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Price and Cost Impacts of Concentration in Food Manufacturing Revisited

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This study estimates the elasticities of wholesale food prices, cost efficiency, and market power with respect to industrial concentration in 35 food processing industries, modifying the model of Lopez, Azzam, and Lirón-España (2002). In contrast to the results of their earlier analysis, findings of this study indicate that further increases in concentration would result in significant processing cost savings (and Lerner index increases) in nearly all industries and that output prices would decline in nearly 50% of the industries, although significantly so in only 20% of them. As industrial concentration rises, price declines occur in industries with low levels of concentration while price increases occur in highly concentrated industries.

Key Words: cost efficiency, food prices, food processing, industrial concentration, market power

Industrial concentration is often measured by summary indexes of the distribution of sales by firms in an industry. Two measures published by the federal government on a comparable basis for a wide range of industries, including those engaged in food manufacturing, are the four-firm concentration ratio (CR4, the share of sales of the four largest companies) and the more comprehensive Herfindahl (H) index.[1] By either measure, concentration has significantly increased across food manufacturing industries in the last three decades (Rogers, 2001).[2]

Increases in industrial concentration occur through mergers, acquisitions, investments, and other means. In the long run, economies of scale, the extent of product

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[1] Formally, the Herfindahl-Hirchman index of industrial concentration is defined by $H = \Sigma_j S_j^2$, where $S_j = q_i / Q$ [see Martin (2002) for a discussion]. It ranges from 0 for perfect competition (where each firm is an insignificantly small part of the market) to 1 for a monopolist. Also note that $H = (1 + CV^2)/N$, where CV^2 is the coefficient of variation of firms' shares and N is the number of firms. If all firms are equal, $H = 1/N$. For a given number of firms, the greater the variability in firms' sizes, the greater is H. The main advantage of H over $CR4$ is that it encompasses all firms (not just the top four) and also accounts for the size dispersion of firms.

[2] Rogers (2001) analyzed food-processing merger waves between 1958 and 1997. In this period, two waves of horizontal consolidation took place in the food processing industries—the first in the 1980s, and the second that started in the late 1990s and continues to the present. Rogers further states that in 1997, the top companies in the food processing sector (out of 16,000 firms) controlled 50% of the value added, which is twice as much as they did in 1967.

differentiation, and absolute capital requirements for entry are important factors shaping concentration. While increases in concentration are positively correlated with market power—a firm's significant ability to affect price or quantity in the marketplace—concentration may induce cost efficiency or cost inefficiency or be cost-neutral. Whether or not cost efficiency effects are able to offset or reinforce market power effects is crucial to the performance of the food system. Thus, concentration can have an impact not only on consumers (to the extent that these savings or cost inefficiencies are passed on to them), but also on international competitiveness and the profitability of domestic food processing companies.

The importance of the impact of concentration on price is highlighted by the fact that the U.S. Department of Justice and the Federal Trade Commission (1997) revised their guidelines to articulate in greater detail how they would treat claims of efficiencies associated with horizontal mergers. In short, the Federal Trade Commission (FTC) often uses a "price" standard to challenge mergers: efficiency should be large enough to preclude any post-merger price increase (Kattan, 1994; Werden, 1996). When compared across food processing industries, the impacts of increased concentration on price and cost efficiency can generate useful preliminary information in terms of identifying and targeting industries where further increases in concentration can be harmful to consumers and competition.

Early econometric studies of the so-called structure-conduct-performance (SCP) relationships, first introduced by Bain (1951), show that there is a positive relationship between U.S. manufacturing industry profits and seller concentration, attributed to the exercise of market power. However, the efficiency effects of concentration were largely ignored, particularly those argued by Schumpeter (1949) on the dynamic relationship between prices and concentration. One of the earlier attempts to distinguish market power from efficiency effects was contributed by Demsetz (1973). Sorting out profits by firm size in U.S. manufacturing, Demsetz argues that the superior efficiency of large share firms is the source of higher profits. Shepherd (1972) estimates a profitability equation including both market share and the concentration ratio, finding that the market share effect (efficiency) is positive, like the concentration effect, but larger and more significant. Peltzman (1977) estimates separate equations for the concentration-price and the concentration-cost relationships, concluding the cost effects so dominate the positive price effects that the observed increase in profits with concentration is due to prices falling less than do costs. Since the 1980s, the concentration-related work has extended along the lines of the so-called New Empirical Industrial Organization (NEIO) work by motivating empirical models through formal theoretical models and increasing use of firm-level data (Martin, 2002).[3]

The U.S. food manufacturing industries have been the subject of several empirical works attempting to separate out the market power and efficiency effects of

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[3] Other approaches that have analyzed structurally the impact of concentration on industries include Bumpass (1987); Perry and Porter (1985); and McAfee and Williams (1992). See Whitley (2003) for an excellent review of the effects of concentration in agricultural markets.

concentration.[4] Gisser (1982, 1999) provides statistical evidence that increased concentration is associated with increased total input productivity which is roughly sufficient to offset oligopoly power-related losses, especially those in the beer industry. Cotterill and Iton (1993) use a Shepherd-type model (including both market share and concentration) with Profit Impact of Market Strategy (PIMS) data. They report positive effects for both market share and concentration. Azzam and Schroeter (1995) and Azzam (1997) use an NEIO-type model in the beef packing industry, finding that efficiency effects overpower market power effects. Employing a structural model to decompose the oligopoly power and the cost effects of concentration in 32 food processing industries, Lopez, Azzam, and Lirón-España (2002, henceforth LAL) conclude that concentration induces efficiency only in one-third of the industries while it results in higher output prices in nearly all industries. In contrast, Dickson and Sun (2004), like Peltzman (1977), develop separate price-concentration and cost-concentration equations assuming constant returns to scale; their findings suggest the overall effect of rising concentration has been to lower prices, attributing the differences in results to the inability of NEIO models to deal with technical change, which may underlie concentration itself.

The thrust of this study is to estimate the elasticities of wholesale food prices, processing cost, and market power with respect to changes in industrial concentration focusing on the role of economies of scale, and to provide alternative results to those of LAL.[5] While the underlying econometric model draws heavily from the work of LAL, the following model modifications are made: (*a*) allowing for equilibrium output adjustments instead of assuming fixed industry output, and (*b*) a double-log, instead of a semi-log, demand form for output. The model is applied to four-digit Standard Industrial Classification (SIC) data from 35 industries for the 1972–1992 period. As a result, the empirical findings seem to be more consistent with previous empirical evidence than those of LAL in that there are efficiency gains associated with concentration increases in most industries. We also find a higher number of industries where rising concentration produces benign effects on consumers—i.e., for 49% of the industries (17 out of 35), prices either decline or price changes are statistically insignificant. Further, our findings indicate the benign effects of concentration pertain to the low-concentration industries, while the highly concentrated industries show the most detrimental effects of further concentration.

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[4] An impressive number of empirical studies consider only the market power effect of concentration in the food processing industries in the SCP tradition (e.g., Peterson and Connor, 1995). A few have focused only on the relationship between concentration and efficiency in these industries (Dickson, 1994; Gopinath, Pick, and Li, 2003).

[5] This paper addresses only the effects of concentration on output prices and does not consider any effects of concentration on input prices, e.g., of raw farm products. For an industry like meatpacking, this issue may be important and has been analyzed extensively, and some authors do not find evidence of significant monopsony power (e.g., Morrison-Paul, 2001). For most industries in the present sample (e.g., malt beverages and bakery products), the issue of monopsony power is not relevant. In addition, some industries (e.g., poultry processing) are vertically integrated.

Impacts of Concentration

Following LAL, consider an industry with N firms, each producing a homogeneous output in the amount q_i, and $Q = \Sigma_i q_i$ is total industry output sold at price P. The output demand function is given by $Q = f(P, \mathbf{Z})$, where $\mathbf{Z}$ is a vector of demand shifters. A firm's food processing cost is represented by $c_i(q_i, \mathbf{w}, t)$, where $\mathbf{w}$ is a vector of exogenous prices and t is the state of technology.

Each firm is assumed to choose its output level in order to maximize profits (π_i):

(1) $$\pi_i = P(Q, z)q_i - c_i(q_i, \mathbf{w}, t).$$

The first-order condition of (1) with respect to q_i yields:

(2) $$P = \frac{mc_i(q_i, \mathbf{w}, t)}{1 - \left(\frac{(1 + \phi_i)S_i}{\eta}\right)},$$

where $\phi_i = \partial \Sigma q_j / \partial q_i$ is firm i's conjecture with respect to the reaction of rivals ($j \neq i$), $S_i = q_i/Q$ is the firm's market share, $\eta = \partial \ln(Q)/\partial \ln(P)$ is the price elasticity of demand in absolute value, and $mc_i(\partial c_i/\partial q_i)$ is the firm's marginal cost.

The food processing cost function for each firm is assumed to take the restricted generalized Leontief form:

(3) $$c_i(q_i, \mathbf{w}, t) = q_i \sum_j^m \sum_k^m \gamma_{jk}(w_j w_k)^{0.5} + q_i t \sum_j^m \gamma_{jt} w_j + q_i^2 \sum_j^m \beta_j w_j,$$

where $\mathbf{w}$ is a vector of exogenous input prices; t is a time variable to capture the state of technology; and γ_{jk}, γ_{jt}, and β_j ($j = 1, \ldots, m$) are fixed parameters.

Summing marginal costs and conjectural variations across firms in the industry, using the market shares as weights, one obtains the industry-level empirical analogue of equation (2):

(4) $$P = \frac{MC}{1 - \left(\frac{\alpha + (1 - \alpha)H}{\eta}\right)},$$

where the share-weighted marginal cost is given by

$$MC = \sum_j^m \sum_k^m \gamma_{jk}(w_j w_k)^{0.5} + t \sum_j^m \gamma_{tj} w_j + 2QH \sum_j^m \beta_j w_j,$$

H is the Herfindahl index (defined in footnote 1), and α is the conjectural variation or collusion parameter denoting the share-weighted change in the output of rivals in response to a change in a firm's output ($\alpha_i = \partial \Sigma q_j / \partial q_i$), following Clarke and Davies

(1982).[6] Note that the industry-level Lerner index of oligopoly power can be expressed as $L = (\alpha + (1 - \alpha)H)/\eta$ in the denominator of (4).

Output demand is assumed to take the double logarithmic form:

$$\ln(Q) = \delta_0 - \eta \ln\left(\frac{P}{d}\right) + \sum_{l=1}^{r} \delta_l \ln(Z_l), \tag{5}$$

where d is a price deflator; Z_i denotes demand shifters; and δ_0, δ_l, and η denote parameters.

Market equilibrium in a particular industry is reached when P and Q fulfill equations (4) and (5) simultaneously. Consequently, the total elasticity of price with respect to the Herfindahl index ($\varepsilon_{P,H}$) can be obtained by:

$$\varepsilon_{P,H} = \lambda\left[\varepsilon_{L,H} + \varepsilon_{MC,H}\right]. \tag{6}$$

The $\varepsilon_{P,H}$ price elasticity is the sum of the Lerner index elasticity, $\varepsilon_{L,H}(= [1 - \alpha]PH/MC\eta)$, and the marginal cost-efficiency elasticity, $\varepsilon_{MC,H}(= 2QH\,\Sigma_j^m \beta_j w_j / MC)$, multiplied by an equilibrium adjustment factor, $\lambda\ (= [1 + \eta\varepsilon_{C,H}]^{-1})$.[7] While the Lerner index elasticity is always positive for these industries, the sign of the marginal cost elasticity can be positive or negative. The magnitude of the adjustment factor (greater or less than 1) depends on economies of size. If there are economies of size, the marginal elasticity is negative and the adjustment factor is greater than 1.

Figure 1 illustrates the industry equilibrium concept. This case shows that an increase of concentration from H_0 to H_1 results in a downward shift in the perceived marginal revenue curve (market power effect) as well as a decrease in marginal cost (efficiency effect). Market equilibria occur at E_0 and E_1, respectively. However, the net effect is an increase in the output price as the market power effect of concentration dominates the efficiency effect. Of course, this case results in an industry output reduction in order to sustain the price increase.

Data and Empirical Implementation

The sample consists of annual data for the period 1972–1992 for 35 U.S. food manufacturing industries at the four-digit (1987) SIC level. The main data source for prices and quantities of outputs and inputs was Bartelsman, Becker, and Gray's (1996)

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[6] When $\alpha = 0$, then $L = H/\eta$ which is the Cournot outcome, whereas $\alpha = 1$, $L = 1/\eta$ is the monopoly outcome. Perfectly competitive behavior is given by $\alpha = -H/(1 - H)$.

[7] Recall that quantity is a function of price (via the demand function), and therefore of H via equation (4). Thus, differentiating (4), one obtains

$$\frac{\partial P}{\partial H} = \frac{1}{1 - L}\left[\frac{(1 - \alpha)P}{\eta} + 2P \sum_{j=1}^{m} \beta_j W_j Q\right],$$

where L is the Lerner index. Multiplying both sides by H/P gives equation (6),

$$\varepsilon_{P,H} = \frac{MC}{MC + 2\beta H \eta Q}\left(\varepsilon_{L,H} + \varepsilon_{C,H}\right),$$

where $\varepsilon_{L,H}$ and $\varepsilon_{C,H}$ are as defined in the text.

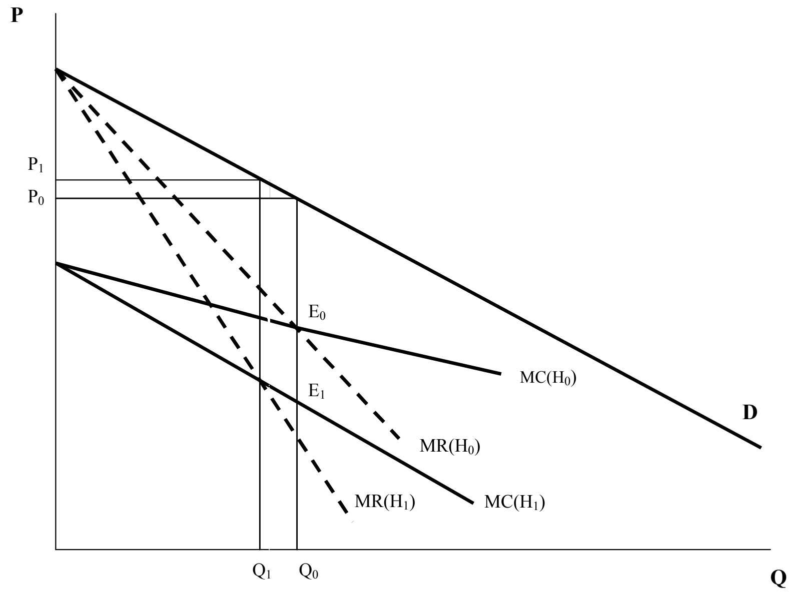

Figure 1. Price increase with market power and efficiency tradeoff

online National Bureau of Economic Research database for U.S. manufacturing industries.[8]

The full model of industry equilibrium consists of five equations, with the pricing equation (4) being of primary interest. The four supplementary equations assist in identifying the parameters in (4): an output demand equation (5) to help estimate the demand elasticity and three input demand equations to help estimate the *MC* parameters.[9]

The endogenous variables are Q, P, and input quantities X_K, X_L, and X_M for capital services, labor, and materials, respectively. The demand shifters are gross domestic product as a proxy for consumer income and time as a proxy for consumer preferences. The price and income values are deflated by the consumer price index (d). The cost shifters consist of a time variable to capture technological changes, the Herfindahl index, and input prices for capital services, labor, and materials (w_K, w_L, w_M) obtained as indexes by dividing expenditures by the respective input quantities.

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[8] The standard caveats apply to the use of Census or Annual Survey of Manufacturers data (MacPhee and Peterson, 1990; Martin, 2002): (*a*) level of aggregation may not reflect the true extent of markets in certain cases; (*b*) product homogeneity is assumed across firms in an industry and over time; and (*c*) geographic dispositions of firms is such that the value of shipments and cost are relatively free of distortions due to differences in technology, but depend on demand differences and factor market conditions. However, by applying a structural model of demand, pricing, and cost, we avoid the pitfalls of using profitability rates or accounting profits which have plagued structure-conduct-performance studies (Martin, 2002).

[9] By applying Shephard's lemma to equation (3), one obtains firm-level input demand functions. These can then be aggregated across firms using market shares as weights to obtain the industry-level demand functions given by:

$$X_j/Q = \sum_j^m \sum_k^m (w_k w_j)^{0.5} + \gamma_{jt} t + HQ\beta_j .$$

Two variables required further assumptions due to the lack of data: the price of capital and the Herfindahl index. The price of capital was obtained by dividing the cost of capital services (provided electronically by the Bureau of Labor Statistics) by the quantity of capital assets for SIC 20 (food manufacturing). Thus, all industries are assumed to face the same price of capital but, of course, are allowed to have different levels of capital assets. The Herfindahl index was estimated for the inter-Census years when it was not available.[10]

Once the variables were operational, the industry model was applied to the data from each individual industry using the nonlinear three-stage least squares (3SLS) estimation procedure with SHAZAM 8.0 software. To allow for industry output adjustment (unlike LAL, 2002), the equilibrium P and Q before and after a 1% increase in the Herfindahl index (at mean values) were determined simultaneously by solving the estimated output demand [equation (4)] and the estimated industry supply relation [equation (5)] with MATLAB 4.0 software. The elasticities and output adjustments of concentration were computed based on equation (6) for each of the 35 U.S. food processing industries in the sample.

Empirical Results

Table 1 presents the nonlinear 3SLS estimates of the selected parameters together with their test statistics for hypothesis testing. In general, the results were plausible and consistent with theory in terms of expected signs and magnitudes of the coefficients. We compare the econometric results of key market parameters to LAL (2002) as well as to Bhuyan and Lopez (1997, henceforth BL). Even though the latter did not include industrial concentration in their model, they provide industry-specific estimates for demand elasticities, the Lerner index, and economies of size.

Using the Wald χ^2 statistic, the null hypothesis of no oligopoly power ($H_0: L = 0$) was rejected in all but two industries (94%) at the 5% level of significance, consistent with the findings of BL. Furthermore, approximately 86% (30 industries) exhibit economies of size (c.f., 57% of the 36 food industries reported by BL and 45% of the 29 industries reported by LAL). The average estimated price elasticity of demand and Lerner indexes (approximately ! 0.49 and 0.27, respectively) are close to those of BL (approximately ! 0.52 and 0.33). The average implied economies of size reported by BL for the food processing industries (approximately 0.84) is lower than for those shown in table 1 (approximately 0.92).

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[10] The first step involved the application of the technique presented by Golan, Judge, and Perloff (1996) in which market shares are forecast by concentration ratio intervals via maximum entropy and then re-forecast for each firm using a third-degree polynomial function. The estimated H index for 1972 and 1977 was the sum of the squares of market shares resulting from the polynomial distribution. The second step involved regressing the Census-year H indexes on a set of instrumental variables (these and the H obtained from U.S. Department of Commerce reports) and then predicting H for the inter-Census years (Chow and Lin, 1971). These regressions yielded an average R^2 of 85%. Then the H indexes were estimated with the predicted values. The use of spline functions and exponential smoothing (using the Curve Expert software) did not significantly alter the results. The H indexes used here are available from the authors upon request.

Table 1. Selected Parameter Estimates, U.S. Food Manufacturing Industries, 1972–1992

		Elasticity of Demand	
SIC	Industry	η	*t*-Statistic
2011	Meat Packing Plants	! 0.415*	! 5.45
2013	Sausages and Other Prepared Meats	! 0.277*	! 2.39
2015	Poultry and Egg Processing	! 0.653*	! 4.27
2021	Creamery Butter	! 0.652*	! 4.75
2022	Cheese, Natural and Processed	! 0.464*	! 5.05
2023	Condensed and Evaporated Milk	! 0.334*	! 3.24
2024	Ice Cream and Frozen Desserts	! 0.525*	! 2.18
2026	Fluid Milk	! 0.561*	! 3.18
2032	Canned Specialties	! 0.495*	! 7.25
2033	Canned Fruits and Vegetables	! 0.108*	! 2.38
2034	Dehydrated Fruits, Vegetables, and Soups	! 0.293*	! 2.19
2035	Pickles, Sauces, and Salad Dressings	! 1.061*	! 3.08
2037	Frozen Fruits and Vegetables	! 0.070*	! 5.99
2041	Flour and Other Grain Mill Products	! 0.162*	! 4.03
2045	Blended and Prepared Flour	! 0.675*	! 5.17
2046	Wet Corn Milling	! 0.330	! 0.91
2047	Dog and Cat Food	! 0.600*	! 5.02
2048	Prepared Feeds (NEC)	! 0.154*	! 2.76
2061	Raw Cane Sugar	! 0.321*	! 6.02
2062	Cane Sugar Refining	! 0.479*	! 6.28
2063	Beet Sugar	! 0.443*	! 7.52
2064	Candy, Other Confectionery Products & Chewing Gum	! 0.467*	! 6.10
2066	Chocolate and Cocoa Products	! 0.484*	! 9.56
2077	Animal and Marine Fats and Oil	! 0.316	! 0.92
2079	Shortening and Cooking Oils	! 0.228*	! 6.85
2082	Malt Beverages	! 0.970*	! 4.01
2084	Wines, Brandy, and Brandy Spirits	! 0.621*	! 4.27
2085	Distilled Liquor, Except Brandy	! 1.675*	! 7.01
2086	Bottled and Canned Soft Drinks	! 0.270*	! 5.84
2087	Flavoring Extracts and Syrups (NEC)	! 0.719*	! 7.84
2091	Canned and Cured Seafood	! 0.552*	! 3.27
2092	Fresh or Frozen Seafood	! 0.010*	! 4.99
2095	Roasted Coffee	! 0.305*	! 6.91
2097	Manufactured Ice	! 0.888*	! 4.10
2099	Food Preparations (NEC)	! 0.530*	! 5.64
Average:		! 0.4888	

Notes: An asterisk (*) denotes significance at the 1% level. The term η stands for elasticity of demand; α denotes the conjectural variation; *L* and $g_{C,Q}$ represent the Lerner index and cost elasticity with respect to output, defined as industry marginal cost (*MC*) divided by industry average cost, respectively. The superscripts "a" and "b" denote significance at the 1% level under Cournot and perfect competition hypotheses, respectively. NEC denotes "not elsewhere classified."

Table 1. Extended

	Conjectural Variation			Lerner Index		Economies of Size	
SIC	α	t_c	t_{pc}	L	χ^2	$g_{C,Q}$	χ^2
2011	0.009[ab]	1.74	8.72	0.108*	51.17	0.935*	19.60
2013	0.027[ab]	1.65	2.75	0.156*	125.74	0.983	1.59
2015	0.045[ab]	2.87	4.61	0.106*	155.02	0.995	1.20
2021	0.006[b]	0.13	2.00	0.113*	5.13	0.881*	6.31
2022	0.010[b]	1.00	6.73	0.130*	130.32	0.977*	5.03
2023	0.045[ab]	1.78	3.77	0.273*	123.13	0.956	2.74
2024	0.088[ab]	1.71	2.24	0.214*	108.70	0.930*	9.19
2026	0.101[ab]	2.75	3.19	0.205*	78.95	0.913*	11.16
2032	0.015[b]	0.86	12.01	0.351*	206.26	0.904*	8.11
2033	0.012[b]	0.98	3.00	0.331*	33.59	0.846*	4.95
2034	0.007[b]	0.23	2.37	0.205*	36.30	1.043	0.95
2035	0.277[ab]	2.47	3.37	0.322*	218.16	0.953*	10.25
2037	!0.008[ab]	!2.44	7.39	0.335*	74.97	0.854*	316.15
2041	0.003[b]	0.23	5.40	0.388*	102.23	0.688*	80.34
2045	0.243[ab]	3.79	5.28	0.456*	705.41	0.740*	110.47
2046	!0.131	!0.92	0.46	0.164	0.34	0.972	0.02
2047	0.109[ab]	2.42	5.66	0.369*	227.15	0.980	0.37
2048	0.011[b]	1.21	3.31	0.181*	92.52	0.921*	14.97
2061	0.038[ab]	1.90	6.15	0.346*	58.71	0.757*	29.16
2062	!0.132[a]	!1.98	1.16	0.128	1.25	0.886	0.86
2063	0.015[b]	0.54	6.78	0.357*	112.89	0.709*	58.84
2064	0.114[ab]	4.64	7.13	0.353*	305.71	0.969	1.42
2066	!0.074[ab]	!1.94	4.94	0.308*	24.06	0.956	0.29
2077	0.033	0.27	0.62	0.227	0.54	1.004	0.01
2079	0.012[b]	1.02	6.65	0.315*	181.83	0.798*	64.67
2082	!0.047[b]	!1.30	5.15	0.153*	30.65	1.030	0.81
2084	0.103[ab]	2.81	5.32	0.285*	244.41	0.955*	5.13
2085	0.570[ab]	5.38	6.24	0.362*	141.54	1.041	0.72
2086	0.065[ab]	5.14	7.00	0.320*	880.77	0.900*	63.68
2087	0.179[ab]	4.51	9.45	0.434*	269.34	1.220*	15.66
2091	0.005[b]	0.19	4.00	0.153*	22.79	0.974	2.49
2092	0.010[ab]	2.22	5.55	0.261*	137.64	0.886*	20.17
2095	0.089[b]	0.36	7.70	0.528*	115.15	0.624*	51.99
2097	0.227[ab]	3.75	4.05	0.272*	199.36	0.978	1.56
2099	0.174[ab]	5.06	5.82	0.365*	879.73	0.931*	32.42
Average:	0.0876			0.2735		0.9168	

Table 2. Concentration Related Elasticities, U.S. Food Manufacturing Industries, 1972–1992

			Price Elasticity	
SIC	Industry	Rank	$g_{P,H}$	χ^2
2011	Meat Packing Plants	23	!0.048*	4.78
2013	Sausages and Other Prepared Meats	16	0.035	2.20
2015	Poultry and Egg Processing	17	0.031*	7.70
2021	Creamery Butter	31	!0.320	1.20
2022	Cheese, Natural and Processed	14	0.079*	25.00
2023	Condensed and Evaporated Milk	12	0.101*	4.95
2024	Ice Cream and Frozen Desserts	26	!0.100	2.50
2026	Fluid Milk	29	!0.181*	5.60
2032	Canned Specialties	5	0.314*	59.93
2033	Canned Fruits and Vegetables	22	!0.039	0.13
2034	Dehydrated Fruits, Vegetables, and Soups	6	0.306*	8.46
2035	Pickles, Sauces, and Salad Dressings	19	!0.010	0.66
2037	Frozen Fruits and Vegetables	4	0.340*	12.71
2041	Flour and Other Grain Mill Products	32	!0.360*	9.44
2045	Blended and Prepared Flour	35	!1.001*	9.23
2046	Wet Corn Milling	1	0.620	0.50
2047	Dog and Cat Food	8	0.264*	15.24
2048	Prepared Feeds (NEC)	21	!0.034	0.85
2061	Raw Cane Sugar	33	!0.368*	4.42
2062	Cane Sugar Refining	9	0.232	0.88
2063	Beet Sugar	34	!0.506	3.15
2064	Candy, Other Confectionery Products & Chewing Gum	11	0.107*	6.81
2066	Chocolate and Cocoa Products	2	0.600*	27.85
2077	Animal and Marine Fats and Oil	18	0.017	0.21
2079	Shortening and Cooking Oils	28	!0.140	2.15
2082	Malt Beverages	7	0.275*	32.03
2084	Wines, Brandy, and Brandy Spirits	15	0.078*	10.87
2085	Distilled Liquor, Except Brandy	13	0.100	2.11
2086	Bottled and Canned Soft Drinks	27	!0.117*	73.08
2087	Flavoring Extracts and Syrups (NEC)	3	0.544*	108.96
2091	Canned and Cured Seafood	10	0.120*	18.40
2092	Fresh or Frozen Seafood	24	!0.050	0.66
2095	Roasted Coffee	30	!0.245	1.64
2097	Manufactured Ice	20	!0.026	0.40
2099	Food Preparations (NEC)	25	!0.096*	10.57
Summary Averages:				
	Low Concentration ($\bar{H}$ < 0.1), n ' 27	20	!0.050	
	Medium Concentration (0.1< $\bar{H}$ < 0.18), n ' 6	13.5	0.165	
	High Concentration ($\bar{H}$ > 0.18), n ' 2	4.5	0.438	
	All Industries, n ' 35	18	0.015	

Notes: An asterisk (*) denotes significance at the 1% level. The ranking of industries is based on the price elasticities of concentration from the highest (most positive = 1) to the lowest (most negative = 35); $g_{P,H}$ is the price elasticity of concentration; $g_{L,H}$ is the elasticity of market power; $g_{C,H}$ is the efficiency elasticity; and λ is the price-quantity adjustment. NEC denotes "not elsewhere classified."

Table 2. Extended

	Lerner Elasticity		Cost Elasticity		Adjustment Parameter	Herfindahl Index
SIC	$g_{L,H}$	χ^2	$g_{C,H}$	χ^2	λ	H
2011	0.095*	24.75	!0.140*	17.16	1.07	0.036
2013	0.071*	5.01	!0.037	1.53	1.02	0.017
2015	0.043*	15.69	!0.012	1.19	1.01	0.026
2021	0.008*	20.00	!0.271*	4.89	1.22	0.068
2022	0.126*	21.55	!0.049*	4.79	1.03	0.051
2023	0.190*	7.95	!0.093	2.50	1.04	0.048
2024	0.060	3.70	!0.152*	7.94	1.09	0.027
2026	0.032*	7.75	!0.192*	9.35	1.13	0.016
2032	0.494*	28.43	!0.214*	6.64	1.12	0.160
2033	0.329*	4.09	!0.366	3.54	1.05	0.024
2034	0.231*	3.92	0.082	1.03	0.98	0.054
2035	0.091*	4.16	!0.100*	9.28	1.12	0.090
2037	0.674*	23.03	!0.344*	6.81	1.03	0.031
2041	0.605*	10.73	!0.910*	38.00	1.18	0.060
2045	0.180*	12.38	!0.704*	62.76	1.91	0.090
2046	0.668	0.72	!0.060	0.02	1.02	0.163
2047	0.298*	14.06	!0.042	0.35	1.03	0.124
2048	0.139*	6.74	!0.172*	12.68	1.03	0.018
2061	0.351*	22.44	!0.643*	16.44	1.26	0.076
2062	0.462*	24.72	!0.260	0.68	1.15	0.057
2063	0.503*	35.47	!0.823*	29.73	1.58	0.145
2064	0.169*	23.18	!0.066	1.33	1.04	0.057
2066	0.665*	47.60	!0.094	0.27	1.05	0.207
2077	0.159	0.58	0.008	0.01	0.10	0.040
2079	0.384*	36.64	!0.507*	41.20	1.14	0.060
2082	0.236*	11.63	0.050	0.85	0.96	0.185
2084	0.168*	11.71	!0.095*	4.67	1.07	0.083
2085	0.034*	7.46	0.078	0.78	0.89	0.083
2086	0.116*	25.58	!0.225*	51.47	1.07	0.022
2087	0.328*	25.89	0.355*	23.05	0.80	0.162
2091	0.171*	8.69	!0.056	2.34	1.04	0.091
2092	0.209*	20.93	!0.258*	15.79	1.03	0.014
2095	1.056*	20.50	!1.210*	19.03	1.59	0.153
2097	0.022*	9.66	!0.047	1.49	1.05	0.018
2099	0.063*	20.03	!0.151*	28.02	1.09	0.025
Summary Averages:						
Low Concentration	0.192		!0.210		1.068	0.047
Med. Concentration	0.558		!0.332		1.190	0.151
High Concentration	0.451		!0.220		1.005	0.196
All Industries	0.269		!0.221		1.081	0.077

Table 2 presents the computed elasticities of price with respect to the Herfindahl index ($\eta_{P,H}$) as well as their components: market power elasticities ($\eta_{L,H}$), efficiency elasticities ($\eta_{MC,H}$), and quantity adjustment factors (λ). The average price elasticity with respect to concentration was positive and estimated at 0.070, indicating that, on average, greater concentration leads to a modest increase in output price. However, concentration leads to price declines in nearly 49% of the industries (17 of the 35 industries), in contrast to the findings of LAL, who observed price decreases in only 16% of the cases (5 of 32). Price-concentration elasticities range from −1.001 for blended and prepared flour (SIC 2045) to 0.600 for chocolate and cocoa products (SIC 2066).

The statistical tests to determine whether or not increases in concentration significantly affect price, while taking into account market power and efficiency effects, consisted of the following hypothesis testing using the Wald χ^2 statistic: $H_0: \eta_{P,H} = 0$ versus $H_1: \eta_{P,H} \neq 0$. The null hypothesis of no price effect was rejected in 20 industries (57%) at the 5% level of significance. Thus, concentration significantly affects output price in a majority of the industries. Furthermore, concentration would significantly decrease output price in seven industries ($H_1: \eta_{P,H} < 0$), or 20% of the industries studied. On the other hand, further concentration would result in a significant price increase ($H_1: \eta_{P,H} > 0$) in 37% of the industries analyzed. In 15 industries (43%), the net effect on price is not statistically significant at the 5% level.

Table 2 also shows that most U.S. food processing industries (27 of 35, or 77%) are in the "low concentration" category according to FTC (1997) guidelines. A smaller group (six, or 17%) is in the "moderate concentration" group. In fact, only two industries (SIC 2066, chocolate and cocoa products, and SIC 2082, malt beverages) are in the "high concentration" category at the four-digit SIC level.[11]

Note that for the "low concentration" industries, on average, concentration is benign to consumers as it generally decreases price while generating efficiencies. The "medium concentration" group produces medium increases in prices with stronger market power and efficiency effects than the "low concentration" group. The "high concentration" group (although only two food manufacturing industries fall in this category) produces the highest price increases relative to increases in concentration. These findings support the FTC guideline recommendations in not challenging mergers in low concentration markets but challenging those in the other two groups.

The average Lerner index elasticity for the entire sample was 0.269 (table 2). The elasticity ranged from 0.008 for creamery butter (SIC 2021) to 1.056 for roasted coffee (SIC 2095). The statistical tests to determine whether or not increases in concentration will increase price by enhancing market power consisted of the following

[11] The FTC will not challenge mergers in unconcentrated markets, where the post-merger H is below 0.10 (or 1.000 based on a maximum H of 10,000). In moderately concentrated markets, where the post-merger H is between 0.10 and 0.18, the agency will challenge mergers that have increased H by more than 0.01 (or 100 points based on 10,000). In highly concentrated markets, where post-merger H is above 0.18 and the merger increases H by more than 0.05, the agency will require further study. Also, note that the definition of a "market" is usually more detailed than the one considered in this study.

hypothesis testing using the Wald χ^2 statistic: H_0: $g_{L,H} = 0$ versus H_1: $g_{L,H} > 0$. The null hypothesis of no market power effect of concentration was rejected in 32 industries (94%) at the 5% level of significance. This result is not surprising, and confirms the traditional wisdom that greater concentration leads to higher prices, as found in market power studies.

The average marginal cost elasticity of concentration for the entire sample was estimated at ! 0.221. The elasticity ranged from ! 1.210 for roasted coffee (SIC 2095) to 0.355 for flavoring extracts and syrups (SIC 2087). The statistical tests to determine whether or not increases in concentration affect price via changes in marginal cost consisted of the following hypothesis testing, again using the Wald χ^2 statistic: H_0: $g_{C,H} = 0$ versus H_1: $g_{C,H}$ ... 0. The null hypothesis of no efficiency effect generally was rejected in 19 industries (54%) at the 5% level of significance. As confirmed by this result, concentration leads to efficiency effects in the U.S. food manufacturing industries. Given that concentration also leads to a significant market power effect in nearly 75% of the industries, the crucial question is which effect predominates.

Computed adjustment values were in accordance with cost elasticity or efficiency elasticity estimates—i.e., adjustments are greater than one for those industries with negative efficiency elasticity and lower than one for those with positive efficiency elasticity. The average factor adjustment value for the entire sample is slightly greater than one (1.081), ranging from 0.80 for flavoring extracts and syrups (SIC 2087) to 1.58 for beet sugar production (SIC 2063), indicating that output generally expands with concentration.

Concluding Remarks

U.S. food processing industries are increasingly becoming concentrated, raising questions as to the effects on market power, cost efficiency, and wholesale food prices. This study has analyzed the impact of concentration on output prices via concentration elasticities based on an econometric model of industry equilibrium applied to 35 food processing industries.

Empirical results show that, in most cases, increases in industrial concentration lead to cost efficiency due to widespread economies of size in the food processing industries. At the same time, they also lead to increases in market power. On balance, in nearly 50% of the industries, increases in concentration ultimately result in lower processed food product prices, although such a benign effect of concentration is statistically significant in only 20% of the industries analyzed. In 43% of the industries, the impact of concentration on output prices is not statistically discernable. However, in 37% of the industries, the effect of concentration on prices is positive and statistically significant, as conventionally expected. Overall, these results show a much more benign effect of concentration on wholesale food prices than those reported by Lopez, Azzam, and Lirón-España (2002), and the results are more consistent with the efficiency effects of concentration found in previous studies.

The results also reveal that, on average, increases in industrial concentration in low concentration markets lead to price declines. Fortunately, this is the case in over two-thirds of the industries analyzed. Quite the opposite is true for highly concentrated industries, where further increases in concentration lead to increases in prices. Thus, the results lend support to the Federal Trade Commission guidelines in terms of challenging mergers in moderately and highly concentrated markets. These levels of concentration, however, exist only in a handful of the food processing industries, such as wet corn milling, chocolate and cocoa products, and malt beverages.

Extending the current research through models that explicitly consider product differentiation, product variety, or through use of firm- or brand-specific data in more refined market definitions could prove a fruitful area of further inquiry, given the nature of processed food products. Another interesting avenue of research is the simultaneous consideration of technological change or innovation and concentration, invoking the dynamic effects of concentration advocated by Schumpeter more than 50 years ago. This may be accomplished by extending the current model so that concentration interacts with technological change, or through an additional equation explaining concentration in terms of productivity or technological change.

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