1984) used the vertical integration level as the dependent variable with average firm size in industry, industry demand growth, and concentration ratio as independent variables in his empirical analysis. The data he used were at the corporate level and aggregated to the SIC three-digit industry level. The vertical integration variable (VI) was measured by the ratio of value added to sales. Average firm size (AS) was measured as industry sales divided by the number of firms in the industry and deflated by the producer price index. Demand growth (DG) was calculated as current price deflated sales divided by the preceding period's price deflated sales. Four-firm concentration ratios of four-digit industries were available in the Census of Manufactures reports. To obtain industry concentration ratios corresponding to the IRS industries, four-digit concentration ratios (CN) were weighted by the number of employees in each of the constituent four-digit SIC industries of firms in the Link industries[1]. Data were for 1963, 1967, and 1972. Ordinary Least Squares (OLS) and Random Effects modeling were used and the final data set contained 38 different industries for each of the three years. The equations were estimated in both log and linear form.

[1] Levy's data are from the Internal Revenue Service as reported by the US Census of Manufacturers. The IRS classifies "corporation" as the industry accounting for the largest percentage of sales. "Link industries" data are establishment level data collected by the Census of Manufacturers using the financial statistics of the owning companies (as reported to the IRS); therefore, data were at the corporate level.

### 3. Levy's Methodology and Results

#### a. Linear methodology

Levy (1984) estimated two sets of regressions: levels and changes. In the first set, the variables were all in terms of the industry levels and the cross sectional data were pooled for three census years (1963, 1967, 1972). The variables were differenced in a second set of equations, so that each variable was measured in terms of its industry percentage change over the period from 1963 to 1972. OLS and the random effects models were estimated for the first set of models, and OLS only for the second because there was no time effect left. The levels and difference equations were estimated in log and linear form, but only the equations in log form were reported because the choice of functional form did not substantially affect the results, according to Levy (1984).

#### b. Levy's Results

Levy's REM results are reported below and in Table 11. The t-statistics are reported in parentheses. Levy's error components (random effects) results are presented in Table 11. The coefficient of average firm size (AS) is significantly negative, whereas the effects of industry demand growth (DG) and concentration ratio (CN) are both significantly positive. Levy stated that these "…results are analogous to those which could be obtained from estimating a model with industry-specific dummy variables but without time-specific dummy variables".

**Table 11. Levy's Random Effects Model Results, with Vertical Integration (VI) as the Dependent Variable**

| Variables | Coefficients | T-ratios |
|---|---|---|
| INTERCEPT | -0.673 | (-4.34)** |
| CN | 0.093 | (1.91)* |
| DG | 0.070 | (2.23)** |
| AS | -0.151 | (-7.23)** |

Transformed M.S.E. = 0.0044

$\delta_i^2 = 0.0035$

$\delta_t^2 = 0.0001$

$\delta_{ti}^2 = 0.0044$

* Statistically significant at the 10% level
** Statistically significant at the 5% level

### c. Application of Levy's Model to the Food Industry

The objective of this section is to determine whether Levy's (1984) treatment is universal and can be replicated for any industry or group of industries with the same results as Levy (1984) found for manufacturing. A side-by side list of Levy's industries versus the present study is seen in Table 12. Stigler's concept that "The Division of Labor is Limited by the Extent of the Market", albeit widely accepted, has been the subject of criticism in its empirical testing (Perry (1989), Tucker and Wilder (1977), and Stuckey (1983). Concerns of the criticism were on the definition and measurement of the variables used in testing the hypotheses. In his study, Levy (1984) used vertical integration as the dependent variable, and the concentration ratio, average firm size, and industry demand growth as independent variables, and he interprets coefficients of regression as impacting vertical integration in manufacturing industries. Examining different industry groupings simultaneously could cast doubt on the validity of the models and the meaning of those results like in Levy's study. In this dissertation, Levy's conclusions were tested by using pooled data for 41 food manufacturing industries at the 4-digit SIC level. OLS, REM and FEM were used in study.

### 1. Extension and Evaluation of Levy's Results

In this study, 41 food manufacturing industries were used. The explanatory variables used were concentration ratio, industry demand growth, and average firm size. The total factor productivity variable was also added based on later studies reported below. The variables, vertical integration, industry demand growth, average firm, and total factor productivity were constructed from the NBER database of 1996 (Table 8). Data were for 1967, 1972, 1977, 1982, 1987, and 1992. The four-firm concentration ratios of four-digit industries were available in the Census of Manufactures reports. The final industries are listed in Table 9.

**Table 12. Industries Used by Levy (1984) vs. The Present Study**

| Levy (1984) Link SIC | Industry Name | Present Study SIC Code | Industry Name |
|---|---|---|---|
| 2020 | Dairy Products | 2011 | Meat packing |
| 2040 | Grain Mill Products | 2013 | Sausage & other prepared meat |
| 2050 | Bakery Products | 2021 | Creamery butter |
| 2082 | Malt Liquors and Malt | 2022 | Cheese, natural & processed |
| 2086 | Bottled Soft Drinks and Flavorings | 2023 | Dry, condensed & evaporated dairy |
| 2100 | Tobacco Manufacturers | 2024 | Ice cream & frozen desserts |
| 2228 | Weaving Mills & Textile Finishing | 2026 | Fluid milk |
| 2250 | Knitting Mills | 2032 | Canned specialties |
| 2310 | Mens's & Boys' Clothing | 2033 | Canned fruits & vegetables |
| 2380 | Miscellaneous Apparel & Accessories | 2034 | Dehydrated fruits, vegetables and soups |
| 2430 | Millwork, Plywood & Prefabricated Structural Products | 2035 | Pickles, sauces & salad dressings |
| 2510 | Household Furniture | 2037 | Frozen fruits & vegetables |
| 2620 | Pulp, Paper & Board | 2041 | Flour & other grain mill products |
| 2712 | Periodicals | 2043 | Cereal breakfast foods |
| 2715 | Books, Greeting Cards & Miscellaneous Publishing | 2044 | Rice milling |
| 2830 | Drugs | 2045 | Prepared flour mixes & doughs |
| 3098 | Miscellaneous Plastic Products | 2046 | Wet corn milling |
| 3140 | Footwear, except Rubber | 2051 | Bread, cake, and related products |
| 3198 | Leather & Leather Products Not Elsewhere Classified | 2052 | Cookies and crackers |
| 3240 | Cement, Hydraulic | 2061 | Raw cane sugar |
| 3270 | Concrete, Gypsum & Plaster Products | 2063 | Beet sugar |
| 3298 | Other Nonmetallic Mineral Products | 2065 | Sweet & confectionery products |
| 3310 | Ferrous Metal Processing & Basic Products, & Primary Metal Products Not Elsewhere Classified | 2066 | Chocolate & cocoa products |
| 3410 | Metal Cans | 2067 | Chewing gum |
| 3450 | Screw Machine Products, Bolts, & Similar Products | 2074 | Cottonseed oil mills |
| 3461 | Metal Stampings | 2075 | Soybean oil mills |

Source: US Census of Manufacturers, Link industries, 1963, 1967, 1972 and U.S. Department of Commerce, Census of Manufactures, 1997.

**Table 12. Industries Used by Levy (1984) vs. The Present Study (continued)**

| Levy (1984) Link SIC | Industry Name | Present Study SIC Code | Industry Name |
|---|---|---|---|
| 3530 | Construction, Mining, & Materials Handling Machinery & Equipment | 2076 | Vegetable oil mills |
| 3550 | Special Industry Machinery | 2077 | Animal & marine fat oils |
| 3570 | Office & Computing machines | 2079 | Edible oils and fats, n.e.c |
| 3580 | Service Industry Machines | 2082 | Malt beverages |
| 3598 | Other Machinery, Except Electrical | 2083 | Malt |
| 3698 | Other Electrical Equipment & Supplies | 2084 | Wine, brandy and brandy spirits |
| 3730 | Ship & Boatbuilding & Repairing | 2085 | Distilled & blended liquors |
| 3798 | Transportation Equipment, Not Elsewhere Classified | 2086 | Bottled & canned soft drinks |
| 3810 | Scientific & Mechanical Measuring Instruments | 2087 | Flavoring extracts & syrups |
| 3830 | Optical, Medical, & Ophthalmic Equipment | 2091 | Canned and cured fish and seafood |
| 3860 | Photographic Equipment & Supplies | 2092 | Prepared fresh/frozen fish/seafood |
| 3980 | Ordnance, Except Guided Missiles | 2095 | Roasted coffee |
| | | 2097 | Manufactured ice |
| | | 2098 | Macaroni & spaghetti |
| | | 2099 | Food prepared, n.e.c |

Source: US Census of Manufacturers, Link industries, 1963, 1967, 1972 and U.S. Department of Commerce, Census of Manufactures, 1997.

## 2. Different View on Theoretical Relationship

The theoretical relationship of Levy's study can be augmented by adding more relevant variables, like technology. In this study, in addition to all the variables used by Levy, the total factor productivity variable was added to correct for the potential shortcomings of the missing technology factor. Armour and Teece (1980) found a positive, and statistically significant relationship between vertical integration and technological innovation (TP). Gopinath and Yonghai (2003), Hortaççu and Syverson (2005) also used a TP variable.

Forty-one food producing industries were used and six different census years were used. Levy's procedures for calculating the data were applied, and his analysis was replicated using the same variables and adding the total factor productivity. The major difference between the analysis to follow and Levy's analysis is the use of only the food manufacturing industry, rather than the wide spectrum of industries employed by Levy and the included extra total factor productivity variable (TP).

## 3. Methodology

Ordinary Least Squares (OLS) was initially used by Levy (1984) but he did not report the results, admitting that this method is unable to capture a complete picture of the industry-specific and inter-temporal effects. Instead he described only the random effects model (REM). In addition to a REM, the current study also used a fixed effects model (FEM) to test whether more efficient estimates of the industry specific and inter-temporal effects might be obtained (Greene, 2000).

The advantage of using fixed-effects models and random-effects models instead of OLS is that they capture both the time-specific effects and industry-specific effects. The commonly used methods for incorporating industry-specific and time-specific effects are to either include separate dummy variables for each cross sectional unit and each time period, or to use a random effects model to capture these differences in the error specification. In the random effects model the error term $\varepsilon_{it}$ is composed of a problem specification component, component due to industry, and a temporal component.

In the OLS, REM and FEM models, the variables were all estimated at the 4-digit food industry level rather than at the firm level, and the cross sectional data were recorded for six census years. In the equations, there were sufficient degrees of freedom to control for industry-specific and time-specific effects.

## C. Food Industry's Regression Results

### 1. OLS Model: Empirical Results Based on Modified Stigler's Analysis

Following Levy simple OLS and REM were used in 41 selected food manufacturing industries. A FEM was also estimated to allow for an alternative cross-industry and cross time specification. The results of the OLS model are reported in Table 13. The coefficients of the concentration ratio (CN) and industry demand growth (DG) are significant at the 5% level and have positive signs, indicating a positive relationship between those variables and vertical integration. This agrees with the expectations for these coefficients, as mentioned by Levy (1984). However, contrary to Levy's finding, the firm average size (AS) coefficient is not statistically significant. When the total factor productivity (TP) variable was added to the model, that coefficient was not significant either. The adjusted $R^2$ equaled 10%, which indicates that the model had a low explanatory power. Initially, a Durbin-Watson test indicated that there was some evidence of positively autocorrelated disturbances at the 5% critical value, so both models' covariance matrices were corrected using the Newey-West estimator.

The concentration ratio coefficient was 0.00248. Thus, a 1.0 percentage point increase in the concentration ratio will increase the vertical integration ratio by 0.00248 percentage point. The concentration ratio thus does not appear to be responsible for an increase in vertical integration. The most significant effect on vertical integration came from the industry demand growth. A 1.0 percentage point increase in demand growth increased the vertical integration ratio by 0.1208 percentage point. The average firm size, and the total factor productivity variables were not statistically significant.

**Table 13. OLS Results for the Food Manufacturing Industry, with Vertical Integration (VI) as the Dependent Variable**

| | Without TP | | With TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.24856 | (0.0000) | 0.15700 | (0.0941) |
| CN | 0.00252 | (0.0001) | 0.00248 | (0.0001) |
| DG | 0.11344 | (0.0030) | 0.12080 | (0.0016) |
| AS | -0.00030 | (0.3994) | -0.00029 | (0.4210) |
| TP | | | 0.09250 | (0.3396) |

| Without TP | With TP |
|---|---|
| $R^2$ = 0.11 | $R^2$ = 0.12 |
| Adj $R^2$ = 0.10 | Adj $R^2$ = 0.10 |
| F (3, 242), (prob) = 10.11, (0.0000) | F (4, 241), (prob) = 8.07, (0.0000) |
| DF = 242 | DF = 241 |
| DW = 0.4912628 | DW = 0.7527289 |
| Robust VC Newey-West, Periods =1 | Robust VC Newey-West, Periods =1 |

### 1. Random Effects Model Results

The results are reported in Table 14. The random effects model was used to capture not only individual-specific effects but also time-specific effects. The commonly used methods to incorporate industry-specific and time-specific effects are (1) to include separate dummy variables for each cross sectional unit and each time period, or (2) the random effects model. The random effects model loses fewer degrees of freedom than the dummy variable model and is more appropriate if the results obtained with a randomly chosen sample are used to make inferences about a larger population (Hsiao, 2003) and Judge, et al. (1988)).

The p-values are reported in parentheses. The CN, DG, and AS coefficients are all insignificant whereas the TP is the only significant one. The concentration ratio, demand growth and the firm average size should be significant according to Levy (1984).

**Table 14. Random Effect Model Results, Vertical Integration (VI) as the Dependent Variable**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.30687480 | (0.0000) | 0.36509809 | (0.0000) |
| CN | 0.00016105 | (0.6382) | 0.00052502 | (0.1171) |
| DG | -0.00813839 | (0.5303) | -0.01385565 | (0.2945) |
| AS | -0.158182D-04 | (0.8550) | -0.187058D-4 | (0.8337) |
| TP | 0.07512147 | (0.0007) | | |

| With TP | Without TP |
|---|---|
| $\sigma_i^2 = 0.00143604$ | $\sigma_i^2 = 0.00152453$ |
| $\sigma_t^2 = 0.0118603$ | $\sigma_t^2 = 0.0103527$ |
| $\sigma^2_u = 0.0104056$ | $\sigma^2_u = 0.0119077$ |
| $\sigma^2_{uit} = 0.891997$ | $\sigma^2_{uit} = 0.886502$ |
| Lagrange Multiplier Test = 398.20 | Lagrange Multiplier Test = 397.64 |
| Hausman (FEM vs. REM) = 39.35 | Hausman (FEM vs. REM) = 37.71 |

### a. Lagrange Multiplier Test

The Lagrange multiplier test considers the equality of the OLS and REM estimates. It is a test of heteroskedasticity. If there is no heteroskedasticity, the OLS estimates are preferred. If heteroskedasticity is found, the REM estimates are preferred, since they model it (LIMDEP 8.0, 2002). The test is based on the restricted estimators; specifically, the extent to which the first-order conditions for maximizing the likelihood function are violated when the unrestricted estimates are replaced by the restricted ones (Kmenta, 1986; LIMDEP 8.0, 2002). The Lagrangian multiplier statistic is 398.20, which far exceeds the 95 % critical value for chi-squared with four degrees of freedom (9.49). It can be concluded that the classical regression model with a single constant term is inappropriate for the data. The result of the test is to reject the null hypothesis of the OLS model in favor of the random effects model.

## 3. Comparison between OLS and Random Effects Model Results

This study found that using OLS specification produced significantly different results from a random-effects specification when estimating the vertical integration equation using a sample of 41 food manufacturing industries from 1967 to 1992 based on the LaGrange multiplier test. In comparing these two estimates, it is apparent that the effects of concentration ratio, average firm size, demand growth, and total factor productivity differ widely (relative to their significance and their coefficient signs) in the two models. OLS is close to Levy's results whereas the random effect is completely different from it. Only the demand growth variable was significant in both the OLS and the REM models

### 4. Fixed Effects Model Results

The fixed-effects specification was estimated. The results are reproduced in Table 15. The p-values are reported in parentheses. The intercept, DG, and AS are statistically significant but have unexpected signs, whereas, the coefficient of TP is significant and has the expected positive sign, and CN is insignificant. The F statistic for testing the joint significance of the industry effects is highly significant. The $R^2$ is also high (94%).

The high $R^2$ coupled with significant Levy-type variables means that almost all of the variation is accounted for by the industry and time dummies. This not only calls for individual industry studies, but it also indicates that ignoring such variation as in the OLS model or putting it in the residual as in the REM may result in serious biases in the estimated coefficients.

**Table 15. Fixed Effects Estimates with Vertical Integration (VI) as the Dependent Variable**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.31875417 | (0.0000) | 0.38014014 | (0.0000) |
| CN | -0.00021124 | (0.5704) | 0.00023781 | (0.5108) |
| DG | -0.01589533 | (0.2258) | -0.02299389 | (0.0859) |
| AS | -0.320715D-06 | (0.9971) | 0.215186D-05 | (0.9810) |
| TP | 0.08217631 | (0.0004) | | |

| | | | |
|---|---|---|---|
| Number of observations | = 246 | Number of observations | = 246 |
| Parameters | = 50 | Parameters | = 49 |
| Degrees of freedom | = 196 | Degrees of freedom | = 197 |
| $R^2$ | = 0.96 | $R^2$ | = 0.95 |
| Adjusted $R^2$ | = 0.94 | Adjusted $R^2$ | = 0.94 |
| F[ 49, 196] (prob) | = 88.06 (0.00) | F[ 48, 197] (prob) | = 88.06, (0.00) |
| Chi-sq [ 49] (prob) | = 771.48 (0.00) | Chi-sq [ 49] (prob) | =771.48, (0.00) |

**a. Test Statistics for the Classical Model and Hypothesis Tests**

Table 16 presents the summary results of five different model specifications of various fixed effect structures. The full 2-way fixed effect specification can be viewed as:

$$Y = \tau + \Sigma\beta_i X_i + \Sigma\delta_j DI_i + \Sigma\gamma_k DT_i + \epsilon$$

Where:

$\tau$ = constant of overall effect

$X_i$ = $i^{th}$ explanatory variables,

$DI_j$ = $_j^{th}$ industry dummies,

$DT_k$ = $k^{th}$ time dummies,

$\epsilon$ = residual components,

and $\beta_i$, $\delta_j$ and $\gamma_k$ are unknown coefficients. Thus, as the models are identified in Table 15, Model (1) assumes $\beta i = \delta_j = \gamma_i = 0 \ \forall i, j, k$ or that all coefficients but the intercept term are zero and therefore, the $X_i$ variables, industry dummies and time dummies do not explain vertical integration.

Model (2) assumes $\beta_i = \gamma_k = 0 \ \forall i, k$ meaning that the industry dummies are allowed to explain VI, but not the $X_i$ explanatory variables or time dummies.

Model (3) assumes $\delta_j = \gamma_k = 0, \ \forall j, k$ meaning that the $X_i$ the explanatory variables are allowed to affect VI but the industry and time dummies are constrained to be zero.

Model (4) assumes $\gamma_k = 0, \ \forall k$ meaning that both explanatory variables and industry dummies are allowed to explain VI but the time dummy effects are constrained to be zero.

Model (5) allows all coefficients to be non-zero.

Thus, a test of model (2) vs. model (4) is a test of Ho: $\beta = 0$ (i.e. the joint significance of explanatory variables, $X_i$); a test of model (3) vs. (4) is a test of $\delta = 0$ (i.e. the joint significance of industry effects). A test of model (5) vs. model (4) is a test of Ho: $\gamma = 0$ (i.e. a test of the joint significance of time effects); and a test of model (5) vs. model (3) is a test of Ho: $\delta = 0$ and $\gamma = 0$ (i.e. a test of the joint significance of industry and time effects).

Table 16 contains the estimated vertical integration model with individual industry effects, specific period effects, and both industry and period effects. The critical value with a probability of 0.0000 for the joint significance of $X_i$, so the evidence is strongly in favor of a joint variable specific effect in the data. The joint significance of industry effects is significant. The same computation for the joint significance of time effects, in the absence of the firm effects produces with a probability of 0.0000, which is significant. There does, therefore, appear to be a significant vertical integration difference across the different periods that are not accounted for by the concentration ratio, demand growth, average firm size, and total factor productivity. For the joint significance of industry and time effects, the probability of 0.0000 which shows that the industry effects and the time effects are significant.

**Table 16. Test Statistics for the Classical Model**

| Model | Log-Likelihood | Sum of Squares | R-squared |
|---|---|---|---|
| (1) Intercept only | 98.29 | 65 | 0.00 |
| (2) Group dummies effects only | 402.53 | 54 | 0.91 |
| (3) X - variables only | 113.76 | 51 | 0.12 |
| (4) X and group effects | 447.36 | 38 | 0.94 |
| (5) X ind.&time effects | 484.03 | 28 | 0.96 |

(1) Intercept only = all coefficients ($X_i$ variables, industry dummies and the time dummies) are zero except the intercept.

(2) Industry group dummies effects only = industry group dummies only, no regressors, no time dummies.

(3) X - variables only = all regressors and overall constant term, no industry and time dummies

(4) X and group effects = explanatory variables and industry dummies effects (full one way fixed effects model), no time dummies

(5) X individual & time effects = (full two way fixed effects model), explanatory variables, industry and time dummies effects.

**Hypothesis Tests**

| | Likelihood Ratio Test | | | F Tests | | | |
|---|---|---|---|---|---|---|---|
| | Chi-squared | d.f. | Prob. | F | num. | denom. | P-value |
| (2) vs. (1) | 608.488 | 40 | 0.00 | 55.679 | 40 | 205 | 0.00 |
| (3) vs. (1) | 30.939 | 4 | 0.00 | 8.075 | 4 | 241 | 0.00 |
| (4) vs. (1) | 698.136 | 44 | 0.00 | 73.460 | 44 | 201 | 0.00 |
| (4) vs. (2) | 89.650 | 4 | 0.00 | 22.090 | 4 | 201 | 0.00 |
| (4) vs. (3) | 667.200 | 40 | 0.00 | 70.660 | 40 | 201 | 0.00 |
| (5) vs. (4) | 73.350 | 5 | 0.00 | 13.620 | 5 | 196 | 0.00 |
| (5) vs. (3) | 740.550 | 46 | 0.00 | 82.210 | 46 | 196 | 0.00 |

Numbers in parentheses are models

The test statistics for the classical regression model show an explanatory power of 0.12 for the group dummies effects only, variables only, variables only and group effects and the explanatory variables and time effects with respectively an $R^2$ of 0.91, 0.12, 0.94 and 0.96. The model that combines industry-specific dummy variables with time-specific dummy variables has the highest explanatory power. The hypothesis tests also show that all five sets of zero restriction can be rejected.

Comparing REM (Table 14) and FEM (Table 15), it is apparent that the effects of concentration ratio, average firm size, demand growth, and total factor productivity differ widely (relative to their standard errors and their coefficient signs) in the two models. Levy's variables do not have any explanatory power in the FEM which is the best model.

**b. Hausman's specification test for the random effects model**

According to Greene (2000, p.301) "The Hausman specification test devised by Hausman (1978) is used to test for orthogonality of the random effects and the regressors. The test is based on the idea that under the hypothesis of no correlation, both OLS in the LSDV (Least squares dummy variable) model and GLS are consistent, but OLS is inefficient, whereas under the alternative, OLS is consistent, but GLS is not. Therefore, under the null hypothesis, the two estimates should not differ systematically, and a test can be based on the difference." Hausman's essential result is that the covariance of an efficient estimator with its difference from an inefficient estimator is zero. "The Hausman (1978) test is used in the following setting: there are two estimators of the parameter vector $\beta$, $b_o$ and $b_1$. Under $H_o$, $b_o$ and $b_1$ are both consistent but $b_o$ is inefficient (so $b_1$ is preferred). Under $H_1$, $b_o$ is consistent; $b_1$ is not so $b_0$ is preferred. In the present case, the null hypothesis is that the random effects model is appropriate (i.e. the preferred estimator $b_1$ is generalized least squares or REM). The alternative hypothesis is that the fixed effects model is appropriate, (i.e. the preferred estimator is least squares with dummy variables or FEM)" (LIMDEP 8.0, page R11.7, 2002). The Hausman test for the fixed and random effects regressions is based on the parts of the coefficient vectors and the asymptotic covariance matrices that correspond to the slopes in the models, ignoring the constant term(s) (Greene, 2000). The Hausman test statistic is $H = (\beta_{REM}-\beta_{FEM})' [Cov[\beta_{REM}-\beta_{FEM}]]^{-1} (\beta_{REM}-\beta_{FEM})$

$$H \sim \chi^2(K).$$

From Table 14, the calculated value of this test statistic is 39.35 and the critical value from the chi-squared table with four degrees of freedom is 9.49, less than the test value. Thus, the hypothesis that the individual industry effects are uncorrelated with the other regressors in the model can be rejected.

The Hausman test favors the FEM over the REM and The Lagrange multiplier test favors the REM over the OLS. Therefore, the FEM is the best model. The Hausman test, reported in Table 14, favors the fixed effect model in this study whereas the random one was used in Levy's.

This study found that a fixed-effects specification was a significantly better model than a random-effects specification when estimating a vertical integration equation using a sample of 41 food manufacturing industries from 1967 to 1992. In comparing these two estimates, it is apparent that the effects of concentration ratio, average firm size, demand growth, and total factor productivity differ widely (relative to their standard errors and their coefficient signs) in the two models.

The FEM is significantly better than the REM according to the Hausman test. But they both show three out of the four theoretical variables as statistically insignificant.

### 5. Differences between FEM and REM

A comparison between FEM and the REM provides the most direct evidence of how Levy's empirical results are not statistically replicable to a heterogeneous industry. Table 14 and Table 15 report the regression results using the random effects and the fixed effects models. The models were applied to a sample of food manufacturing sub-industries. Two-way (industry and time specifics) fixed effects and random-effects models were applied. As indicated in Table 16, the chi-squared and F-tests for the pooled models, as well as the LM statistic, test the null hypothesis of no effects. As these tests are significant, they suggest rejection of the ordinary least squares model. The Hausman test indicates that the fixed effects model is preferred over random effects. The results in Table 14 indicate that the model is not robust with regard to the independent variables that capture industry-by-industry differences in vertical integration. Only one variable, total factor productivity is significant in both the fixed effects model and the random effects model. However, the regression in Table 15 to some extent, and Table 14 to any extent, do not support Levy's hypotheses as an explanation of vertical integration in the food manufacturing industry. The concentration ratio is not a significant explanatory variable in any versions of the model. Total factor productivity is the only significant explanatory variable in the random and fixed effects models and it was not used by Levy (1984).

When using only pooled data for the food industry from 1967 to 1992 and analyzing by the random effects model with or without the total factor productivity variable, Levy's conclusions could not be supported for the food industry. Levy's study favors the random effects model, whereas this present one favors the fixed effects one. The differences between this study and Levy's in estimating vertical integration as a function of concentration ratio demand growth, average firm size and total factor of productivity are substantial and demonstrate the importance of the problem of "aggregation error" in Levy's results.

### 6. Industry by Industry Results

Pooling different industries in the food manufacturing industry did not produce results similar to that of Levy (1984). This study favors the fixed effect model whereas Levy's one was the random effects model. The results were completely different with regard to the signs and their significance levels. Therefore, industry by industry analysis was conducted. The results show that there is no homogeneity in the effects of Levy's variables among industries included in the food industry. Levy's choice of pooling data may have been inappropriate. The results of the OLS model of the Meat Packing, Fluid Milk, Cereal Breakfast Foods, Chewing Gum, Malt Beverages, and Prepared Fresh/Frozen Fish/Seafood industries with and without total factor productivity growth are reported in Tables 17, 18, 19, 20, 21 and 22 respectively. To inquire into Levy's arguments on vertical integration at the higher level of disaggregation, the vertical integration ratio was regressed on the same set of independent variables in the original model for each of the following industries separately: the Meat Packing, Fluid Milk, Cereal Breakfast Foods, Chewing Gum, Malt Beverages, and Prepared Fresh/Frozen Fish/Seafood industries.

Since a complete data set was unavailable linear interpolation was used to predict the missing four years between the census years for the concentration ratio variable as follows: given two observations on $X_0$ and $X_1$ at times $T_0$ and $T_1$, an intermediate value is estimated by

$$X(T) = \frac{T_1 - T}{T_1 - T_0} X_0 + \frac{T - T_0}{T_1 - T_0} X_1 \quad \text{where}$$

$X(T)$ = value to be estimated

$X_0$ = initial value (given) at time $T_0$

$X_1$= value (given) at time $T_1$

$T_1$ = time at the second period

$T_0$ = time at the base time

a. MEAT PACKING PLANTS (SIC 2011)

Meat packing is one of the largest agriculture-based industries in the U. S. Its value of shipments was the highest in 1992, with $50 billion. In the food industry as a whole, meat packing and processing is the second largest employer after bread, cakes, and related products. In recent years the meat packing industry has become much more concentrated. The meat packing industry concentration ratio has grown almost two times faster from 26% in 1967 to 50% in 1992. It was the second highest ranked food industry by total factor productivity growth in 1992 behind prepared fresh/frozen fish/seafood. According to Stumo (1998), the Big Three IBP, Monfort, Excel plus National Beef controlled 82% of the national steer and heifer slaughter in 1997, and in hogs, the Big Three plus Smithfield Foods and Hormel control 63% of pork slaughter. According to the Encyclopedia of American Industries ( (EAI), 2006), Tyson, Excel, Swift, Farmland, and Smithfield control 89 percent of steer and heifer slaughter.

The result of the OLS regression model for the meat packing industry is displayed in Table 17 below. The F-ratio of 7.92 shows the model to be highly significant. The coefficient of determination (the R-square) shows that the model explains 0.60 of the variance in the dependent variable. Only the concentration ratio and the average firm size were significant and had expected positive signs similar to Levy (1984). The demand growth (contrary to Levy) and the total factor productivity variables were insignificant.

**Table 17. Regression Results for the Meat Packing Industry, with Vertical Integration (VI) as the Dependent Variable.**

| | With TP | | Without TP (Levy-style) | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.08577 | (0.1690) | 0.1152 | (0.0000) |
| CN | 0.001456 | (0.0017) | 0.00146678 | (0.0013) |
| DG | -0.02843 | (0.3026) | -0.026102 | (0.3268) |
| AS | -0.001269 | (0.0000) | -0.0012369 | (0.0000) |
| TP | 0.03149 | (0.6267) | | |

| With TP | Without TP (Levy-style) |
|---|---|
| $R^2$ = 0.60 | $R^2$ = 0.60 |
| Adj $R^2$ = 0.53 | Adj $R^2$ = 0.54 |
| F [4, 21] (prob) = 7.92, (0.0005) | F [3, 22], (prob) = 10.85, (0.0001) |
| DF = 21 | DF = 22 |
| DW = 2.69 | DW = 2.74 |

b. FLUID MILK (SIC 2026)

The fluid milk industry is an important subsector of the nation's dairy business. The fluid milk industry was among the industries with the lowest growth in TP in 1992 with 0.84 percent and also the only industry with no change in concentration ratio from 1967 to 1992. It was the second largest in value of shipments in 1992.

The result of the OLS regression model for the fluid milk industry is displayed in Table 18. The F-ratio 22.55 shows the model to be highly significant. The coefficient of determination (the R-square) shows that the model explains 0.81 of the variance in the dependent variable. Only the concentration ratio was both significant and had the positive sign posited by Levy (1984). The total factor productivity variable was also significant but had an expected negative sign. The demand growth and the average firm size were not significant, as opposed to Levy's (1984) result.

**Table 18. Regression Results for the Fluid Milk Industry, with Vertical Integration (VI) as the Dependent Variable.**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.3012 | (0.0022) | 0.0692 | (0.0327) |
| CN | 0.006419 | (0.0049) | 0.010767 | (0.0000) |
| DG | 0.01988 | (0.7846) | -0.02636 | (0.7456) |
| AS | -0.000334 | (0.2151) | -0.00090649 | (0.0001) |
| TP | -0.169 | (0.0102) | | |

| With TP | Without TP |
|---|---|
| $R^2$ = 0.81 | $R^2$ = 0.74 |
| Adj $R^2$ = 0.77 | Adj $R^2$ = 0.70 |
| F[4, 21], (prob) = 22.55, (0.0000) | F[3, 22], (prob) = 20.82, (0.0000) |
| DF = 21 | DF = 22 |
| DW = 1.12 | DW = 0.79 |

c. CEREAL BREAKFAST FOODS (SIC 2043)

According to the National Bureau of Economic Research (2005), the cereal breakfast foods industry shipped $0.79 billion worth of products in 1967. By 1992, it was valued at $9.8 billion. The breakfast cereal industry has been one of the fastest growing of the food industries, with average firm size rising by 305% from 1967 to 1992. The breakfast foods industry ranks fourth in value added, but it is relatively low in ranking by shipments (fourteen). In 1992, breakfast cereals were the fourth most concentrated food industries.

The result of the OLS regression model for the cereal breakfast foods industry is displayed in Table 19. The F-ratio 48.22 shows the model to be highly significant. The coefficient of determination (the R-square) shows that the model explains 0.90 of the variance in the dependent variable. Only the total factor productivity variable was both significant and had the expected positive sign. Although, demand growth and average firm size were significant, they had negative and positive signs, opposite to Levy (1984). The concentration ratio was not significant.

**Table 19. Regression Results for the Cereal Breakfast Foods Industry, with Vertical Integration (VI) as the Dependent Variable.**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.15218 | (0.8011) | 0.4597 | (0.4700) |
| CN | 0.00376 | (0.5728) | 0.001848 | (0.7949) |
| DG | -0.349849 | (0.0000) | -0.33018 | (0.0001) |
| AS | 0.00068955 | (0.0000) | 0.000628 | (0.0000) |
| TP | 0.140947 | (0.0428) | | |

| With TP | Without TP |
|---|---|
| $R^2$ = 0.90 | $R^2$ = 0.88 |
| Adj $R^2$ = 0.88 | Adj $R^2$ = 0.86 |
| F[4, 21], (prob) = 48.22, (0.0000) | F[3, 22], (prob) = 53.82, (0.0000) |
| DF = 21 | DF = 22 |
| DW = 0.90 | DW = 0.73 |

d. CHEWING GUM (SIC 2067)

This industry consists of establishments primarily engaged in manufacturing chewing gum or chewing gum base. The EAI (2006) stated that "The industry's overall success has been the result of low manufacturing costs and aggressive marketing campaigns…, the growth rate of gum fell slightly in the late 1990s, and the $1 billion U.S. gum market showed little signs of growth."

In 1992, the most concentrated industries were chewing gum, followed by malt beverages, vegetable oil mill products, and breakfast cereals. The chewing gum industry was the third-ranked industry based on the value added per shipment.

The result of the OLS regression model for the chewing gum industry is in Table 20. The F-ratio 9.25, shows the model to be highly significant. The coefficient of determination (the R-square) shows that the model explains 0.64 of the variance in the dependent variable. The concentration ratio and the total factor productivity were significant respectively at 5% and 10% levels. The demand growth and the average firm size were not significant.

**Table 20. Regression Results for the Chewing Gum Industry, with Vertical Integration (VI) as the Dependent Variable**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | -0.25108 | (0.5902) | 1.07000 | (0.0003) |
| CN | 0.00718 | (0.1271) | -0.00522 | (0.0828) |
| DG | -0.03470 | (0.5980) | -0.01503 | (0.8475) |
| AS | 0.00025 | (0.2415) | 0.00067 | (0.0026) |
| TP | 0.18960 | (0.0039) | | |

| With TP | Without TP |
|---|---|
| $R^2$ = 0.64 | $R^2$ = 0.46 |
| Adj $R^2$ = 0.57 | Adj $R^2$ = 0.38 |
| F[4, 21], (prob) = 9.25, (0.0002) | F[3,22], (prob) = 6.17, (0.0033) |
| DF = 21 | DF = 22 |
| DW = 2.06 | DW = 1.98 |

e. MALT BEVERAGES (SIC 2082)

This industry includes establishments primarily engaged in the manufacturing of malt beverages, including ale, beer, malt liquor, nonalcoholic beer, porter, and stout. This industry includes only those companies that manufacture beer. The EAI (2006) wrote that “The industry has consistently been dominated by three major U.S. breweries. In the late 1990s, beer industry sales grew about 1.5 percent to 193.3 million barrels. The U.S. beer industry consisted of 54 leading breweries.” From 1967 to 1992, the malt beverages industry had the largest increase in concentration ratio in the food manufacturing industry with 50 percent. In 1992, the second most concentrated food industry was malt beverages and was also the highest ranked value- added food processing industry behind bread, cakes, and related products.

The result of the OLS regression model for the malt beverages industry is displayed in Table 21. The F-ratio 28.72 shows the model to be highly significant. The coefficient of determination (the R-square) shows that the model explains 0.85 of the variance in the dependent variable. This result is completely opposite to that of Levy (1984). Although, all the variables were significant at 5% level, they all had opposite signs contrary to what Levy found. Only total factor productivity had the expected positive sign.

**Table 21. Regression Results for the Malt Beverages Industry, with Vertical Integration (VI) as the Dependent Variable**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.43586 | (0.0000) | 0.416794 | (0.0003) |
| CN | -0.013485 | (0.0000) | 0.002930 | (0.1489) |
| DG | -0.53675 | (0.0002) | -0.71506 | (0.0039) |
| AS | 0.00087 | (0.0403) | 0.00097 | (0.1285) |
| TP | 1.16270 | (0.0000) | | |

| With TP | Without TP |
|---|---|
| $R^2$ = 0.85 | $R^2$ = 0.39 |
| Adj $R^2$ = 0.82 | Adj $R^2$ = 0.31 |
| F [4, 21], (prob) = 28.72, (0.0000) | F[3, 22], (prob) = 4.77, (0.0104) |
| DF = 21 | DF = 22 |
| DW = 1.09 | DW = 0.63 |

f. PREPARED FRESH OR FROZEN FISH AND SEAFOODS (SIC 2092)

The value of shipments in the fresh and frozen seafood processing industry grew from \$0.557 billion in 1967 to \$6.995 billion in 1992. The number of employees in the industry rose by 17% between 1967 and 1992.

The prepared fresh/frozen fish/seafood industry had one of the lowest gains in average firm size (about 13 percent). The industries with the highest total factor productivity growth in 1992 were prepared fresh/frozen fish/seafood (about 1.38 percent) followed by meat packing (about 1.26 percent). The least concentrated were prepared fresh/frozen fish/seafood, food preparations, fluid milk, manufactured ice (all below 25 percent).

The result of the OLS regression model for the prepared fresh or frozen fish and seafoods industry is reported in Table 22. The F-ratio 3.30 shows the model to be significant. The coefficient of determination (the R-square) shows that the model explains 0.39 of the variance in the dependent variable. The average firm size was the only variable used by Levy (1984) that was significant but it had the opposite of his expected sign. The total factor productivity variable added in this study was significant and had the expected positive sign.

**Table 22. Regression Results for the Prepared Fresh/Frozen Fish/Seafood Industry, with Vertical Integration (VI) as the Dependent Variable**

| | With TP | | Without TP | |
|---|---|---|---|---|
| Variables | Coefficient | p-Value | Coefficient | p-Value |
| INTERCEPT | 0.14842 | (0.0020) | 0.22250 | (0.0000) |
| CN | -0.00028 | (0.8805) | 0.00260 | (0.0715) |
| DG | -0.00175 | (0.9593) | -0.00490 | (0.8946) |
| AS | 0.00640 | (0.0094) | 0.00210 | (0.0706) |
| TP | 0.08827 | (0.0426) | | |

| With TP | Without TP |
|---|---|
| $R^2$ = 0.39 | $R^2$ = 0.259 |
| Adj $R^2$ = 0.27 | Adj $R^2$ = 0.15 |
| F[4,21], (prob) = 3.30, (0.0301) | F[3, 22], (prob) = 2.44, (0.0912) |
| DF = 21 | DF = 22 |
| DW = 1.19 | DW = 0.99 |

The overall results show that despite the fact that the regressions attempted to explain the same tendencies as seen in the original Levy model, the efforts are generally unsuccessful. The coefficients have the same signs in some industries and different signs in others compared to Levy (1984). However, there is no consistency in the significance, sign and magnitude of the variables, either with or without TP, in the selected food industries studied here. The results of the OLS model of the selected food industries show that there is no convincing and uniform evidence of the significance of the variables, and the results are inconsistent with Levy's (1984) estimation results. It would thus appear that Levy's results are simply an artefact of aggregation under his specific time and industry conditions, and do not reflect any consistent pattern inherent in the variables.

# VI. SUMMARY AND CONCLUSIONS

The results of this study are not uniform and may suggest that firm and industry behavior vary based on their competitive strategy. The structure and conduct of firms and hence the industry may be altered temporally, spatially, and by organization based on their goals and objectives. Vertical integration as well as firm and industry behavior are dynamic processes. Industries not only try to make a profit, they watch their competitors and use different strategies (mergers, sales tactics, and so on) to ensure their own survival. A classical model covering many different industries may not apply across the economic spectrum. In his study Levy (1984) proposes a universal model which is apparently not applicable at least to the food industry.

The use of the fixed effect model allowed for industry-specific and also for time-specific effects. Considering the period and industry-specific effects on vertical integration, a fixed effects approach to illuminate the "unexplained heterogeneity" problem is used. In the fixed effects model all the variables except the total factor productivity were statistically insignificant. Using OLS in selected subsets of the food manufacturing industry gave different results than were found for the pooled model in sign, magnitude and significance of coefficients. There is no consistency in the significance, sign, and magnitude of the corresponding coefficient estimates with or without total factor productivity in selected subsets of food industry studied. While the vertical integration model developed by Levy (1984) might be applicable to all manufacturing industries, the results reported suggest that it is not.

The ongoing debate about vertical integration in the food industry has raised economic questions but few have been addressed with adequate economic analyses. All these analyses are based on discontinuous data or industries that have been reclassified. Results for the selected food industries using their four-digit SIC codes showed that there is no convincing uniform evidence of the significance of the variables. This result calls into question Levy's pooled data results. Consequently, his results concerning concentration ratio, firm average size, and industry demand growth may be due simply to an artefact of inappropriate pooling of the data and not to any underlying economic phenomenon. Levy's results could not be replicated with the newer data or different industry. Finally, industry-by-industry analysis shows that there is considerably greater diversity in results than is even suggested by the fixed effects model on the aggregated data.

Levy's findings and the ones from this study differ due to the fact that pooling data together, results in loss of information. Levy (1984) proposes a universal model by his reasoning which, according to these results for the food industry, does not appear applicable after all. It thus appears that Levy's general model is not as "general" as he suggests.

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# APPENDIX A

## SIC CODE AND DESCRIPTION IN FOOD MANUFACTURING INDUSTRIES

### A. Meat Products

**Industry 2011, MEAT PACKING PLANTS**

This industry is made up of establishments primarily engaged in the slaughtering, for their own account or on a contract basis for the trade, of cattle, hogs, sheep, lambs, and calves for meat to be sold or to be used on the same premises in canning, cooking, curing, and freezing, and in making sausage, lard, and other products. Also included in These industries are establishments primarily engaged in slaughtering horses for human consumption. Establishments primarily engaged in slaughtering, dressing, and packing poultry, rabbits, and other small game are classified in industry 2015; and those primarily engaged in slaughtering and processing animals not for human consumption are classified in industry 2048. Establishments primarily engaged in manufacturing sausages and meat specialties from purchased meats are classified in industry 2013; and establishments primarily engaged in canning meat for baby food are classified in industry 2032.

**INDUSTRY 2013, SAUSAGES AND OTHER PREPARED MEATS**

This industry is made up of establishments primarily engaged in manufacturing sausages, cured meats, smoked meats, canned meats, frozen meats, and other prepared meats and meat specialties, from purchased carcasses and other materials. Prepared meat plants operated by packing houses as separate establishments are also included in this industry. Establishments primarily engaged in canning or otherwise processing poultry, rabbits, and other small game are classified in industry 2015. Establishments primarily engaged in canning meat for baby food are classified in industry 2032. Establishments primarily engaged in cutting up and resale of purchased fresh carcasses, for the trade, (including boxed beef) are classified in wholesale trade, industry 5147.

**INDUSTRY 2015, POULTRY SLAUGHTERING AND PROCESSING**

This industry is made up of establishments primarily engaged in slaughtering, dressing, packing, freezing, and canning poultry, rabbits, and other small game, or in manufacturing products from such meats, for their own account or on a contract basis for the trade. This industry also includes the drying, freezing, and breaking of eggs. Establishments primarily engaged in cleaning, oil treating, packing, and grading of eggs are classified in wholesale trade, industry 5144; and those engaged in the cutting up and resale of purchased fresh carcasses are classified in wholesale and retail trade.

**B. Dairy Products**

**INDUSTRY 2021, CREAMERY BUTTER**

This industry is made up of establishments primarily engaged in manufacturing creamery butter. The 1992 definition of this industry is the same as that used in the 1987 Standard Industrial Classification (SIC) system. The SIC number and title also are the same.

**INDUSTRY 2022, CHEESE, NATURAL AND PROCESSED**

This industry is made up of establishments primarily engaged in manufacturing natural cheese (except cottage cheese), processed cheese, cheese foods, cheese spreads, and cheese analogs (imitations and substitutes). These establishments also produce byproducts, such as raw liquid whey. Establishments primarily engaged in manufacturing cottage cheese are classified in industry 2026. Establishments primarily engaged in manufacturing cheese based salad dressings are classified in industry 2035.

**INDUSTRY 2023, DRY, CONDENSED, AND EVAPORATED DAIRY PRODUCTS**

This industry is made up of establishments primarily engaged in manufacturing dry, condensed, and evaporated dairy products. Also included in this industry are establishments primarily engaged in manufacturing mixes for the preparation of frozen ice cream and ice milk and dairy and nondairy base cream substitutes and dietary supplements.

**C. Preserved Fruits and Vegetables**

**INDUSTRY 2032, CANNED SPECIALTIES**

This industry is made up of establishments primarily engaged in canning specialty products, such as baby foods and soups, except seafood. Establishments primarily engaged in canning seafoods are classified in industry 2091.

**INDUSTRY 2033, CANNED FRUITS AND VEGETABLES**

This industry is made up of establishments primarily engaged in canning fruits, vegetables, and fruit and vegetable juices. Also included in this industry are establishments primarily engaged in manufacturing catsup and similar tomato sauces, or natural and imitation preserves, jams, and jellies. Establishments primarily engaged in canning seafoods are classified in industry 2091 and those manufacturing canned specialties, such as baby foods and soups, except seafood, are classified in industry 2032.

**INDUSTRY 2034, DEHYDRATED FRUITS, VEGETABLES, AND SOUPS**

This industry is made up of establishments primarily engaged in sun-drying or artificially-dehydrating fruits and vegetables.  Also included in this industry are establishments primarily engaged in manufacturing packaged soup mixes from dehydrated ingredients. Establishments primarily engaged in the grading and marketing of farm-dried fruits, such as prunes and raisins are classified in wholesale trade, industry 5149.

**INDUSTRY 2035, PICKLES, SAUCES, AND SALAD DRESSINGS**

This industry is made up of establishments primarily engaged in pickling and brining fruits and vegetables, and in manufacturing salad dressings, vegetable relishes, sauces, and seasonings. Establishments primarily engaged in manufacturing catsup and similar tomato sauces are classified in industry 2033. .Establishments primarily engaged in packing purchased pickles and olives are classified in wholesale or retail trade.

**INDUSTRY 2037, FROZEN FRUITS AND VEGETABLES**

This industry is made up of establishments primarily engaged in freezing and cold packing fruits, fruit juices, and vegetables. Establishments primarily engaged in freezing food specialties, such as frozen dinners and frozen nationality foods are classified in industry 2038.

**INDUSTRY 2038, FROZEN SPECIALTIES, N.E.C.**

This industry is made up of establishments primarily engaged in manufacturing frozen specialties, such as frozen dinners, frozen nationality foods, frozen pizzas, and other frozen specialties, except seafood and bakery products. Establishments primarily engaged in manufacturing frozen fruits and vegetables are classified in industry 2037.

Establishments primarily engaged in manufacturing frozen dairy specialties are classified in industry group 202.

**D. Grain Mill Products**

**INDUSTRY 2041, FLOUR AND OTHER GRAIN MILL PRODUCTS**

This industry is made up of establishments primarily engaged in milling flour or meal from grain except rice. Establishments primarily engaged in manufacturing prepared flour mixes or doughs from purchased ingredients are classified in industry 2045, and those milling rice are classified in industry 2044. Products of this industry also are collected in the Current Industrial Report (CIR) M-20A, Flour Milling Products. For information regarding the CIR, see Contacts for Data Users at the end of the Census of Manufactures section.

**INDUSTRY 2043, CEREAL BREAKFAST FOODS**

This industry is made up of establishments primarily engaged in manufacturing cereal breakfast foods and related preparations, except breakfast bars. Establishments primarily engaged in manufacturing granola bars and other types of breakfast bars are classified in industry 2064.

**INDUSTRY 2044, RICE MILLING**

This industry is made up of establishments primarily engaged in cleaning and polishing rice and in manufacturing rice flour and mill. Other important products of this industry include brown rice, milled rice, (including polished rice), rice polish, and rice bran.

**INDUSTRY 2045, PREPARED FLOUR MIXES AND DOUGHS**

This industry is made up of establishments primarily engaged in preparing flour mixes or doughs from purchased flour. Establishments primarily engaged in milling flour from grain and producing mixes or doughs are classified in industry 2041.

**INDUSTRY 2046, WET CORN MILLING**

This industry is made up of establishments primarily engaged in milling corn or sorghum grain (milo) by the wet process and producing starch, syrup, oil, sugar, and byproducts, such as gluten feed and meal. Also included in this industry are establishments primarily engaged in manufacturing starch from other vegetable sources (e.g., potatoes, wheat). Establishments primarily engaged in manufacturing table syrups from corn syrup and other ingredients, and those manufacturing starch base dessert powders, are classified in industry 2099.

**INDUSTRY 2047, DOG AND CAT FOOD**

This industry is made up of establishments primarily engaged in manufacturing dog and cat food from cereal, meat, and other ingredients. These preparations may be canned, frozen, or dry. Establishments primarily engaged in manufacturing feed for animals other than dogs and cats are classified in industry 2048.

**INDUSTRY 2048, PREPARED FEEDS, N.E.C.**

This industry is made up of establishments primarily engaged in manufacturing prepared feeds and feed ingredients and adjuncts for animals and fowls, except dogs and cats. Included in this industry are poultry and livestock feed and feed ingredients, such as alfalfa meal, feed supplements, and feed concentrates and feed premixes. Also included are establishments primarily engaged in slaughtering animals for animal feed. Establishments primarily engaged in slaughtering animals for human consumption are classified in industry group 201. Establishments primarily engaged in manufacturing dog and cat food are classified in industry 2047.

### E. Bakery Products

#### INDUSTRY 2051, BREAD, CAKE, AND RELATED PRODUCTS

This industry is made up of establishments primarily engaged in manufacturing fresh or frozen bread and bread-type rolls and fresh cakes, pies, pastries, and other similar "perishable" bakery products. Establishments primarily engaged in producing "dry" bakery products, such as biscuits, crackers, and cookies are classified in industry 2052. Establishments primarily engaged in manufacturing frozen bakery products, except bread and bread-type rolls are classified in industry 2053.

Establishments producing bakery products primarily for direct sale on the premises to household consumers are classified in retail trade, industry 5461.

#### INDUSTRY 2052, COOKIES AND CRACKERS

This industry is made up of establishments primarily engaged in manufacturing fresh cookies, crackers, pretzels, and similar "dry" bakery products. Establishments primarily engaged in producing other fresh bakery products are classified in industry 2051.

#### INDUSTRY 2053, FROZEN BAKERY PRODUCTS, EXCEPT BREAD

This industry is made up of establishments primarily engaged in manufacturing frozen bakery products, except bread and bread-type rolls. Establishments primarily engaged in manufacturing frozen bread and bread-type rolls are classified in industry 2051.

### F. Sugar and Confectionery Products

**INDUSTRY 2061, RAW CANE SUGAR**

This industry is made up of establishments primarily engaged in manufacturing raw sugar, syrup, and molasses, and finished (granulated or clarified) cane sugar from Sugar cane. Establishments primarily engaged in refining sugar from purchased raw cane sugar or sugar syrup are classified in industry 2062.

**INDUSTRY 2062, CANE SUGAR REFINING**This industry is made up of establishments primarily engaged in refining purchased raw cane sugar and sugar syrup.

**INDUSTRY 2063, BEET SUGAR**

This industry is made up of establishments primarily engaged in manufacturing sugar from sugar beets. Establishments primarily engaged in the manufacturing of raw cane sugar is classified in industry 2061. Establishments primarily engaged in cane sugar refining are classified in industry 2062.

**INDUSTRY 2064, CANDY AND OTHER CONFECTIONERY PRODUCTS AND INDUSTRY 2067, CHEWING GUM**

This industry is made up of establishments primarily engaged in manufacturing candy, including chocolate candy, other confections, and related products. Also included in this industry are establishments primarily engaged in manufacturing chewing gum or chewing gum base. Establishments primarily engaged in manufacturing solid chocolate bars from cacao beans are classified in industry 2066. Establishments primarily engaged in roasting and salting nuts and seeds are classified in industry 2068.

In the 1992 Census of Manufactures, Industry 2064, Candy and Other Confectionery Products, and Industry 2067, Chewing Gum, were combined.

**INDUSTRY 2066, CHOCOLATE AND COCOA PRODUCTS**

This industry is made up of establishments primarily engaged in shelling, roasting, and grinding cacao beans for the purpose of making chocolate liquor from which cocoa powder and cocoa butter are derived, and in the further manufacture of solid chocolate bars, chocolate coatings, and other chocolate and cocoa products. Also included is the manufacture of similar products, except candy, from purchased chocolate or cocoa. Establishments primarily engaged in manufacturing candy from purchased cocoa products are classified in industry 2064.

**INDUSTRY 2068, SALTED AND ROASTED NUTS AND SEEDS**

This industry is made up of establishments primarily engaged in manufacturing salted, roasted, dried, cooked, or canned nuts, or in processing grains or seeds in a similar manner for snack purposes. Establishments primarily engaged in manufacturing confectionery-coated nuts are classified in industry 2064. Establishments primarily engaged in manufacturing peanut butter are classified in industry 2099.

## G. Fats and Oils

**INDUSTRY 2074, COTTONSEED OIL MILLS**

This industry is made up of establishments primarily engaged in manufacturing cottonseed oil, cake, meal, and linters, or in processing purchased cottonseed oil other than into edible cooking oils. Establishments primarily engaged in refining cottonseed oil into edible cooking oils are classified in industry 2079.

**INDUSTRY 2075, SOYBEAN OIL MILLS**

This industry is made up of establishments primarily engaged in manufacturing soybean oil, cake, and meal and soybean protein isolates and concentrates, or in processing purchased soybean oil other than into edible cooking oils. Establishments primarily engaged in refining soybean oil into edible cooking oils are classified in industry 2079.

**INDUSTRY 2076, VEGETABLE OIL MILLS, N.E.C.**

This industry is made up of establishments primarily engaged in manufacturing vegetable oils, cake and meal, except corn, cottonseed, and soybean, or in processing similar purchased oils other than into edible cooking oils. Establishments primarily engaged in manufacturing corn oil and its byproducts are classified in industry 2046. Establishments primarily engaged in refining vegetable oils into edible cooking oils are classified in industry 2079.

**INDUSTRY 2077, ANIMAL AND MARINE FATS AND OILS**

This industry is made up of establishments primarily engaged in manufacturing animal oil, including fish oil and other marine animal oils, and fish and animal meal; and those rendering inedible stearin, grease, and tallow from animal fat, bones, and meat scraps. Establishments primarily engaged in manufacturing lard and edible tallow and stearin are classified in industry group 201.

**INDUSTRY 2079, EDIBLE FATS AND OILS, N.E.C.**

This industry is made up of establishments primarily engaged in manufacturing shortening, table oils, margarine, and other edible fats and oils, not elsewhere classified. Establishments primarily engaged in producing corn oil are classified in industry 2046.

## H. Beverages

### INDUSTRY 2082, MALT BEVERAGES

This industry is made up of establishments primarily engaged in manufacturing malt beverages. Establishments primarily engaged in bottling purchased malt beverages are classified in industry 5181.

### INDUSTRY 2083, MALT

This industry is made up of establishments primarily engaged in manufacturing malt or malt byproducts from barley or other grains.

### INDUSTRY 2084, WINES, BRANDY, AND BRANDY SPIRITS

This industry is made up of establishments primarily engaged in manufacturing wines, brandy, and brandy spirits. Also included in this industry are establishments primarily engaged in blending wines from bonded wine cellars. Establishments primarily engaged in bottling purchased wines, brandy, and brandy spirits, but which do not manufacture wines and brandy are classified in wholesale trade industry 5182.

### INDUSTRY 2085, DISTILLED AND BLENDED LIQUORS

This industry is made up of establishments primarily engaged in manufacturing alcoholic liquors by distillation, and in manufacturing cordials and alcoholic cocktails by blending processes or by mixing liquors and other ingredients. Establishments primarily engaged in manufacturing industrial alcohol are classified in industry 2869. Establishments primarily engaged in bottling purchased liquor are classified in wholesale trade industry 5182.

**INDUSTRY 2086, BOTTLED AND CANNED SOFT DRINKS**

This industry is made up of establishments primarily engaged in manufacturing soft drinks and carbonated waters. Establishments primarily engaged in manufacturing fruit and vegetable juices are classified in industry group 203. Establishments primarily engaged in manufacturing fruit syrups for flavorings are classified in industry 2087.

**INDUSTRY 2087, FLAVORING EXTRACTS AND SYRUPS, N.E.C.**

This industry is made up of establishments primarily engaged in manufacturing flavoring extracts, syrups, powders, and related products, not elsewhere classified, for soda fountain use or for the manufacture of soft drinks, and colors for bakers' and confectioners' use. Establishments primarily engaged in manufacturing chocolate syrup are classified in industry 2066.

**I. Miscellaneous Food and Kindred Products**

**INDUSTRY 2091, CANNED AND CURED FISH AND SEAFOODS**

This industry is made up of establishments primarily engaged in cooking and canning fish, shrimp, crabs, and other seafoods. Also included in this industry are establishments primarily engaged in smoking, salting, drying, or otherwise curing fish and other seafoods. Establishments primarily engaged in shucking and packing fresh oysters in nonsealed containers or in preparing fresh fish are classified in industry 2092.

**INDUSTRY 2092, FRESH OR FROZEN PREPARED FISH**

This industry is made up of establishments primarily engaged in preparing fresh or frozen fish. Also included in this industry are establishments primarily engaged in preparing surimi and surimi-based products.

**INDUSTRY 2095, ROASTING COFFEE**

This industry is made up of establishments primarily engaged in roasting coffee. Also included in this industry are establishments primarily engaged in manufacturing coffee concentrates and extracts in powdered, liquid, or frozen form, including freeze-dried. Coffee roasting by wholesale grocers is classified in wholesale trade, industry 5149.

**INDUSTRY 2096, POTATO CHIPS AND SIMILAR SNACKS**

This industry is made up of establishments primarily engaged in manufacturing potato chips, corn chips, and similar snacks. Establishments primarily engaged in manufacturing pretzels and crackers are classified in industry 2052. Establishments primarily engaged in manufacturing packaged unpopped popcorn are classified in industry 2099.

**INDUSTRY 2097, MANUFACTURED ICE**

This industry is made up of establishments primarily engaged in manufacturing ice for sale. Establishments primarily engaged in manufacturing dry ice are classified in industry 2813.

**INDUSTRY 2098, MACARONI AND SPAGHETTI**

This industry is made up of establishments primarily engaged in manufacturing dry macaroni, spaghetti, vermicelli, and noodles. Establishments primarily engaged in manufacturing canned macaroni and spaghetti are classified in industry 2032, and those manufacturing fried noodles such as chinese noodles are classified in industry 2099.

**INDUSTRY 2099, FOOD PREPARATIONS, N.E.C.**

This industry is made up of establishments primarily engaged in manufacturing prepared foods and miscellaneous food specialties, not elsewhere classified, such as baking powder, yeast, peanut butter, packaged tea, and vinegar and cider. Establishments primarily engaged in manufacturing flour mixes are classified in industry group 204.

**Source: US census of manufactures**

**Nota Bene:** The 1992 definition of this industry is the same as that used in the 1987 Standard Industrial Classification (SIC) system. The SIC number and title also are the same for all the industries.

## APPENDIX B: TP measurement

TP is a measure of total factor productivity growth based on a five-factor production function: capital, production worker hours, non-production workers, non-energy materials, and energy. A Divisia index of TP growth is calculated as the growth rate of output (real shipments) minus the revenue-share-weighted average of the growth rates of each or the five inputs. The shares (average of current and previous period) are taken from the ASM data on the expenditures for each input, divided by the industry's value or shipments. Capital's share is calculated as a residual, so the shares add to 1. The labor inputs are measured in real terms as the number of production worker hours and number or non-production workers. Nominal expenditures on energy and non-energy materials are deflated by their respective deflators. The real capital input is assumed to be proportional to the measured real capital stock, so the capital stock growth rate is used to measure capital input growth; there is no adjustment for capacity utilization).

## APPENDIX C: Aggregate TP growth sensitivity analysis

The TFP variable for each industry included in the MP database is constructed in the following manner:

$TP = Q - \Sigma \alpha_i X_i$, $i$ Є K,N,L,M,E

Where Q is real output, $\alpha_i$ is the share (average of current and lagged year) in revenue of factor $i$, $X_i$ is the real input of factor $_i$, and a. denotes a log first difference: The share of capital is computed as one minus the sum of the other shares.

Aggregate TFP is calculated as:

$TFP = \Sigma \Phi_j TFP_j$

Where j indexes industries, and $\Phi_j$ is an appropriate weight for each 4-digit industry. The TP measure turns out to be very sensitive to the types of deflators applied to output and materials, and aggregate TP growth measures are sensitive to the choice of $\Phi_.$ In this section, the influence of different methods of deflation and aggregation on TP is assessed.