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Does Vertical Integration Effect Market Power? Evidence from U.S. Food Manufacturing Industries

Sanjib Bhuyan

The issue of whether vertical integration can raise market power is hotly debated because firms have a market power-related incentive to integrate vertically. Using a sample of U.S. food manufacturing industries, this "market power" motive is empirically tested in this study. Empirical analysis shows that forward vertical ownership integration (or vertical mergers) did not increase food manufacturers' market power in the final product market. The study, however, shows that both market structure and conduct significantly influenced market power in the food industries.

Key Words: food industries, market power, vertical integration, vertical merger

JEL Classifications: L13, L22, Q13

Some form of vertical coordination, whether in the form of contracts or outright ownership, is an integral part of the industrialization process of the U.S. food manufacturing industries. As the U.S. food system becomes more and more consumer driven, vertical coordination, either through outright ownership integration (i.e., 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. Among the food industries, the poultry industry has been vertically integrated since the early

1960s, whereas vertical coordination (mostly in the form of production contracts) has been spreading rapidly since the early 1980s into other food industries. For example, the percent of total production under ownership integration and contracts during the early 1990s was 100% in the poultry industry, 98% in the processed vegetables industry, 26% in the processed milk industry, 16% in the meat packing industry, and 21% in the hog industries (O'Brian), and the trend is continuing. Vertical integration in lamb and sheep production has increased from 12% in 1970 to 28% in 1990, and vertical integration in potato production and marketing increased from 25% in 1970 to 40% in 1990 (Martinez and Reed).

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It is believed that vertical integration and contracts have resulted in improved, consistently higher-quality, more-uniform food products and more choices of food products for consumers. Critics argue, however, that such vertical coordination, particularly vertical integration, may increase market power and, thereby, adversely affect market performance.

That is, increased market power results in higher welfare loss. Thus, whether vertical integration can raise market power is a hotly debated issue in the industrial organization literature (Carlton and Perloff, p. 379). Whereas the Chicago School argues that vertical mergers cannot transfer market power from one level to another, the opposite view is that "when vertical mergers displace open transactions, it often forecloses the market and excludes rivals" (Shepherd and Shepherd, p. 255). Given such a debate, the principal objective of this study is to examine the question, "Does vertical integration raise market power in the U.S. food industries?"¹

This study is limited to a snapshot of vertical ownership integration or vertical merger (these two terms are used here interchangeably) as it relates to market power at that point in time. To maintain that focus, no attempt was made to analyze changing vertical ownership or merger activities in the food industries, e.g.,

¹ Although at the first glance, this article and Bhuyan may seem to address the same issue, these two articles are different in terms of their respective objectives, theoretical principles that led to the empirical models, and their estimated results. As we know, one of the motivations behind vertical integration is to increase efficiency by reducing costs and thereby increasing profit. Using *computed*, industry, price-cost margins as a measure of profitability, Bhuyan empirically tested that very motivation in the food industries. Findings show that vertical integration did not have the expected, i.e., positive, effect on profits. The aim of this article, on the other hand, is to empirically examine the question "Does vertical integration have any impact on the market power of the U.S. food industries?" This objective is based on the theoretical argument that firms may pursue vertical integration to take advantage of market power-related conditions created by vertical integration. Thus, the objective of this article is to empirically test the market power motive of vertical integration—a different objective from that of Bhuyan.

Both this article and Bhuyan, however, use literature from a common pool to establish the respective rationales and build the respective empirical models. Thus, it should not be surprising that these two articles are very similar in terms of some of the arguments made and the modeling approaches used. Because of their separate, but seemingly related, aims, although the theoretical principles used to develop the *main, testable hypotheses* in these two articles were different, a few control variables were common in the respective empirical models, e.g., capital intensity.

this study does not analyze why mergers take place in the food industries. Additionally, this study addresses *only* the downstream or forward ownership integration (see Frank and Henderson for backward integration in the U.S. food industries).

Review of the Literature

Economics literature has abundant studies that show beneficial impact of vertical integration. One strand of such literature, led by Williamson, argues that vertical integration creates efficiencies by reducing the transaction costs associated with market exchange. According to this strand of literature, typical of the Chicago School for which the reliance on open market transactions is considered too risky or unreliable, integrated firms may be able to reduce allocative inefficiency by diversifying risks, assuring supplies or markets, capturing economies of scope or scale, and internalizing externalities in production, pricing, and marketing decisions (Klein, Crawford and Alchian; Perry). Adding to such arguments from a statutory viewpoint, Bork and Posner contended that vertical integration takes place only for reasons of technological efficiency because it does not involve any more or less monopolization than what existed in the preintegration period. Therefore, they argued that vertical ownership integration enhances economic efficiency and, thus, should not be opposed.

One of the major economic concerns regarding vertical ownership integration, is its potentially harmful effects on competition in both input and output markets. There is evidence that vertical ownership integration not only enhances oligopolistic coordination but is often a prerequisite to the successful exercise of market power under oligopoly (Martin, 1994, p. 308). Scherer and Ross (Ch. 14) argue that business firms may undertake vertical mergers not to increase the level of market power at one stage of the marketing system, but to increase such market power throughout each successive stage. Although vertical integration may be a response to the transaction costs of using markets, such integration may give rise to firms that have substantial market

power by creating entry barriers (George, Joll, and Lynk, Ch. 3). Responding to the efficiency benefits of vertical integration, Riordan and Salop argued that the effects of the efficiency benefits of vertical integration on price are often smaller (or even nonexistent) than the anticompetitive effect on prices. Finally, Azzam and Pagoulatos (1999) concluded that the potential competitive effects of vertical ownership integration are often "too ambiguous" in theory and may limit competition in practice.

Given that many industries in the U.S. food manufacturing sector have been found to have market power (e.g., Azzam and Pagoulatos 1990; Bhuyan and Lopez 1997; among others), a legitimate concern is whether vertical integration raises the market power of the U.S. food manufacturing industries. The argument is that if increased vertical integration results in higher market power, food manufacturing firms may engage in vertical integration to raise their market power (which is detrimental to welfare). Therefore, the Chicago School argument that vertical ownership integration would increase efficiency and would not harm competition or welfare becomes questionable.²

Evaluating the anticompetitive and efficiency benefits of vertical ownership integration is complex because vertical integration can simultaneously have efficiency benefits and anticompetitive effects on price and output. That is, gains and losses in economic performance can take place simultaneously, and researchers may not be able to analyze such

effects separately. There are a limited number of empirical studies in this area and most focus on the foreclosure issue only. Azzam and Pagoulatos (1999) sum up one of the serious gaps in evaluating the effects of vertical ownership integration as follows: "... limited empirical work that has been done in this area is based on case studies that make generalization difficult to achieve." (p. 11). According to Scherer and Ross, it is difficult to evaluate the motive or effects of vertical ownership integration because explanations are less elegant theoretically and more difficult to present in a mathematically tractable model. Therefore, although the effect of vertical ownership integration on market power needs careful evaluation, the "dogmatic insistence" that market power cannot result from such integration is unwarranted (Scherer and Ross, p. 527).

Interest in vertical integration (or coordination) is not new in the agricultural marketing literature as evident from a long strand of literature since the early 1960s. Many of these studies have examined the vertical relationship between upstream agriculture production and downstream value-added food industries, e.g., O'Brien and Frank and Henderson, among others. The estimates of vertical integration provided by these 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. In addition, there are several other studies on backward vertical integration that focus on a particular industry, such as pork, beef, or broiler (e.g., Kleibenstein and Lawrence; Rhodes; Martinez), or focus on issues such as the motivation behind vertical integration, efficiencies of alternative vertical structures (i.e., contractual versus ownership integration), or the impact of vertical integration on farm-retail price spreads (e.g., Kinnucan and Nelson). In a recent study, Bhuyan examined the impact of forward vertical integration on the profitability of the U.S. food industry and showed that it did not have the expected positive effect.

Although there is a legitimate, economic concern about the effect of vertical ownership integration on market power and consequent

² Although not explored in this study, a clearly anticompetitive impact of vertical integration is market foreclosure, that is, the merger of vertically related firms might result in an upstream-downstream company that can either deny downstream rivals a source of inputs or deny upstream competitors a market for their product (Pepall, Richards, and Norman, Ch. 8). Current public policies toward mergers in the United States do not consider vertical ownership integration (i.e., vertical mergers) harmful unless foreclosure becomes an issue. At the time of this study, there were no market foreclosure cases in the literature involving the U.S. food manufacturing industries. A very good, nontechnical discussion on U.S. policies toward mergers and other potentially noncompetitive behavior can be found in Chapter 19 ("Antitrust Laws and Policy") of Carlton and Perloff and Chapter 11 of Shepherd and Shepherd.

market performance in the U.S. food industries (Sexton, p. 1101), existing studies do not evaluate such issues. An attempt is made here to address this gap in the agricultural industry literature, i.e., this study empirically tests the question "Can vertical ownership integration, i.e., vertical mergers, raise market power in the U.S. food industries?" or "Do vertical mergers have any impact on market power in the U.S. food industries?"

Analytical Framework

Vertical Integration and Market Power

Shepherd and Shepherd commented that although "the meaning of vertical integration seems intuitively simple, it is surprisingly hard to measure" (p. 256). The same sentiment was echoed by Bhuyan, who measured the degree of forward vertical integration in the U.S. food industries. The values of forward vertical ownership integration or vertical mergers from Bhuyan are used in this study and are presented in Table 1 (see the Appendix on how to construct the vertical integration index).

The fundamental proposition in analyzing industrial organizations is that what society wants from the producers of goods and services is good performance (Scherer and Ross; Shepherd). Market power is generally defined as the ability of firms to raise price (P) above marginal cost (MC) or the ability of firms to profitably raise prices from the competitive levels. Market power directly and adversely affects allocative efficiency because it moves the market equilibrium away from the maximum efficiency achieved at $P = MC$. Thus, higher market power implies poorer market performance and, therefore, the market power motive behind vertical integration becomes a policy issue. The focus on examining the effect of vertical ownership integration on the market power also addresses efficiency issues in the U.S. food manufacturing industries.

The two principal empirical approaches to analyzing market power are the structure-conduct-performance (SCP) approach and the new empirical industrial organization (NEIO) approach (see Bresnahan; Schmalensee; Carl-

ton and Perloff, pp. 260–263 for more on these topics). The SCP approach is weakly based on microeconomic theory and focuses more on the impact of market structure on market performance or market power. The NEIO approach, on the other hand, is rooted firmly in microeconomic theory and is able to measure conduct and performance more explicitly. In essence, the fundamental advantage of the NEIO methodology is that instead of using an accounting proxy to represent industry market power (or markup), it econometrically estimates industry market power. Most NEIO studies on the U.S. food industries are limited to either single industry analyses (e.g., Schroeter and Azzam; Wann and Sexton), or multi-industry analyses (e.g., Bhuyan and Lopez).

Using the profit-maximizing behavior of firms, Bhuyan and Lopez defined the industry average markup or market power index as follows: $\mathcal{L} = (P - MC)/P = \Phi/\eta$, where \mathcal{L} is the market power index ($1 \leq \mathcal{L} \leq 0$), P is the product (or output) price, MC is marginal cost, Φ is the conjectural variation elasticity representing conduct ($1 \leq \Phi \leq 0$), and η is the own-price elasticity of demand. Note that under perfect competition both \mathcal{L} and Φ equal zero, and under monopoly, both equal 1. Bhuyan and Lopez estimated both Φ and η parameters econometrically using the NEIO approach to obtain an index of market power for each of the four-digit standard industrial classification (SIC) industries in the U.S. food manufacturing sector.³ This study uses the market power estimates of Bhuyan and Lopez as the dependent variable in an econometric model (explained below).

To measure the effect of vertical integration on market power, a measure of vertical integration that is linked to the market power index would be ideal. Because such linkages are difficult to establish, as well as nonexistent in literature (Shepherd and Shepherd), the modeling of the impact of vertical ownership integration on market power is achieved by mirroring widely accepted mod-

³ See Bhuyan and Lopez for a detailed discussion on their NEIO methodology and estimated results.

Table 1. Indices of Forward Vertical Integration and Market Power in U.S. Food Manufacturing Industries

SIC	Industry Description	Vertical Integration Index	Market Power Index
2011	Meat packing plants	0.1261	0.4150
2013	Sausages and other prepared meats	0.2710	0.2100
2015	Poultry slaughtering and processing	0.1623	0.3920
2021	Creamery butter	0.2909	0.5000
2022	Cheese, natural and processed	0.0584	0.2540
2023	Dry, condensed, and evaporated dairy products	0.0511	0.5930
2024	Ice cream and frozen desserts	0.2805	0.3320
2026	Fluid milk	0.2697	0.2360
2032	Canned specialties	0.0546	0.1160
2033	Canned fruits and vegetables	0.0793	0.2420
2034	Dehydrated fruits, vegetables, and soups	0.1846	0.0810
2035	Pickles, sauces, and salad dressings	0.0446	0.5300
2041	Flour and other grain-mill products	0.0210	0.6790
2044	Rice milling	0.0505	0.1090
2045	Prepared flour mixes and doughs	0.0269	0.6790
2047	Dog and cat food	0.0516	0.1150
2048	Prepared feeds, n.e.c.	0.2162	0.4480
2051	Bread, cake, and related products	0.3275	0.2190
2052	Cookies and crackers	0.0259	0.2190
2053	Frozen bakery products, except bread	0.1269	0.2190
2061	Raw cane sugar	0.0603	0.3300
2063	Beet sugar	0.0954	0.3300
2064	Candy and other confectionery products	0.0660	0.1600
2066	Chocolate and cocoa products	0.0832	0.2110
2067	Chewing gum	0.0765	0.1470
2074	Cottonseed oil mills	0.0437	0.1470
2075	Soybean oil mills	0.1399	0.5160
2077	Animal and marine fats and oils	0.0792	0.2960
2079	Edible fats and oils, n.e.c.	0.1564	0.3880
2082	Malt beverages	0.0236	0.4890
2083	Malt	0.0467	0.4890
2084	Wines, brandy, and brandy spirits	0.0876	0.2280
2086	Bottled and canned soft drinks	0.3355	0.5950
2087	Flavoring extracts and syrups, n.e.c.	0.1866	0.1840
2092	Fresh or frozen prepared fish	0.0797	0.0920
2095	Roasted coffee	0.1652	0.5070
2096	Potato chips and similar snacks	0.1370	0.2870
2098	Macaroni and spaghetti	0.0866	0.1700
	Industry average	0.1229	0.3198
	Standard deviation	0.091	0.1721

Source: Bhuyan for the vertical integration index and Bhuyan and Lopez for the market power index.

SIC is Standard Industry Classification; n.e.c. is not elsewhere classified.

els with similar objectives (an explanation follows). As mentioned earlier, Bhuyan's earlier article on measuring the impact of forward vertical integration on the profitability of the food industry used a similar empirical approach.⁴ This study seeks to identify the factors or variables that influence market power and examines the links between these factors and market power. Over the years, both econometric techniques and the economic theory behind testing this type of relationships have improved considerably, and the model presented here is based on such improvements.⁵

Keeping the principal objective of this study in mind, it is hypothesized that vertical ownership integration (or vertical merger) acts as a source of market power. Industrial organization literature shows that market power is also influenced by market structure and conduct. Therefore, the measurement of the effect of vertical ownership integration on market power in an industry j takes the following general form (with subscript j implied):

$$(1) \quad \mathcal{L} = f(FVI, M),$$

where FVI is an index of forward vertical integration, M is a vector of factors measuring market structure and conduct characteristics, and \mathcal{L} is the Lerner index of market power. Using Equation (1) as stylized facts or relationships, this study examines how vertical ownership integration affects market power while controlling for various industry characteristics such as market structure, firm strategic behavior, etc.

⁴ Although some may argue that the dependent variable in Bhuyan is an index of market power, given the discussions in Bresnahan or Schmalensee, it should be agreed that it was merely an index of industry profitability and was an accounting measure. Accordingly, given the very similar but parallel objectives of the current study and Bhuyan, it is not surprising that both studies follow an almost identical approach to building their respective empirical models, albeit with different dependent variables.

⁵ See Martin (1993, Chapters 16, 17, and 18) for a detailed discussion on the modeling approach adopted here and improvements that have been made in such a modeling approach.

Earlier discussions have established that forward vertical integration (FVI) can have competitive as well as anticompetitive effects in a market. Therefore, there is no *a priori* knowledge of which of these two effects dominates in the U.S. food manufacturing industries. The components of the vector of market structure and conduct characteristics, M , are concentration, regional concentration, advertising and capital requirements, and demand conditions, as follows.

Concentration. It is commonly argued in industrial organization literature that industry (or market) concentration will have a positive and significant impact on market power, indicating the ability of a few firms in highly concentrated industries to influence the terms of trade and negatively impact market performance (Martin 1993, Ch. 17). Although a substantial strand of the literature suggests that dynamic efficiency gains may outweigh static efficiency losses (for instance, because of market power), examining such issues is beyond the scope of this article; a principal reason for this is that this is a cross-sectional study and is not able to measure any such dynamic efficiency-related issues. Industry concentration is represented by the four-firm concentration ratio ($CR4$) as defined by the U.S. Bureau of Census.

Regional concentration. Some of the food industries showing lower $CR4$ may have a more relevant local or regional market rather than a national market (e.g., fluid milk, animal feed), and in such cases, the national concentration data may not be relevant. Although local or regional concentration data for food manufacturing industries is not available, given that a single milk processor is able to supply fluid milk to a large retail market (or metropolitan statistical area) or a single feed mill is able to supply to hundreds of feedlot operators and ranchers, it is likely that such industries have high local or regional concentration. A locational, dummy variable (REG , where 1 = local/regional, and 0 = otherwise) represents these local and regional industries, such as fluid milk, ice cream, and prepared feeds (e.g., REG for fluid milk, or SIC 2026, is equal to 1, and so on). This study maintains the con-

centration hypothesis and expects to find a positive and significant impact of *REG* on market power.

Advertising and capital requirement. To represent the difference in entry conditions across industries, two variables are introduced, namely advertising intensity (*ADVT*) and capital requirement (*KINT*). Each of these variables is a part of the strategic behavior that firms in an industry may adopt to compete, deter entry, raise entry barriers, increase profitability, and enhance market power (Martin 1993), i.e., these variables represent firm conduct. Regarding advertising, whereas it has the beneficial impact of providing some useful information to the buyer, it also raises rivals' costs of competition or entry or even deters entry because of advertising's inherent lag effects. An index of such an entry barrier is used here in terms of advertising intensity (*ADVT*) defined as the advertising-to-sales ratio.

In terms of capital requirement to enter a food industry, any industry that requires heavy capital investment will have fewer new and potential entrants because sunk costs are likely to be higher in such industries. The index of capital intensity is defined as the capital-to-sales ratio (*KINT*) and, in this study, is used to represent such capital requirements. Both *ADVT* and *KINT* are expected to create entry barriers in the food industry and, thereby, to help raise market power, i.e., these two variables are expected to have positive and significant relationships to market power.

Demand conditions. Demand conditions across industries vary. To measure the fluctuation of downstream demand for food manufacturers' output and to control for differences across industries in demand conditions, the shipment data of the food manufacturing industry for census years 1982, 1987, 1992, and 1997 were used to compute a coefficient of variation for each industry in the sample. This coefficient of variation (of industry demand) is a measure of relative dispersion, and it was used to represent the fluctuation in demand for the food industry's output (*DEMFLUC*). Although highly fluctuating demand can dampen the ability of food manufacturing firms to exert market power because of the uncertainty

associated with such demand conditions, there was no *a priori* belief about the impact of demand fluctuations on market power in the U.S. food industries.

Import discipline. It is commonly argued in the literature that import competition can significantly lower domestic market power and improve market performance (Esposito and Esposito). Import competition, defined as the import-to-sales ratio (*IMPORT*) or the competition from foreign firms, was expected to have a negative and significant impact on the domestic market power of U.S. food manufacturers.

Finally, like its predecessors, this is an industry-level study and, therefore, is likely to have some aggregation bias. Following Davies and Morris, the hypothesis used here is that such aggregation bias would have negative regression coefficients. To correct for such potential bias, an aggregation bias variable (*INTRA*) is defined as the proportion of total industry sales that are accounted for by sales within the industry, e.g., the value of shipment in the meat packing industry (SIC 2011) that is accounted for by SIC 2011, as recorded in the national input-output tables.

Based on the factors discussed, vector *M* (from Equation [1]) consists of industry concentration, advertising intensity, capital intensity, domestic demand fluctuations, and the degree of import competition. Additionally, we have a variable to account for the potential aggregation bias in the data. Thus, the empirical model to explain the impact of vertical integration on market power in the U.S. food industries takes the following form:

$$(2) \quad \begin{aligned} \mathcal{L} = & \beta_0 + \beta_1 FVI + \beta_2 CR4 + \beta_3 REG \\ & + \beta_4 ADVT + \beta_5 KINT + \beta_6 DEMFLUC \\ & + \beta_7 IMPORT + \beta_8 INTRA + u, \end{aligned}$$

where \mathcal{L} is the market power index as defined in Equation (1), and u is an error term. Thus, Equation (2) contains variables that represent both industry structure and behavior. Data construction of both dependent and explanatory variables is described below.

Data and Empirical Procedure

The focus of this study is on the U.S. food manufacturing sector at the census, four-digit, industry group or SIC level. 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 (data available upon request). Required data on the vertical integration index (*FVI*) and the market power index (\mathcal{L}) were obtained from Bhuyan and Bhuyan and Lopez, respectively. The vertical integration index was not reported for the six industries (for SICs 2043, 2062, 2068, 2076, 2085, and 2097), and the market power index was not reported for five industries (for SICs 2037, 2038, 2046, 2091, and 2099). Thus, these 11 food manufacturing industries were dropped from this study, and the remaining 38 were used.

The four-firm concentration ratio (*CR4*) is the most accepted and commonly used measure of market concentration (Rogers), and it is used to represent market concentration in this study. Data on *CR4* were obtained from the 1992 *Census of Manufacturers, Industry Series* reports (U.S. Department of Commerce 1997). Data on regional concentration (represented by the dummy variable, *REG*) advertising intensity (*ADVT*) and capital intensity (*KINT*), the later two expressed as a percent of 1992 sales, were kindly provided by Professor Richard T. Rogers of the University of Massachusetts at Amherst. The *Industrial Productivity Database*, which is publicly available courtesy of the National Bureau of Economic Research (NBER, www.nber.org), was the source for industry sales data for 1982 (adjusted to the 1987 SIC definition), 1987, and 1992 to compute the demand fluctuations (*DEMFLUC*) variable. The variable import intensity (*IMPORT*), defined as a percentage of imported, processed food to 1992 sales, was obtained using trade data from the NBER's trade data bank. The 1992 *Benchmark Input-Output Accounts of the United States* (U.S. Department of Commerce 1998) data were used to construct the *INTRA* variable as a per-

centage of 1992 sales to control for aggregation bias.

The level of aggregation used here has masked the more interesting, firm-level variations within an industry and across industries. However, as Perry noted, such firm-level analysis is impossible because of the lack of firm-specific data. Additionally, as in any empirical study, this study also suffers from data that do not perfectly represent the theoretical variables. But it is believed that in the absence of conceptually desirable data, use of available data should not diminish the importance of the linkage between market power and vertical integration. Given such data constraints, readers are urged to use their good judgment when perusing the results presented in a later section.

Because the dependent variable \mathcal{L} is bounded between 0 and 1, it was transformed into the log-odds functional form, $\ln[\mathcal{L}/(1 - \mathcal{L})]$ for estimation in Equation (2).⁶ Preliminary screening showed evidence of heteroskedasticity (Glejser test, χ^2 9 d.f. = 18.293). To obtain heteroskedasticity-consistent estimates of standard errors, White's method was employed (an alternative technique, the weighted least-square method, yields similar results). Summary statistics and a correlation matrix of variables used in Equation (2) are presented in Appendix Tables 1 and 2, respectively.

A common criticism of econometric estimation of such a reduced-form model of market power (i.e., Equation [2]) is that such models may have simultaneity bias or endogeneity bias. For instance, if the market power index is simultaneously determined with the vertical merger index, Equation (2) cannot be estimated in a single-equation, reduced-form framework. Similarly, if some elements of market structure (e.g., concentration) or market con-

⁶ This transformation is done to limit the predicted values of the dependent variable (\mathcal{L}) within its theoretical boundaries of 0 and 1. Given such theoretical boundaries of the dependent variable, correct interpretation of the impact of explanatory variables on \mathcal{L} is ineffectual without such transformation. See Caves and Bradburd (p. 274) for a similar transformation. Such a transformation, however, does not render the estimated model a logit (or discrete choice) model.

duct (e.g., advertising) that are used as explanatory variables are endogenous, then they cannot be used as explanatory variables in Equation (2). Fortunately, there are econometric techniques to test for the existence of such biases, namely the Hausman test (see Gujarati, pp. 669–673, for details). The simultaneity test shows that the vertical integration index (*FVI*) was not simultaneously determined with the dependent variable \mathcal{L} (the residual of *FVI* was not statistically significant, p -value = 0.810). The hypothesis that market concentration, advertising intensity, and capital intensity were endogenous was rejected as well (F statistic = 0.927, with 3 and 29 degrees of freedom, p -value = 0.440). Thus, using the Hausman test, the hypotheses that simultaneity and endogeneity biases exist in the reduced-form Equation (2) are rejected.

Results and Discussion

The principal question empirically tested in this study was: Does vertical integration raise market power in the U.S. food industries? Because of the paucity of firm-level data, industry-level (4-digit SIC) data were used to test that question. Thus, the inferences drawn here reflect industry-level conduct and performance rather than representing any particular firm's or industry's conduct and performance. The forward vertical integration index presented in Table 1 shows that, on average, the degree of forward vertical ownership integration in U.S. food manufacturing industries was only about 12% out of a possible 100% under a fully integrated scenario. Within the food manufacturing sector, variation among individual industries in terms of the degree of forward vertical ownership integration was low (st. dev. = 0.091). Given such a low level of forward vertical integration in the food industries, it is probably unlikely that those food manufacturing firms that have vertically integrated downstream have the ability to deny or at least make it difficult for their competitors to find a market for their products. That is, it is unlikely that these food manufacturing firms have the ability to foreclose the product (output) market. In terms of market power in the

U.S. food industries, the market power index presented in Table 1 shows that the average degree of market power in the food industries was 0.32, i.e., on average there was a 32% mark-up in the U.S. food manufacturing industries.

Table 1 shows that the degree of forward vertical ownership integration in the U.S. food manufacturing industries is quite low. Whether even this low level of vertical integration could still raise market power in the U.S. food industries was examined, given the motivation for this study. Regression analysis was employed to estimate Equation (2) to evaluate whether forward vertical integration influenced market power in U.S. food manufacturing industries. Regression results are presented in Table 2.

Because forward vertical integration (*FVI*) may have competitive as well as anticompetitive effects in a market, there is no *a priori* knowledge of which of these two effects dominate in U.S. food manufacturing industries. Results in Table 2 show that neither effect was prominent in the U.S. food industries during the study period. Although the direction of the relationship supports a positive impact of forward vertical integration on market power, the estimated coefficient was not statistically significant. This may be due to the very low level of forward vertical integration in the U.S. food industries or may be due to the extremely low degree of association between market power and forward vertical integration (correlation coefficient is 0.041, Appendix Table 2). Whereas some previous studies (e.g., Martin 1994, p. 308) found that increased vertical integration led to increased oligopolistic coordination and market power, this study was unable to find such a link between vertical integration and market power in the U.S. food industries. Thus, the results of this study do not support the hypothesis that forward vertical integration significantly impacts (either positively or negatively) market power in the U.S. food industries.

In terms of the impact of market concentration on the food industry's market power, results in Table 2 show that market power would increase if an industry is concentrated

Table 2. Effect of Vertical Integration on Market Power of the U.S. Food Manufacturing Industries ($n = 38$); Dependent Variable: Market power index (\mathcal{L})

Variable Name	Expected Sign	Estimated Coefficient (absolute t -statistics)
Vertical Integration (FVI)	+/-	0.3543 (0.914)
Market Concentration ($CR4$)	+	0.008*** (5.043)
Regional Dummy (REG)	+/-	0.450*** (4.268)
Advertising Intensity ($ADVT$)	+	0.053*** (4.086)
Capital Intensity ($KINT$)	+	-1.647*** (6.289)
Domestic Demand Fluctuations ($DEMFLUC$)	+/-	-0.015*** (6.377)
Import Competition ($IMPORT$)	-	-0.406 (0.381)
Aggregation Bias ($INTRA$)	-	1,096.3 (1.073)
CONSTANT		-0.741*** (5.762)
R^2 between observed and predicted	0.337	

Note: *** Implies significance at 99% level.

either at the national level ($CR4$) or at the local or regional levels (REG). These findings support the *a priori* reasoning presented earlier and lend support to previous studies that showed that higher concentration will enhance market power (e.g., Martin 1993; Scherer and Ross; Rogers). In terms of the impact of industry conduct on industry market power, study results show that advertising ($ADVT$) had a positive and significant impact on market power as expected. Past studies have shown similar evidence on the impact of advertising on market power (Martin 1993, Chapter 16). This implies that advertising (or product differentiation) may have created entry barriers by raising rivals' costs of competition or entry. That is not surprising because there is ample evidence in the literature that advertising raises barriers to entry and has an adverse effect on competition (Shepherd and Shepherd, p. 265). Thus, high market concentration and higher advertising in the food industries would lead to increased market power, and consequently would have a detrimental ef-

fect on allocative efficiency in the food industries.

Capital intensity ($KINT$) had a significantly negative impact on market power and did not support the *a priori* causality reasoning. Noting that the variable $KINT$ was one of the variables used to represent strategic behavior that firms in an industry can adopt to deter entry in an effort to enhance their market power (Martin 1993), it can be argued that food manufacturing firms in the study period were unable to create entry barriers (the correlation coefficient between market power and capital intensity is negative and extremely low, approximately -0.04, Appendix Table 2). A similar argument was made by Bhuyan that food manufacturing firms were unable to erect effective entry barriers using capital as a strategic variable.

The demand fluctuation variable ($DEMFLUC$) used to test the impact of demand variability (or demand uncertainty) on industry market power shows that if demand is fluctuating highly, it will have a significantly neg-

ative impact on a firm's (industry's) ability to exert market power in the product market. This is also intuitive because highly uncertain and risky conditions of market demand may prevent firms from making long-term (or even medium-term) plans for adopting certain production or marketing strategies that may eventually lead to their ability to raise prices or control quantities.

In terms of the market disciplinary power of import competition, although the coefficient of the *IMPORT* carried the expected sign, it was statistically not significant, i.e., this study fails to show the disciplinary impact of import competition on the domestic market power of the U.S. food manufacturing industries. This result is contrary to the findings of Esposito and Esposito or Pagoulatos and Sorensen who found that competition from foreign firms limits the ability of domestic firms to exercise control over price. As suspected, there was some aggregation bias in the data, but it was not serious enough to adversely impact the model estimates, i.e., the coefficient of the aggregation bias variable *INTRA* was negative but not statistically significant.

Overall, the results of this cross-sectional study accord reasonably well with previous interindustry studies on the impact of vertical integration, market structure, and market conduct on market power and support the explanatory power of the estimated model, i.e., Equation (2). Given that this study is cross-sectional and the purpose of the econometric model is explanatory and not predictive, the overall fit of the model is acceptable (pseudo $R^2 = 0.337$).

Concluding Remarks

In the industrial economics literature, whether vertical integration can raise market power (or whether it has any effect on market power) is a hotly debated issue. This is because, according to the doctrine of the Chicago School, vertical ownership integration would not raise market power and, therefore, will have no adverse impact on allocative efficiency. Although vertical integration is a common strategic behavior undertaken by food manu-

facturing firms, previous studies have ignored this issue. To address this gap in the literature of the agricultural industrial organizations, the aim of this study was to empirically examine the question, "Does vertical ownership integration effect market power in the U.S. food industries?"

Focusing on 38 four-digit SIC level U.S. food manufacturing industries and using publicly available data, this study shows that there was no evidence to support the hypothesis that vertical integration significantly influenced market power in those industries. For public policy, the implications from the findings of this study suggest that it is, perhaps, unsurprising that the U.S. antitrust authorities generally do not pay attention to vertical ownership integration unless foreclosure becomes an issue, and no market foreclosure cases were found in the literature, involving the food manufacturing industries. However, the results of this study support the argument in the literature that market power is impacted by market structure (concentration) and conduct. For corporate decision makers in the U.S. food manufacturing sector, if vertical integration was used as a strategic variable to attain market power, such strategy did not bear fruit.

There was an apparent lack of clear theoretical linkages between vertical integration and market power in the model tested here. Thus, there is a need for theoretical work regarding the linkage between market power and vertical integration (or vertical coordination). In addition, there is a need to examine the effect of alternative types of vertical relationships (e.g., contracts) on market power because the motivations behind different types of vertical relationships are different and may have different impacts on market power. Finally, this study is based on aggregated industry-level data; therefore, readers should use judgment when studying the results and inferences.

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Appendix

Measuring Vertical Integration

The following discussion on constructing a forward vertical integration index is based on Bhuyan. This definition of vertical integration was based on models presented by both Caves and Bradburd and Davies and Morris. Using census data on manufacturing industries (See Bhuyan for data sources), a

forward vertical integration index was constructed where a food manufacturing firm i in industry j owns plants or firms in another industry k ($j \neq k$), where k can include wholesalers, retailers, or other food manufacturing firms. Such a measurement reflects integration between business units in a given industry and those in industries downstream from it, thereby, offering the potential for testing the impact of such integration on the performance of markets in which these integrated firms exist. Note that such a measurement will miss any integrated enterprises that operate in vertically-related industries but that do not actually transfer intermediate products between their units (Caves and Bradburd).

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

$$FVI_j = \sum_{k=1}^R \sum_{i=1}^N \frac{X_{j,k}^i}{X_j}$$

where FVI_j is the index of forward vertical integration of industry j , $X_{j,k}^i$ is i th firm's intrafirm flows between industry j and downstream industry k , and X_j is the total sales of industry j . If there are no intrafirm flows between industry j and k , then $FVI_j = 0$ indicating a lack of vertical integration. Similarly, if industry j is fully integrated to downstream industry k , then $FVI_j = 1$. Thus, the value of the forward vertical integration will lie between 0 and 1, or $0 \leq FVI_j \leq 1$.

Equation (1) is used as follows to compute the FVI for the meat packing industry (SIC 2011): According to the 1992 *Census of Manufacturers*, shipments from companies in the meat packing industry to other establishments of the same company included \$4,132.93 million or 8.19% to wholesale establishments (ws), i.e., $\sum_{i=1}^N X_{2011,ws}^i / X_{2011} = 0.0819$, \$193 million or 0.38% to retail stores and outlets, \$1,883.42 million or 3.73% to other manufacturing establishments, and \$151.15 million or 0.30% to other nonmanufacturing establishments. Thus, the forward vertical integration index in the meat packing industry is $FVI_j = FVI_{2011} = 0.819 + 0.0038 + 0.0373 + 0.003 = 0.126$ (Table 1, third column). Similar computations were carried out for other food industries as shown in Table 1.

Appendix Table 1. Descriptive Statistics for Variables Used in Regression Analysis

Variable	<i>n</i>	Mean	SD	Variance	Minimum	Maximum
<i>LERNER</i>	38	0.3198	0.1721	0.0296	0.0810	0.6790
<i>FVI</i>	38	0.1229	0.0910	0.0083	0.0210	0.3355
<i>CR4</i>	38	49.2110	17.5520	308.0600	19.0000	90.0000
<i>REG</i>	38	0.1316	0.3426	0.1174	0.0000	1.0000
<i>ADVT</i>	38	1.7339	2.8116	7.9052	0.0000	16.4000
<i>KINT</i>	38	34.1780	17.4760	305.4300	8.2900	97.3600
<i>DEMFLUC</i>	38	23.5610	14.9600	223.8000	3.2600	93.7100
<i>IMPORT</i>	38	4.6094	2.6422	6.9814	1.3046	8.3483
<i>INTRA</i>	38	0.0083	0.0162	0.0003	0.0000	0.0924

Lerner is the Lerner index of market power; *FVI* is vertical integration; *CR4* is market concentration; *REG* is regional dummy; *ADVT* is advertising intensity; *KINT* is capital intensity; *DEMFLUC* is domestic demand fluctuations; *IMPORT* is the import-to-sales ratio; and *INTRA* is the aggregation bias.

Appendix Table 2. Correlation Matrix of Variables Used in Regression Analysis

<i>LERNER</i>	1.0000									
<i>FVI</i>	.0414	1.0000								
<i>CR4</i>	-.0015	-.3833	1.0000							
<i>REG</i>	.1058	.7066	-.4273	1.0000						
<i>ADVT</i>	-.1279	-.1607	.1622	-.1150	1.0000					
<i>KINT</i>	-.0399	-.3359	.3296	-.0436	.0390	1.0000				
<i>DEMFLUC</i>	-.2016	-.1344	-.0374	-.1169	.7389	-.2238	1.0000			
<i>IMPORT</i>	-.1538	-.2060	.4147	-.3052	.3325	.4450	.1241	1.0000		
<i>INTRA</i>	.1473	-.2016	.1155	-.1547	-.2035	.7039	.2591	.2986	1.0000	
	<i>LERNER</i>	<i>FVI</i>	<i>CR4</i>	<i>REG</i>	<i>ADVT</i>	<i>KINT</i>	<i>DEMFLUC</i>	<i>IMPORT</i>	<i>INTRA</i>	

Lerner is the Lerner index of market power; *FVI* is vertical integration; *CR4* is market concentration; *REG* is regional dummy; *ADVT* is advertising intensity; *KINT* is capital intensity; *DEMFLUC* is domestic demand fluctuations; *IMPORT* is the import-to-sales ratio; and *INTRA* is the aggregation bias.