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## **What Determines Vertical Mergers in U.S. Food Manufacturing Industries? <sup>1</sup>**

JEL classification: L13, Q13

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# **What Determines Vertical Mergers in U.S. Food Manufacturing Industries?**

## **Abstract**

Vertical mergers have become an important business strategy among food manufacturers because it allows them to manage and customize their production according to consumer needs. Economic theories have shown that vertical mergers may be induced by transaction costs, demand variability, and other factors. Using an input-output methodology, a measure of vertical merger is developed for U.S. food manufacturing industries and the transaction cost hypotheses tested in an attempt to examine the factors that motivate vertical mergers in the food manufacturing industries. The results are consistent with previous studies that confirm the role of transaction cost factors, such as lock-in effects in terms of asset specificity and managerial diseconomies.

**Key words:** vertical mergers, ownership integration, transaction cost, food manufacturing

# What Determines Vertical Mergers in U.S. Food Manufacturing Industries?

## Introduction

As the U.S. food system becomes more and more consumer driven, vertical coordination, either through ownership integration (mergers) or through contracts, as a business strategy has become increasingly important because it allows both farmers and food manufacturers to manage and customize their production according to market needs. It is believed that vertical coordination has resulted in improved, consistently higher quality, more uniform food products and more choices of food products for consumers. There are many studies that examine vertical coordination in the U.S. food industries since early the 1960s, starting with that of Mighell and Jones (1963). Most of these studies focus on the vertical relationship between the value-added food industries (i.e., food manufacturers) and the upstream production agriculture (i.e., farmers), e.g., Marion (1986), Frank and Henderson (1992), Barkema (1994), O'Brian (1994), among others. Past studies have shown that among the food industries the poultry industry has been vertically integrated since the early 1960s, while vertical coordination has been spreading rapidly since early 1980s into other food industries. For example, the percent of total production under ownership integration and contracts during early 1990s in the poultry industry was 100%, in the processed vegetables industry it was 98%, in the processed milk industry it was 26%, in the meat packing industry it was 16%, and in the hog industries it was 21% (O'Brian, Perry et al., 1996) and the trend is continuing. The estimates provided by the existing studies are very similar and the general finding is that spot market transactions have been gradually replaced, mostly by contracts vis-à-vis vertical ownership integration.

Most of the reasons that firms choose to vertically integrate have to do with reducing costs or eliminating externalities that are associated with buying from or selling to other firms (Carlton and Perloff, Chapter 12, 1999).<sup>1</sup> Economic theories have shown that vertical integration may be induced by transaction costs, market imperfections, and other factors.<sup>2</sup> One of the most important reasons why firms integrate has to do with transaction costs, such as the expenses associated with writing and enforcing contracts (Williamson, 1974, 1975, 1986; Klein, Crawford, and Alchian, 1978). The more complicated a contract is, the higher the transaction cost of enforcing and monitoring such a contract. Thus, the inducement for vertical merger rises as the transaction cost of using the marketplace rise.

To our knowledge, no study other than Frank and Henderson quantitatively addresses the issue of economic factors that drive vertical coordination in the U.S. food manufacturing industries. For instance, some of the existing studies on vertical coordination in the U.S. food industries focus on the process and implications of such integration in a particular industry, such as pork, beef or broiler (e.g., Kliebenstein and Lawrence, 1995; Rhodes, 1995; Martinez, 1999; Ward, 1997). Others have focused on an explanation of vertical organization in the food industries (e.g., Boehlje and Schrader, 1998; Cotterill, 2001) or on efficiencies of alternative vertical mechanisms or the impact of vertical integration on market performance (e.g., Kinnucan and Nelson, 1993; Azzam, 1996; Bhuyan, 2002). Among the few studies that focus some of their attention on the motives behind vertical coordination in the U.S. food industries, Mighel and Jones and Marion qualitatively examine vertical coordination in the U.S. food industries and casually link transaction costs to vertical coordination (Frank and Henderson, p. 941). Frank and Henderson, on the other hand, empirically examined the effects of transaction cost factors on backward or upstream vertical coordination and found a positive relationship between transaction costs and vertical coordination via contracts. Empirical studies focusing on non-food sectors also report transaction cost linkages to vertical coordination (ownership or contracts), e.g., Levy (1985), Martin (1986), Caves and Bradburd (1988), and Lieberman (1991).

Although relatively narrower in scope, this study could be considered complementary to Frank and Henderson's study. Like their study, we use an input-output methodology to construct an index of vertical mergers for the U.S. food manufacturing industries and use econometric analysis to test hypotheses regarding transaction cost motives behind vertical mergers. However, unlike Frank and Henderson's study, which addresses the *upstream or backward* vertical ties, this study addresses the *downstream or forward* vertical ties of U.S. food manufacturers to their final product markets in terms of forward vertical mergers (from here, the terms

“vertical mergers” and “forward vertical mergers” are used interchangeably). The general objective of this study is to examine the factors affecting vertical mergers in the U.S. food manufacturing sector. The study has two specific objectives: (1) to construct an index of vertical mergers for U.S. food manufacturing industries, and (2) to test the transaction cost motives for vertical mergers in these food industries. The rest of the paper is organized as follows: the index of vertical mergers and the testable hypotheses are presented in the next section followed by an explanation of the data and estimation procedures used in this study. Empirical results are presented thereafter, followed by concluding comments.

### **Framework for Analysis**

The analytical framework is divided into two parts: (1) we present the methodology behind the measurement of the vertical merger index, and (2) we present an economic model to test the hypotheses for transaction cost motives for vertical mergers in the U.S. food manufacturing industries. This framework is very similar to the one followed by Frank and Henderson.

#### ***Measurement of Vertical Merger Index: A Working Definition***

Difficulty in measuring the degree of vertical ownership integration is well known (Hay and Morris, 1991, p. 345; Caves and Bradburd, p. 265). Such measuring difficulties obviously pose serious problems in attempts to analyze the impact of vertical ownership integration in the U.S. food manufacturing industries. Adelman’s (1955) value added-to-sales ratio is considered the seminal work on the empirical measurement of vertical ownership integration. More recent attempts at measuring vertical integration rely on the national input-output (I-O) tables, a trend started by Maddigan (1981) with her “vertical industry connection index” for a given firm. Maddigan’s index was based on the extent of technological relatedness, as revealed by I-O tables, among the set of industries within which the firm operates. That is, Maddigan’s index specified industries within which a firm operates and incorporated vertical interdependencies revealed by I-O tables. Her index captured all backward and forward linkages that a firm had in the production-distribution chain.

Improving on the Maddigan index of vertical connection, Frank and Henderson developed a vertical coordination index to analyze various forms of vertical ties, such as spot market transactions, supply contracts, and ownership integration that existed in the U.S. food manufacturing sector. This vertical coordination index represented the degree of backward vertical coordination that existed between U.S. food manufacturers (e.g., cheese manufacturers) and the suppliers of raw agricultural produce (e.g., dairy farmers). Frank and Henderson’s vertical coordination index ranged from zero for spot markets to one hundred percent for complete backward vertical ownership integration. Using 1982 input-output data at the four-digit SIC (standard industrial classification) level, they found that the average vertical coordination index for food manufacturing industries was 0.47, i.e., on average the degree of backward vertical coordination between U.S. farms and food manufacturers was almost at the mid-point on a scale with fully independent farms on one end and fully integrated farms (with food manufacturers) on the other end.

The vertical merger index proposed in this study is based on the simple notion that vertical integration is revealed by larger *internal flows of output* (i.e., output flows that take place within a firm’s different plants in successive stages of production and distribution) as a substitute for market transactions. Therefore, intra-firm integration is incorporated in the measurement of vertical mergers. MacDonald (1985) was the first to measure intra-firm linkages as the proportions of shipments from an industry that are made to (or bought from) affiliated units in another industry at a success stage in the production and distribution chain. For instance, in the case of downstream or forward successive stages, such affiliated units may include input and output producing plants, sales offices, wholesale, and retail establishments (and would include input suppliers in the case of upstream or backward successive stages).

The essence of vertical integration is the decision by the individual firm to organize exchanges internally (within the firm) or externally (in the marketplace). However, because it is difficult, if not impossible, to obtain information on the internal and market exchange of individual firms (Perry, 1989), we present a theoretically cruder, but more practical, working definition of a vertical merger index for an industry. This working definition

is based on models presented by both Caves and Bradburd, and Davies and Morris (1995). It also takes both intra-firm and inter-industry flows into consideration which can be explained as follows: suppose that firm  $i$ 's plants in industry  $j$  sells a product worth \$100 to industry  $k$ , while its plants in industry  $k$  purchase \$80 of product from its own plants in industry  $j$ . Thus, while the inter-industry flow is \$100, the intra-firm flow is \$80.

Using the national I-O tables and other related data (see explanation later), we construct an index of forward vertical ownership integration where a food manufacturing firm  $i$  in industry  $j$  owns plants or firms in another industry  $k$  ( $j \neq k$ ), where  $k$  may include wholesaler, retailers, or other downstream food manufacturers. Such measurement reflects ownership integration between both business units in a given industry and those in industries downstream from it, thereby offering the potential for testing the transaction cost hypotheses on such vertical relationships. Note that such a measurement will miss any integrated enterprises that operate in vertically-related industries but do not actually transfer intermediate products between their units (Caves and Bradburd).

Then, in an economy comprised of  $N$  firms and  $R$  industries, the extent of *forward vertical merger* in industry  $j$  is measured by the proportion of industry sales accounted for by the intra-firm flows of output from firms in that industry to their plants in other industries downstream, i.e.,

$$FVI_j = \sum_{\substack{k=1 \\ k \neq j}}^R \sum_{i=1}^N \frac{X_{j,k}^i}{X_j}, \quad (1)$$

where  $FVI_j$  is the index of forward vertical merger of industry  $j$ ,  $X_{j,k}^i$  is  $i$ th firm's intra-firm flows between industry  $j$  and downstream industry  $k$ , and  $X_j$  is the total sales of industry  $j$ . If there are no intra-firm flows between industry  $j$  and  $k$ , then  $FVI_j = 0$  indicating the lack of a *measurable level* of vertical ownership integration (given data and methodological constraints). Similarly, if industry  $j$  is fully integrated to downstream industry  $k$ , then  $FVI_j = 1$ . Thus, the value of the forward vertical merger integration will lie between 0 and 1 or  $0 \leq FVI_j \leq 1$ . Some of the features of this vertical ownership integration index are as follows: (a) it is based on the explicit notion of what constitutes vertical ownership integration and measures intra-firm and inter-industry integration, (b) this index can be computed using public domain data and does not require any subjective assessment of firm or industry definition, and (c) this index can be calculated at either the firm or the industry level or both (however, as Perry noted, it almost impossible to find firm level data, and not surprisingly we use industry level data in this study).

Equation 1 can be explained using input-output and revenue data of firms in the meat packing industry (SIC 2011). According to the 1992 *Census of Manufacturers* and 1992 *Benchmark Input-output Accounts* data (U.S. Department of Commerce, 1997 and 1998), shipments from companies in the meat packing industry to establishments owned by the same company in other sectors included \$4,132.93 million or 8.19% of total revenue to downstream wholesale establishments (ws), i.e.,  $\sum X_{2011,ws} / X_{2011} = 0.0819$ , \$193 million or 0.38% to owned retail stores and outlets, \$1883.42 million or 3.73% to other owned manufacturing establishments, and \$151.15 million or 0.30% to other owned nonmanufacturing establishments. Thus, the forward vertical merger index in the meat packing industry is  $FVI_j = FVI_{2011} = 0.126$ . Similar computations were carried out for other food manufacturing industries and the results are reported in the "Empirical Results" section. Note that the vertical merger index,  $FVI_j$ , does not reveal which party initiated the merger.

### **Determinants of Vertical Mergers**

In the transaction cost theories of Williamson, and Klein, Crawford, and Alchian, vertical integration is induced by the problems of small-numbers bargaining and asset specificity. Such problems can arise either due to small number of firms in the market, *ex ante*, or due to transaction specific assets and switching costs that create lock-in problems, *ex post*. In the former case, fewness of buyers and sellers should positively predict vertical integration as firms may utilize ownership integration to reduce the potential opportunistic behavior when few firms bargain (Caves and Bradburd). In the latter case, each party to the transaction has the potential to

expropriate quasi-rents derived from the other firm's investment and if long-term contracts can not be written to avoid potential hold-up problems, firms must resort to integration (Lieberman).

The evidence to support the hypothesis that vertical integration rises with supplying industry market concentration, representing fewness of sellers, has been obtained in various prior studies (e.g., Caves and Bradburd, MacDonald, Levy, and Martin). In terms of food industries, Frank and Henderson find supporting evidence for backward vertical integration in the U.S. food manufacturing industries. Such findings are consistent with the argument that the small-numbers bargaining problem induces vertical integration and we hypothesize as such. We also hypothesize that forward vertical merger is more likely when the upstream industry must commit to large sunk investments in assets. In this regard, the importance of investment in specific human capital as an incentive to integrate vertically was emphasized by both Masten, Meehan, and Snyder (1989) and Caves and Bradburd. For example, Caves and Bradburd found that vertical integration rises with spending on research and development, which was used as a measure of investment in highly specific human capital. Frank and Henderson's study arrives at a similar conclusion.

Regarding testing the transaction cost motives for vertical mergers in the U.S. food manufacturing industries, we use the four firm concentration ratio (*CR4*) to capture the fewness of sellers because it is the most accepted and traditional measure of market concentration (Rogers, 2001). To capture the lock-in problem in terms of asset specificity in these industries, we consider the capital that is potentially sunk and specific to an industry. Following previous studies, such as Caves and Bradburd, we use the food manufacturing industry's assets-to-employee ratio (*EMPASS*) and research and development expenditures-to-sales ratio (*RND*) to capture such lock-in effects. Frank and Henderson, for instance, call such variables "idiosyncratic investments" that capture differential characteristics and asset specificity of a cross-section of food manufacturing industries. Higher asset specificity would increase the lock-in effect and would provide incentive for vertical mergers in the food industries.

Williamson (1974, pp. 1443-1456) points to diseconomies of scale as a factor limiting the extent of vertical integration. This is because the same transactional inefficiency factors promoting vertical coordination also limit the extent of internalization (Frank and Henderson, p. 947). Both Martin and Scherer and Ross (1990) note possible unfavorable impacts of such diseconomies on vertical mergers. Following the literature, we employ two variables to capture such diseconomies of scale in the U.S. food manufacturing industries: (1) average firm size (*AVFMSZ*), measured in millions of dollars per firm in an industry; and (2) operational diseconomies (*OPDIS*), measured as the average number of plants per firm in an industry. The first variable was used to capture the potential loss of managerial control, *ceteris paribus*, in large firms. The second variable is based on the ground that the cost of handling transactions within a firm should be greater, *ceteris paribus*, the larger the number of plants per firm. Thus, the predicted effect of these two variables based on transaction cost theory on vertical mergers in the food manufacturing industries is negative.

According to Lieberman, although demand fluctuations alone are not sufficient to induce vertical integration, several studies have shown that vertical integration can be induced by fluctuations in demand. For example, Carlton (1979) has proposed that firms integrate (or may rely on nonmarket coordination methods) to minimize the total costs attributable to demand fluctuations. Uncertain demand (or supply) makes it very costly or impossible for firms to anticipate all contingencies and induce firms to rely more on nonmarket coordinating methods, including vertical mergers (Frank and Henderson, p. 946). To measure the fluctuation of downstream demand for food manufacturers' output, we use the percentage of change in food manufacturers' output between 1987 and 1992 (*DEMFLUC*). We hypothesize that food manufacturers are motivated to use vertical merger as a business strategy to rectify demand uncertainty in their output markets.

Finally, like many of its predecessors, this is an industry-level study (mainly due to data limitations) and therefore, likely to have some integration and aggregation bias. Following Davies and Morris, we hypothesize that such aggregation bias would have negative regression coefficients. To correct for such potential bias, we use two control variables: (1) the number of five digit industries (*SDIGIT*) covered by each food manufacturing industry under study; (2) the proportion of total industry sales accounted for by sales within the industry (*INTRA*), e.g., the value of shipment in the meat packing industry (SIC 2011) that is accounted for by SIC 2011, as recorded in the

input-output tables.

### Data and Estimation Procedure

The focus of this study is on the U.S. food manufacturing industries at the Census four-digit industry group or SIC level.<sup>3</sup> There were 49 food manufacturing industries at the four-digit SIC level in 1992, the year for which all the necessary data for this study were publicly available (the data are available upon request).<sup>4</sup> Census data on vertical ownership was not available for six industries and it prevented us from constructing the *FVI* index for those six industries: SICs 2043, 2062, 2068, 2076, 2085, and 2097. These six food manufacturing industries were dropped from this study and the remaining 43 are used in this study.

As explained earlier in the construction of the *FVI* index using Equation 1, the 1992 *Census of Manufacturer* data on “Distribution of Sales by Class of Customer” and 1992 *Benchmark Input-output Accounts* data were used to construct the forward vertical merger index. The 1992 *Census of Manufacturers* is also used as the source for the following variables: average firm size (*AVFMSZ*), operational diseconomies (*OPRDIS*) – variables to control for integration and aggregation bias (*SDIGIT* and *INTRA*), assets-to-employee ratio (*EMPASS*), and demand fluctuation (*DEMFLUC*). Data on capital assets, used to construct the assets-to-employee ratio, were kindly provided by Professor Richard T. Rogers of the University of Massachusetts. Finally, data on *RND* were obtained from Bhuyan and Lopez (1998).

Because the dependent variable *FVI* is bounded between 0 and 1, it was transformed into the log-odds or logit functional form,  $\ln [FVI/(1 - FVI)]$ , for testing our hypotheses. Preliminary screening showed evidence of heteroskedasticity (chi-square test statistic=19.918 with 8 degrees of freedom). White’s method was employed to obtain heteroskedasticity consistent estimates of standard errors.

A common criticism of the economic model presented here is that such models may have simultaneity bias and/or endogeneity bias because some of the explanatory variables (e.g., *CR4* and *RND*) may be partially endogenous or simultaneously determined. Results of the Hausman tests for simultaneity and endogeneity (see Gujarati, p. 669-673, 1995 for details) rule out such bias. For example, results of the simultaneity tests show that residuals for both *CR4* and *RND* were statistically not significant (absolute t-values for these two variables are respectively 1.581 and 0.119 with 34 degrees of freedom), and results of the endogeneity test for these two variables show that the computed chi-square statistic ( $\chi^2_{2df} = 3.37$ ) was statistically insignificant. Summary statistics and a correlation matrix for the variables used in this study are presented in Appendix tables 1 and 2, respectively. We test the hypotheses presented earlier using the SHAZAM computer program.

### Empirical Results

This analysis examines the role of transaction cost factors on the extent of forward vertical mergers in the U.S. food manufacturing industries. Using an input-output methodology, an index of vertical mergers was computed for 43 food manufacturing industries (Table 1) and that index was later used as the dependent variable to econometrically test the transaction cost hypotheses discussed earlier. Given a possible maximum of 1.00 for the forward vertical merger index (or 100 percent ownership of a downstream stage in a vertical production-distribution chain by its upstream firms), results in Table 1 show that the degree of forward vertical ownership integration in U.S. food manufacturing industries was about 12%, which is quite low.

[Table 1 about here]

Table 1 shows that the forward vertical merger index value ranged from 0.010 in the wet corn milling industry (SIC 2046) to 0.3355 in the soft drinks industry (SIC 2086). This means that firms in the soft drinks industry owned over 33% of their downstream markets (e.g., Coca Cola owning its own bottling plants) and firms in the wet corn milling industries owned about 1.0% of their downstream markets. Some of the industries that show a larger downstream ownership include the bread and bakeries industry (SIC 2051; perhaps due to a large number of bakeries selling their products in their own stores), dairy industries (e.g., SIC 202), and sausages and



other prepared meats industry (SIC 2013). Given that Frank and Henderson's study shows a backward (or upstream) vertical coordination index of 0.47, the results of this study imply that the extent of backward vertical coordination (including mergers, contract, and other forms of vertical coordination) is higher than the extent of forward vertical mergers in the U.S. food manufacturing sector. Such findings support a common belief among agricultural economists that backward vertical ties in the U.S. food production-distribution chain are higher than the forward ties.

The results of the economic model used to test the transaction cost hypotheses are presented in Table 2. The results provide partial support for the transaction cost hypotheses because while the small-numbers bargaining hypothesis was rejected it was also found that the lock-in effects do significantly impact forward vertical mergers in the U.S. food manufacturing industries. All three variables (*RND*, *EMPASS*, and *AVFMSZ*) used to represent lock-in effects in terms of asset specificity and diseconomies of scale appear with their respective expected signs and were statistically significant. The results thus show that while higher asset specificity provides incentive for vertical merger, such inducement is also negated by strong diseconomies of scale. Several prior studies cited earlier have found similar evidence, including Frank and Henderson's.

The significant negative influence of *CR4*, used to capture the fewness of sellers, runs counter to the *a priori* reasoning presented earlier, and to the results of Caves and Bradburd and MacDonald. This outcome strongly rejects the small-numbers hypothesis which predicts a tendency for firms to vertically merge when there are few sellers (or buyers). One explanation is that the sample and study period used in this study simply do not support the small-numbers hypothesis. This would imply that fewness of sellers in the U.S. food manufacturing industries do not trigger vertical mergers, and firms in the successive stages of food manufacturing and firms downstream (i.e., wholesalers and retailers) were able to overcome the potential adverse effects of the transaction costs associated with the fewness of sellers. Part of the answer to the unexpected sign of *CR4* may also lie with the nature of the concentration data which is aggregated at the four-digit SIC level and may have an inherent downward bias. This reasoning is similar to that of Davies and Morris who also observed a negative and significant impact of market concentration on vertical mergers. Another possible explanation is that the sample does not contain a sufficient number of observations to support the null hypothesis (i.e., fewness of sellers would increase vertical merger) for the food manufacturing industries. Use of the Herfindhal-Hirschman index (HHI) of industry concentration instead of *CR4* did not fundamentally alter our results presented in Table 2.

The demand fluctuation variable (*DEMFLUC*) used to test the demand variability/uncertainty hypothesis appear with an unexpected positive sign but it was statistically insignificant. Again, this unexpected sign and statistical insignificance may be due to the insufficient number of observations or lack of data that truly represents demand uncertainty for food manufacturers' output. Results in Table 2 also show that although aggregation and integration bias exist in the computed forward vertical merger index (because both *5DIGIT* and *INTRA* are negative and statistically significant), the results of the transaction cost hypotheses are quite robust. The beta coefficients<sup>5</sup> (Table 2) show that the three most important variables in explaining forward vertical mergers in the U.S. food manufacturing sector were transaction cost factors: average firm size (*AVFMSZ*), fewness of sellers (*CR4*), and asset-to-employee ratio (*EMPASS*). The overall fit of the model was good given that this is a cross-sectional analysis (pseudo  $R^2 = 0.47$ ).

## Conclusions

Testing hypotheses about vertical mergers on cross-sections of industries "is attractive for the variance it supplies in the structural determinants, and for the chance to observe entities in presumed long-run equilibrium" (Caves and Bradburd, P. 265). Additionally, such a vertical merger measure is appropriate for use in cross-sectional analysis because it focuses on inter-industry and intra-industry transactions and mergers (Frank and Henderson, p.950). We construct a measure of forward vertical ownership integration using an input-output methodology that takes intra-firm and inter-industry transactions into account. This measure was used to compute the extent of forward vertical mergers between U.S. food manufacturers and their downstream industries, such as retail and wholesale. Unlike the backward vertical relationship between the U.S. food manufacturers and farmers,

the extent of forward vertical mergers in the food manufacturing industries was quite low. Using the index of vertical mergers constructed, we test several hypotheses that propose that transaction cost driven factors are the primary determinants of forward vertical mergers in the food manufacturing industries. The results of this study indicate that transaction costs can create motivation for forward vertical mergers, however, the small-numbers, i.e., fewness of sellers, hypothesis was rejected. The results show that firms integrate to avoid bargaining problems arising from *ex post* lock-in. The most important factors that provide inducement for vertical mergers are related to asset specificity and scale economies. These findings are consistent with prior empirical studies.

Although somewhat limited in scope compared to Frank and Henderson's study, this study of forward vertical integration complements their study of backward vertical coordination in the U.S. food manufacturing industries. While the results of this study are generally consistent with the existing empirical literature on transaction cost models, several caveats apply. Two of the hypotheses, i.e., small-numbers and demand variability, implied by the transaction cost literature did not receive empirical support. This is probably due to data limitations; however, this study suffers from the same data inconvenience faced by previous studies cited earlier. Thus, the explanatory variables are imperfect measures and may have biased the results. Although the results accord reasonably well with the existing empirical literature, it is also possible that the findings are specific to the food manufacturing industries and care should be taken in generalizing the results.

## Endnotes

1. The focus of this study is on vertical ownership integration, or vertical mergers, which is the more traditional view, as in Carlton and Perloff, Chapter 12. The terms "vertical integration" and "vertical mergers" are used here interchangeably. Additionally, as the analytical framework would show, the focus here is *only* on the downstream or forward vertical merger in the U.S. food manufacturing industries. For an analysis of the upstream or backward vertical relationships (via ownership or otherwise) between food manufacturers and their raw material suppliers or farmers, see Frank and Henderson (1992).
2. See Perry (1989) for an excellent review of the vertical integration literature.
3. The specific reasons for using industry-level data instead of firm-level data are as follows: (1) as Perry and others noted, it is practically impossible to obtain the necessary information on the internal and market exchange of individual firms, (2) the index of vertical ownership integration presented in Equation 1 can be applied at both firm and industry levels, and (3) all the necessary data required to implement Equation 1 and model 4 are publicly available at the four-digit SIC level only. Data availability, therefore, forced this and many other empirical studies (e.g., Frank and Henderson) to focus at the four-digit SIC level.
4. The national account input-output data which were used to construct the index of forward vertical merger (Equation 1) are published only every 10 years at the somewhat aggregated industry (equivalent to the 4-digit SIC) level. As cited earlier, the latest national input-output accounts data available is for 1992 only. Additionally, although some of the latest Economic Census data were available for 1997, the bridge between SIC and NAICS (North American Industrial Classification System which replaced the SIC system effective 1997), has not been completed at the time of this report.
5. Beta coefficients show which variables contribute most to the regression by taking into account the effect of a typical or "equally likely" change in variables. The beta coefficients were calculated by multiplying the estimated coefficients by the standard deviation of each regressor and dividing by the standard deviation of the dependent variable.

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**Table 1. Degree of Vertical Mergers in the U.S. Food Manufacturing Industries, 1992**

<b>SIC Code</b>	<b>Industry description</b>	<b>Forward Vertical Integration Index (<i>FVI</i>)</b>
2011	Meat packing plants	0.1261
2013	Sausages and other prepared meats	0.2710
2015	Poultry slaughtering and processing	0.1623
2021	Creamery butter	0.2909
2022	Cheese, natural and processed	0.0584
2023	Dry, condensed, and evaporated dairy products	0.0511
2024	Ice cream and frozen desserts	0.2805
2026	Fluid milk	0.2697
2032	Canned Specialty	0.0546
2033	Canned fruits and Vegetables	0.0793
2034	Dehydrated Fruits, vegetables and soups	0.1846
2035	Pickles, sauces and salad dressing	0.0446
2037	Frozen fruits and vegetables	0.0541
2038	Frozen specialties, n.e.c.	0.0997
2041	Flour and other grain mill products	0.0210
2044	Rice milling	0.0505
2045	Prepared flour mixes and doughs	0.0269
2046	Wet corn milling	0.0100
2047	Dog and cat food	0.0516
2048	Prepared feeds, n.e.c.	0.2162
2051	Bread, cake, and related products	0.3275
2052	Cookies and crackers	0.0259
2053	Frozen bakery products, except bread	0.1269
2061	Raw cane sugar	0.0603
2063	Beet sugar	0.0954
2064	Candy and other confectionary products	0.0660
2066	Chocolate and cocoa products	0.0832
2067	Chewing gum	0.0765
2074	Cottonseed oil mills	0.0437
2075	Soybean oil mills	0.1399
2077	Animal and marine fats and oils	0.0792
2079	Edible fats and oils, n.e.c.	0.1564
2082	Malt beverages	0.0236
2083	Malt	0.0467
2084	Wines, brandy, and brandy spirits	0.0876
2086	Bottled and canned soft drinks	0.3355
2087	Flavoring extracts and syrups, n.e.c.	0.1866
2091	Canned and cured fish and seafoods	0.2112
2092	Fresh or frozen prepared fish	0.0797

2095	Roasted coffee	0.1652
2096	Potato chips and similar snacks	0.1370
2098	Macaroni and spaghetti	0.0866
2099	Food preparations, n.e.c.	0.1753
<b>Industry Average</b>		<b>0.1214</b>
<b>Maximum</b>		<b>0.3355</b>
<b>Minimum</b>		<b>0.0100</b>
<b>Standard deviation</b>		<b>0.0893</b>

Note: n.e.c. = not elsewhere classified.

**Table 2: Determinants of Vertical Mergers in U.S. Food Manufacturing Industries (N=43)**

<b>Dependent variable: <i>forward vertical mergers (FVI)</i> <sup>a</sup></b>			
<b>Variable Name</b>	<b>Expected sign</b>	<b>Estimated Coefficient</b>	<b>Beta Coefficient <sup>b</sup></b>
Industry Concentration ( <i>CR4</i> )	positive	- 0.01798 *** (0.61E-03) <sup>c</sup>	3.615
Research & Development Index ( <i>RND</i> )	positive	0.9906 *** (0.0737)	2.028
Assets-Employee Ratio ( <i>EMPASS</i> )	positive	0.00047 *** (0.71E-04)	2.988
Average firm size ( <i>AVFMSZ</i> )	negative	- 0.02669 *** (0.77E-03)	7.841
Operational Diseconomies ( <i>OPRDIS</i> )	negative	- 0.08899 ** (0.0361)	0.451
Demand Fluctuations ( <i>DEMFLUC</i> )	negative	0.000025 (0.16E-04)	2.567
Integration and Aggregation bias1 ( <i>SDIGIT</i> )	negative	- 0.05523 *** (0.0035)	1.684
Integration and Aggregation bias2 ( <i>INTRA</i> )	negative	- 1832.10 *** (191.90)	4.100
Constant		- 1.1676 (0.0544)	
<b><i>R</i><sup>2</sup> between observed and predicted</b>	0.4723		

Notes:(i) a= logit transformed vertical merger index, b= beta coefficients are in absolute terms, and c= heteroscedasticity-consistent estimates of standard errors (obtained using White's procedures) are in parenthesis, (ii) \*\*\* = significant at 99% level, \*\* = significant at 95% level.

**Appendix table 1: Descriptive Statistics for Variables Used in Regression Analysis**

NAME	N	MEAN	ST. DEV.	MINIMUM	MAXIMUM
<i>FVI</i>	43	0.121	0.0893	0.0100	0.3355
<i>CR4</i>	43	47.953	17.934	19.000	90.000
<i>RND</i>	43	0.314	0.183	0.0001	0.728
<i>EMPASS</i>	43	213.74	567.66	15.286	3786.70
<i>AVFMSZ</i>	43	27.659	26.226	5.245	138.14
<i>OPRDIS</i>	43	1.411	0.452	0.903	3.077
<i>DEMFLUC</i>	43	9033.7	9168.2	602.00	48923.00
<i>5DIGIT</i>	43	4.256	2.735	1.000	12.000
<i>INTRA</i>	43	0.745E-04	0.154E-03	0.000	0.923E-03

**Appendix table 2: Correlation Matrix of Variables Used in Regression Analysis (N=43)**

<i>FVI</i>	1.000								
<i>CR4</i>	-0.405	1.000							
<i>RND</i>	-0.147	0.307	1.000						
<i>EMPAS</i>	-0.177	0.154	0.075	1.000					
<i>AVFMS</i>	-0.196	0.254	0.208	0.105	1.000				
<i>OPRDIS</i>	-0.255	0.094	-0.033	0.136	0.395	1.000			
<i>DEMFL</i>	0.310	-0.266	-0.199	-0.173	0.127	-0.145	1.000		
<i>5DIGIT</i>	0.146	-0.336	-0.039	-0.158	-0.046	-0.091	0.659	1.000	
<i>INTRA</i>	-0.186	0.130	-0.082	0.487	-0.007	0.355	-0.204	-0.155	1.000
	<i>FVI</i>	<i>CR4</i>	<i>RND</i>	<i>EMPAS</i>	<i>AVFMSZ</i>	<i>OPRDIS</i>	<i>DEMFLUC</i>	<i>5DIGIT</i>	<i>INTRA</i>