

Welfare Losses Under Alternative Oligopoly Regimes: The U.S. Food and Tobacco Manufacturing Industries

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Abstract

This article systematically estimates the allocative efficiency losses in the U.S. food and tobacco manufacturing industries under alternative oligopoly pricing regimes using a formal model of oligopoly. Using 1987 data for 44 industries and an industry-wide oligopoly pricing scheme, these losses were estimated at approximately 3% of sales--2% in the food industries and 19% in the tobacco industries. Five additional oligopoly pricing regimes, four of which are price leaderships, are simulated and their results compared and tested relative to the industry-wide pricing regime. Findings underscore the importance of cost structure assumptions and that the impact of the type of oligopoly behavior assumed is not as dramatic when differences in demand and cost specifications are smoothed out.

Key Words: food and tobacco industries, market power, oligopoly regimes, welfare loss.

Introduction

Accurate estimation of allocative efficiency losses due to oligopolistic behavior is crucial because the allocation of antitrust enforcement efforts is closely related to such estimates (Preston and Connor, 1992). Consequently, there is a vast amount of literature measuring welfare losses due to oligopoly power in the U.S. manufacturing sector; however, there are often contradictory findings regarding the magnitude of these losses. For example, Siegfried and Tiemann (1974) concluded that welfare losses in the U.S. manufacturing sector were negligible, while Cowling and Mueller (1978) arrived at much larger estimates for the sector. Such contradictory findings are also common in the U.S. food and tobacco manufacturing sector.

Differences in production, demand, and pricing behavior assumptions used in this literature have led to quite divergent allocative efficiency results for the U.S. food manufacturing industries. Gisser (1982) estimates oligopoly welfare losses to be well below one percent of industry sales and thus opposes government intervention, while Willner (1989) estimates these losses to exceed five percent of sales, questioning the performance of these industries. More recently, Bhuyan and Lopez (1993) and Connor and Peterson (1994) presented additional estimates of the oligopoly welfare losses in the U.S. food processing sector and found a wide spectrum of estimates for the same industries. For example, according to the simulation results of Connor and Peterson, the welfare loss estimates in the food industry (SIC 20) ranged from 0.2 percent

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to an impossibly high of 289 percent of sales. In spite of the apparent contradictions in empirical evidence, the current literature lacks a consistent comparison of welfare losses due to alternative oligopoly pricing regimes while smoothing out the differences due to demand and cost specification assumptions.

The objective of this article is to systematically estimate allocative efficiency losses in the U.S. food and tobacco manufacturing industries under alternative oligopoly pricing regimes stemming from the same model.¹ This is necessary in order to focus on the impact of such pricing behavior on welfare loss by overcoming a common drawback of the current literature - comparing estimates of welfare losses derived from different models with dissimilar demand and marginal cost specifications (e.g., Gisser, 1982 vs. Willner, 1989; Connor and Peterson, 1994). This is important because, beyond a pedagogical interest, antitrust policy debates are often based on estimates of oligopoly welfare losses which are subject to the researcher's discretion in adopting model assumptions. Therefore, using the same core model to explore the sensitivity of welfare loss estimates to alternative market and cost structure assumptions is timely.

The estimates of this study are derived from a formal model of oligopoly that relies on a built-in collusion parameter as well as explicit demand and marginal cost elasticities. The baseline scenario consists of industry-wide oligopoly pricing where every firm in the industry uses the same pricing rule (Willner and Ståhl, 1992). This is extended to accommodate price leadership regimes. Six alternative pricing behaviors are empirically implemented: the baseline scenario (which uses a collusion parameter computed from data), industry-wide Cournot behavior, and four price leadership scenarios corresponding to Cournot and perfectly collusive versions of Gisser's (1982) and Willner's (1989) pricing behaviors. Data for 44 food and tobacco manufacturing industries at the four-digit SIC level for 1987, the most recently available, are applied to the models.

Statistical tests of the differences of the means of the welfare losses reject industry-wide Cournot and Willner's collusive price leadership regimes. It is concluded that although much of the

debate on welfare losses in the food and tobacco manufacturing has been focused on whose estimates are right, many of the results do not differ greatly when the type of pricing behavior is taken into account, *ceteris paribus*. The results also underscore the importance of cost structure assumptions.

The Model

The basic oligopoly model draws from the work of Dickson and Yu (1989) which is then extended to the price leadership case. For numerical convenience, both the perfectly competitive output and price are indexed to 1. The industry demand curve is represented by $Q = 1/P^\eta$; $\eta > 0$ where Q , P and η are industry output, output price and absolute value of the price elasticity of demand, respectively. The industry marginal cost (MC) curve is denoted by $Q = MC^\epsilon$, where ϵ is the marginal cost flexibility.² Following Clarke and Davies (1982), the Lerner index of oligopoly power (\mathcal{L}) is given by

$$\mathcal{L} = \frac{P_o - MC_o}{P_o} = \frac{H + \alpha(1-H)}{\eta} \tag{1}$$

where P_o , MC_o , H , and α are oligopoly price, oligopoly marginal cost, the Herfindahl index and the collusion parameter. The collusion parameter denotes the proportional change in the output of rivals in response to a proportional change in a firm's output. In other words, α represents the degree of industry-wide collusion, where Cournot and perfectly collusive behavior are given by $\alpha = 0$ and $\alpha = 1$, respectively. Note that if the industry is perfectly competitive ($\mathcal{L} = 0$), then $\alpha = -H/(1-H) < 0$.³

Using the industry marginal cost curve and (1), the oligopoly price can be expressed as

$$P_o = \frac{\eta Q_o^{\frac{1}{\epsilon}}}{\eta - [H + \alpha(1-H)]} \tag{2}$$

where Q_o is oligopoly output. Substituting for P_o in the market demand curve yields

$$Q_o = \frac{1}{P_o^\eta} = \left(\frac{\eta - [H + \alpha(1-H)]}{\eta} \right)^{\frac{\eta\epsilon}{\eta - \epsilon}} \tag{3}$$

A Harberger (1954) index of welfare loss⁴ (*WL*) can then be expressed as

$$WL = \int_{Q_0}^1 \left((1/Q)^{\frac{1}{\eta}} - Q^{-\frac{1}{\varepsilon}} \right) dQ. \tag{4}$$

To extend the basic model to the price leadership case, consider the case where a subset of *n* firms behave as price leaders.⁵ The corresponding Lerner index for the group of leaders (\hat{Q}^n) can be expressed as $\hat{Q}^n = [H^n + \alpha^n(1 - H^n)]/\eta_D$, where η_D is the elasticity of the residual demand faced by the leaders, and other notation is as defined before but superscripted with *n*. If the leaders behave as a Cournot oligopoly among themselves then $\alpha^n = 0$, and if they collude then $\alpha^n = 1$. Following Carlton and Perloff (1990), the leaders' residual demand elasticity can be expressed as $\eta_D = [\eta + \theta(1 - CRn)]/CRn$, where *CRn* is the sales share of the leaders or *n*-firm sales concentration ratio and θ is the fringe firms' supply elasticity.

Using the previous procedure, the oligopoly price set by the leaders is given by

$$P_o = \frac{\eta_D Q_0^{1/\varepsilon}}{\eta_D - [H^n + \alpha^n(1 - H^n)]}. \tag{5}$$

The resultant oligopoly output is

$$Q_o = \left(\frac{\eta_D - [H^n + \alpha^n(1 - H^n)]}{\eta_D} \right)^{\frac{\eta\varepsilon}{\eta + \varepsilon}} \tag{6}$$

As before, Q_o is then used in equation (4) in order to compute an index of welfare loss for a given industry. Note that in both cases, the actual dollar value of the welfare losses divided by observed sales is equivalent to the indexed welfare losses (*WL*) divided by the indexed sales ($P_o Q_o$). Hence, the actual dollar value of the deadweight loss is given by $WL * S / P_o Q_o$, where *S* is the observed dollar sales.

Consider the implications of Gisser's (1982) marginal cost assumptions for the leaders and fringe firms ($\varepsilon = \theta = 1$) vis-à-vis Willner's (1989) assumptions $\varepsilon = \infty, \theta = 0$. From (6), it is clear that Gisser assumes the residual demand faced by the

leaders to be more price elastic than in Willner's model. Thus, Gisser's model is less restrictive than Willner's under any given collusion parameter in terms of obtaining positive prices and quantity by using (5) and (6), since both require η_D to exceed H^n for the Cournot case and to exceed 1 for the collusive price leadership case. This is especially critical since food industry demands are generally price inelastic. Likewise, Gisser's model is also bound to yield lower estimates of welfare losses merely due to his marginal cost assumptions which imply a higher price elasticity of demand facing the leaders (for the same industry demand) as well as the fringe firms' ability to respond to the leaders' prices in the short run.

Data and Estimation Procedures

Based on equation (4), the computation of welfare losses using the industry-wide oligopoly model requires data on η , ε , *H*, α as well as dollar sales per industry. Data for these variables were collected for 44 industries at the 4-digit SIC level for 1987, the most recent year available. The estimates of industry demand elasticity (η) were taken from Pagoulatos and Sorensen (1986).⁶ The values of *H* and dollar sales were taken from the 1987 Census of Manufacturers. Due to lack of data, the marginal cost flexibility parameter (ε) was assumed to be equal to infinity across industries (i.e., constant marginal cost), for the industry-wide oligopoly cases. Using (1), the parameter α was estimated by $\hat{\alpha} = (\hat{Q} \eta - H)/(1 - H)$, where \hat{Q} is the computed Lerner index.

As in Domowitz, Hubbard, and Peterson (1986), the Lerner index was computed by $\hat{Q} = [S + \Delta I - (W + M + rA)] / (S + \Delta I)$, where *S* is dollar sales, ΔI is the change in inventories, *W* and *M* are the cost of labor and materials, respectively, *r* is the rate of discount, and *A* is the value of fixed assets.⁷ The above index is corrected for the opportunity cost of capital by introducing *rA*. Based on previous estimates, it was assumed that $r = 0.084$ (Atlas, 1994). Data on the value of fixed assets are obtained from the 1987 Census of Manufacturers. The above data were applied to equation (4) in order to compute the oligopoly welfare losses for all food and tobacco manufacturing industries, here after called the *baseline* scenario.

Five additional scenarios were simulated corresponding to industry-wide Cournot behavior as well as Gisser's and Willner's price leadership under Cournot and perfectly collusive regimes.⁸ Note that Gisser's (1982) analysis was conducted for the food industries as a whole (SIC=20) and that he did not consider the Cournot pricing scheme. For these price leadership regimes, two combinations of leaders' marginal cost flexibilities and fringe firm supply elasticities are used, corresponding to Gisser's and Willner's assumptions. Assuming that the largest four firms are the industry leaders (n_4) and that each of these firms has one-quarter of the total leading four-firm sales share, then $H^m = H^f = 0.25$ and $CR_n = CR_4$. These assumptions are made due to lack of data and for simplicity. The results are presented below.

Welfare Loss Estimates

The results for the six oligopoly pricing regimes for the food and tobacco industries at the 4-digit SIC level are presented in Table 1.⁹ The results for these industries at the 2-digit SIC level were also computed by using the weighted averages of the 4-digit level estimates, using their dollar sales as weights.¹⁰

For consistency, the baseline scenario is a maintained hypothesis throughout the analysis even though no standard errors can be attached to its results. That is, the baseline results are treated as factual and its underlying assumptions (e.g., elasticities of demand and cost) are assumed to remain constant when α changes. Thus, the simulation of the core model using different behavioral assumptions should be regarded as counterfactual experiments, i.e., how would welfare losses change in comparison to the baseline estimates if a different value of the collusion parameter is used.

The baseline results suggest that the total estimated dollar value of welfare losses in these industries was over \$10.13 billion in 1987, which corresponds to approximately 3% of total value of sales. The welfare losses in the food industries (SIC 20) amounted to approximately \$6.34 billion or approximately 2% of sales. The aggregate welfare losses in the tobacco industries (SIC 21) were estimated at \$3.94 billion or approximately

19% of sales. At the 4-digit SIC level, the estimated losses ranged from 0.14 percent of sales in the meat packing industry to over 21% of sales in the cigarette manufacturing industry.

In terms of the baseline results, the following industries show significantly higher welfare losses compared to either the food or the tobacco industry average: SICs 2021 (creamery butter), 2043 (cereal preparation), 2082 (malt beverages), 2099 (miscellaneous foods), 2121 (cigarettes), and 2131 (chewing and smoking tobacco). Perhaps not surprisingly, most of these six industries have been the focus of various market power or antitrust related studies.

Simulating an industry-wide Cournot assumption generally resulted in lower welfare losses than the baseline results. For example, the overall welfare losses were estimated at approximately 1% of 1987 sales for the food industries, 7% for tobacco manufacturers, and 1.44% for the overall sample (c.f., 3% in the baseline results). For seven industries, the Cournot assumption did not yield positive prices and quantity because the industry demand elasticity did not exceed the Herfindahl index. This, of course, does not mean that the Cournot assumption is not justifiable for these industries, but rather that the assumption does not suit the model and the data for these seven industries.

As expected, simulation of Gisser's Cournot and collusive price leadership models yielded lower welfare losses than Willner's results for the same type of price leadership behavior. For instance, the Gisser-Cournot regime yields an overall welfare loss at approximately 0.71% of 1987 sales while the corresponding Willner-Cournot regime estimate is approximately 1.99% of sales. For the collusive price leadership scenarios, Gisser's regime yields welfare losses at approximately 6.59% of sales while Willner's regime yields an estimate of approximately 14% of sales. The difference between Gisser's and Willner's welfare loss estimates underscores the importance of marginal cost assumptions. Although the cost assumptions in Willner's model may be more representative of the technological differences between the leaders and fringe firms,¹¹ his model yielded economically meaningful solutions for far fewer scenarios: 38 for

Table 1. Welfare Losses under Alternative Oligopoly Regimes in the U.S. Food and Tobacco Manufacturing Industries, 1987

SIC	Industry	Baseline	Cournot	Cournot Price Leadership		Collusive Price Leadership	
				Gisser	Willner	Gisser	Willner
Percent of 1987 Sales							
2011	Meat Packing	0.144	0.119	0.073	0.499	1.292	10.051
2013	Saus. & Prep Meat	0.893	0.039	0.069	0.545	0.779	6.802
2016	Poultry & Egg Pr.	0.493	0.148	0.068	0.611	1.002	10.719
2021	Creamery Butter	9.405	0.350	0.421	2.748	2.492	19.154
2022	Cheese	0.633	0.553	0.175	1.136	3.306	28.602
2023	Cond. & Evap. Milk	1.578	0.940	0.240	3.410	4.483	—
2024	Ice Cream	4.354	0.113	0.084	1.226	0.760	14.337
2026	Fluid Milk	0.258	0.116	0.024	0.973	0.387	—
2032	Canned Specialties	0.533	—	0.083	—	—	—
2033	Canned Fr. & Veg.	1.537	0.209	0.076	1.793	1.043	—
2034	Dried Fr. & Veg.	1.716	0.945	0.145	3.306	2.546	—
2035	Pickled Sauces	2.151	1.322	0.203	3.582	3.714	—
2037	Frozen F&V & Juice	1.145	0.463	0.135	2.450	2.233	—
2041	Flour & Grain Milk	2.416	0.533	0.296	2.519	4.000	—
2043	Cereal Preparation	12.371	7.974	4.238	1.188	—	—
2044	Rice Milling	0.986	2.354	0.359	4.021	12.134	—
2046	Wet Corn Milling	0.290	—	0.223	—	—	—
2047	Pet Food	0.684	—	0.111	—	—	—
2048	Prepared Feeds	0.345	0.047	0.029	0.515	0.422	9.507
2051	Bread & Bakery	2.386	1.117	0.182	3.648	3.086	—
2061	Refined Sugar	0.580	3.360	0.249	1.105	16.317	—
2065	Candy & Confec.	0.594	—	0.084	—	2.651	—
2066	Chocol. & Cocoa.	2.400	7.863	0.548	3.241	—	—
2067	Chewing Gum	3.633	—	0.973	1.738	—	—
2074	Cottonseed O. M.	0.477	0.669	0.172	1.459	3.699	—
2075	Soybean O. M.	0.228	4.788	0.316	1.453	—	—
2076	Vegetable O. M.	0.458	2.558	0.354	1.161	26.974	—
2077	Anim. & Mar. Fat	1.086	0.573	0.114	1.829	1.912	—
2079	Lard & Cook. Oil	0.694	1.172	0.190	2.825	4.462	—
2082	Malt Beverages	7.918	4.032	2.482	6.273	58.242	—
2084	Wine & Brandy Sp.	3.851	0.296	0.228	1.403	1.832	12.790
2085	Distilled Liquor	7.103	0.857	0.758	4.779	7.428	—
2086	Soft Drinks	2.864	0.081	0.134	0.953	1.091	8.659
2087	Fla. Extr. & Syr.	0.219	—	0.005	—	—	—
2091	Can. & Cured Sea.	1.873	0.072	0.082	0.590	0.740	5.841
2092	Fresh Fish Proc.	1.177	0.021	0.032	0.266	0.312	2.746
2095	Roasted Coffee	5.187	2.015	0.987	3.907	13.927	87.370
2097	Manufactured Ice	0.216	0.314	0.005	—	0.081	—
2098	Macaroni & Spagh.	1.004	—	0.280	6.137	—	—
2099	Misc. Food	7.138	0.044	0.136	1.154	—	7.537
2111	Cigarettes	21.566	7.731	7.351	5.619	21.507	—
2121	Cigars	5.743	1.824	1.530	5.240	—	133.179
2131	Chew. & Smok. Tob.	19.040	9.274	3.773	9.948	—	—
2141	Tobacco Stemming	0.078	1.609	0.254	1.020	16.554	—
20	All Food	2.087	1.051	0.342	1.745	5.514	13.907
21	All Tobacco	19.132	7.146	6.395	5.387	20.978	133.18
20-21	All food & tobacco	3.135	1.437	0.714	1.991	6.587	14.051

Note: Percent welfare losses at the two-digit level are weighted averages of the respective industries using industry sales as weights.

the quantity-setting Cournot behavior (c.f., 44 under Gisser's model) and 14 for the collusive leadership (c.f., 32 under Gisser's model). This illustrates the restrictiveness of Willner's marginal cost assumptions and perhaps the limited applicability of his pricing regimes to most food and tobacco industries. To further assess the differences among the welfare loss estimates, t-tests were conducted to ascertain whether the weighted means of the welfare losses estimated under the five simulated alternative scenarios were significantly different from the weighted mean welfare losses of the baseline

estimates using matched samples.¹² Of the five resultant tests, only the means from Gisser's collusive price leadership results ($t=1.98$ for $N=32$) and Willner's Cournot results ($t=1.78$ for $N=32$) were not statistically different from the baseline means at the 5% level. The null hypotheses that the means of the remaining three scenarios were not different from the mean of the baseline estimates were rejected at the 5% level of significance. Further t-tests revealed that the means of the four price leadership regimes were all significantly different from each other at the 5% level. In sum,

we failed to reject the hypothesis that the simulated Gisser-collusion and Willner-Cournot results are significantly different from our baseline results. However, our results significantly differ from the industry-wide Cournot results as well as from the Willner's collusive price leadership results.

It should be noted that except for the baseline scenario, the other five oligopoly pricing schemes are calibrated with external assumptions about key parameters such as the collusion parameter. Such calibration/simulation was necessary due to the lack of econometrically estimated equivalent parameters. For improved estimation of allocative efficiency losses, statistical estimates of the cost and demand structure parameters will be required instead of the current practice of arbitrarily assuming their values, particularly for cost parameters.

Concluding Remarks

Based on the baseline scenario which uses collusion parameters computed from data, allocative efficiency losses from industry-wide oligopoly pricing in the U.S. food and tobacco manufacturing industries are estimated at approximately 3% of sales in 1987. In terms of the food industries alone, the estimated losses amount to slightly over 2% of sales. The estimated welfare losses for the tobacco manufacturing industries, on the other hand, amount to 19% of their value of shipments. Over the 44 four-digit SIC level industries, these losses ranged from 0.14 percent of sales in the meat packing industry to 21.56% of sales in the cigarette manufacturing industry.

Compared to the baseline estimates, simulating an industry-wide Cournot behavior assumption led to lower welfare loss estimates, while collusive price leadership regimes showed substantially higher losses. Moreover, a comparison of the baseline welfare loss estimates with the five simulated alternative oligopoly pricing schemes showed that the industry-wide Cournot and Willner's collusive price leadership behavior may be unlikely. However, we failed to reject the hypothesis that the Gisser-collusion and the Willner-Cournot results are significantly different from our baseline results. Overall, comparison of simulated alternative oligopoly pricing schemes underscores the importance of behavioral and cost structure assumptions in determining the magnitude of allocative efficiency losses.

Some limitations of the analysis may be important. Like other similar studies, the current welfare loss estimates are subject to the functional forms assumed for cost and demand. In this regard, Shapiro (1989), Willner and Ståhl (1992), and Connor and Peterson (1994) indicate that the outcome of oligopolistic interactions is very sensitive to the underlying model and, in particular, to the functional form of demand. In addition to the static nature of the results, another limitation is the exclusion of possible market failures, such as the externality (health) costs of cigarette and alcohol consumption, since oligopoly price increases may be welfare enhancing by partially internalizing those costs. Finally, like many other industries, the food and tobacco manufacturing industries are increasingly becoming global in nature, advocating a model with open trade.

References

- Appelbaum, Elie. "Estimation of the Degree of Oligopoly Power." *Journal of Econometrics*, 19 (1982):287-299.
- Atlas, Riva. "Food, Drink, and Tobacco." *Forbes*, Industry Analysis section, pp. 152-154, January 3, 1994.
- Azzam, Azzedine and Emilio Pagoulatos. "Testing Oligopolistic and Oligopsonistic Behavior: An Application for the U.S. Meat-Packing Industry." *Journal of Agricultural Economics*, 41 (1990): 362-370.

- Bhuyan, Sanjib and Rigoberto A. Lopez. "Oligopoly Welfare Losses in U.S. Food Manufacturing." Selected paper, American Agricultural Economics Association Meetings, Orlando, Florida, August 1993.
- Carlton, Dennis W. and Jeffrey Perloff. *Modern Industrial Organization*. Glenview, IL: Scott, Foresman/Little Brown Higher Education, 1990.
- Clarke, R. and S.W. Davies. "Market Structure and Price-cost Margins." *Economica*, 49 (1982):277-287.
- Collins, N. R. and L. E. Preston. "Price-cost Margins and Industry Structure." *Review of Economics and Statistics*, 51 (1969):271-286.
- Connor, John M. and Everett B. Peterson. *New Estimates of Welfare and Consumer Losses in U.S. Food Manufacturing*. NE-165 Working Paper WP-39, April 1994.
- Cowling, K. and D. C. Mueller. "The Social Costs of Monopoly Power." *Economic Journal*, 88 (1978):727-748.
- Demsetz, Harrold. "Industry structure, Market rivalry, and Public policy." *Journal of Law and Economics*, 16,1 (1973):1-9.
- Dickson, V.A., and Weiqiu Yu. "Welfare Losses in Canadian Manufacturing Under Alternative Oligopoly Regimes." *International Journal of Industrial Organization*, 7 (1989):257-267.
- Domowitz, Ian, R. G. Hubbard, and B. C. Peterson. "Business Cycles and the Relationship between Concentration and Price-cost Margins." *Rand Journal of Economics*, 17, 1 (1986):1-17.
- Ferguson, C. E. *The Neoclassical Theory of Production and Distribution*, London: University Press, 1979.
- Gisser, Micha. "Welfare Implications of Oligopoly in U.S. Food Manufacturing." *American Journal of Agricultural Economics*, 64 (1982):616-624.
- "Price leadership and Welfare losses in U.S. Manufacturing." *American Economic Review*, 76 (1986):756-67.
- Gould, Brian W., Thomas L. Cox, and Frederico Perali. "Demand for Food Fats and Oils: The Role of Demographic Variables and Government Donations." *American Journal of Agricultural Economics*, 73 (1991):212-221.
- Harberger, Arnold C. "Monopoly and Resource Allocation." *American Economic Review*, 44,2 (1954):77-87.
- Heien, Dale and Greg Pompelli. "The Demand for Alcoholic Beverages: Economic and Demographic Effects." *Southern Economic Journal*, 55(1989): 759-770.
- Martin, Stephen. *Industrial Economics: Economic Analysis and Public Policy*. New York, NY: McMillan, 1989.
- Neter, John, William Wasserman, and G.A. Whitmore. *Applied Statistics*. Boston, MA: Allyn and Bacon, 1993.

- Pagoulatos, Emilio and Robert Sorensen. "What Determines the Elasticity of Industry Demand?" *International Journal of Industrial Organization*, 3,4(1986):237-250.
- Preston, Warren P. and John M. Connor. "An Economic evaluation of Federal Antitrust Activity in the Manufacturing Industries." *Antitrust Bulletin*, Winter (1992):969-996.
- Scherer, F. M. and David Ross. *Industrial Market Structure and Economic Performance*. 3rd ed., Boston, MA: Houghton Mifflin, 1990.
- Schroeter, John R. "Estimating the degree of Market Power in the Beef-Packing Industry." *Review of Economics and Statistics*, 70(1988): 158-162.
- Shapiro, Carl. "Theories of Oligopoly Behavior." in *Handbook of Industrial Organization*, ed., R. Schmalensee and R. D. Willig, Amsterdam: Elsevier, 1989.
- Siegfried, J. J. and T. Tiemann. "The Welfare Cost of Monopoly: An Inter-industry Analysis." *Economic Inquiry*, 12 (1974):190-202.
- Tullock, Gordon. "The Welfare Cost of Tariffs, Monopolies, and Theft." *Western Economic Journal*, 5 (1967):224-232.
- Willner, Johan. "Price Leadership and Welfare Losses in US Manufacturing: Comment." *American Economic Review*, 7,3(1989):604-613.
- Willner, Johan and Leila Ståhl. "Where are the Welfare Losses of Imperfect Competition Large?" *European Journal of Political Economy* 8(1992): 477-491.
- U.S. Department of Commerce, Bureau of Census. *1987 Census of Manufactures: General Summary*, Washington, D.C., 1991.

DATA APPENDIX

SIC	Industry	Collusion para. (α)	Conj. var. clas. (β)	Elas. of dem. (η)	Herf. index (H)	Conc. ratio (CR4)	Sales (mil. \$)
2011	Meat Packing	0.004	0.044	0.703	0.040	0.320	44,991
2013	Saus. & Prep Meat	0.082	0.103	0.648	0.022	0.260	16,623
2016	Poultry & Egg Pr	0.032	0.069	0.521	0.038	0.280	14,912
2021	Creamery Butter	0.252	0.302	0.662	0.066	0.400	1,420
2022	Cheese	0.006	0.083	0.585	0.077	0.430	12,948
2023	Cond. & Evap. Milk	0.019	0.084	0.262	0.066	0.450	5,857
2024	Ice Cream	0.130	0.154	0.349	0.028	0.250	3,915
2026	Fluid Milk	0.009	0.029	0.172	0.019	0.210	20,591
2032	Canned Specialties	-0.160	0.024	0.064	0.159	0.590	5,350
2033	Canned Fruit & Veg	0.049	0.077	0.229	0.030	0.290	11,890
2034	Dried Fruit & Veg	0.020	0.077	0.207	0.059	0.390	1,820
2035	Pickled Sauces	0.019	0.091	0.232	0.073	0.430	5,050
2037	Frozen F&V & Juice	0.026	0.070	0.247	0.046	0.370	6,606
2041	Flour & Grain Mill	0.071	0.131	0.420	0.064	0.440	2,067
2043	Cereal Preparation	0.054	0.263	0.420	0.221	0.870	6,557
2044	Rice Milling	-0.036	0.066	0.251	0.099	0.560	1,235
2046	Wet Corn Milling	-0.176	0.017	0.054	0.164	0.740	4,789
2047	Pet Food	-0.147	0.026	0.061	0.151	0.610	5,639
2048	Prepared Feeds	0.028	0.045	0.310	0.017	0.200	10,899
2051	Bread & Bakery	0.029	0.093	0.220	0.066	0.410	22,511
2061	Refined Sugar	-0.118	0.076	0.540	0.173	0.640	5,531
2065	Candy & Confectionery	-0.053	0.027	0.074	0.076	0.450	9,158
2066	Chocolate & Cocoa Pr.	-0.090	0.110	0.304	0.183	0.690	2,960
2067	Chewing Gum	-0.231	0.102	0.187	0.270	0.960	1,090
2074	Cottonseed Oil Mills	-0.012	0.061	0.420	0.072	0.430	471
2075	Soybean Oil Mills	-0.151	0.040	0.370	0.166	0.710	9,074
2076	Vegetable Oil Mills	-0.117	0.077	0.690	0.174	0.740	432
2077	Anim. & Marine Fats	0.020	0.073	0.277	0.054	0.350	1,763
2079	Lard & Cooking Oil	-0.017	0.056	0.250	0.072	0.450	4,151
2082	Malt Beverages	0.107	0.317	0.840	0.236	0.870	14,150
2084	Wine & Brandy Sp.	0.166	0.221	0.768	0.066	0.370	3,179
2085	Distilled Liquor	0.157	0.231	0.500	0.088	0.530	3,411
2086	Soft Drinks	0.156	0.184	0.700	0.033	0.300	22,006
2087	Flavor Extr. & Syrups	-0.249	0.005	0.008	0.203	0.650	4,646
2091	Canned & Cured Seafood	0.127	0.155	0.736	0.032	0.260	767
2092	Fresh Fish Proc.	0.106	0.121	0.695	0.017	0.180	5,752
2095	Roasted Coffee	0.101	0.244	0.720	0.159	0.660	6,401
2097	Manufactured Ice	-0.002	0.011	0.030	0.013	0.190	290
2098	Macaroni & Spaghetti	-0.175	0.041	0.102	0.184	0.730	1,315
2099	Miscellaneous Food	0.237	0.254	0.596	0.023	0.260	14,627
2111	Cigarettes	0.184	0.403	0.619	0.268	0.920	17,372
2121	Cigars	0.126	0.262	0.756	0.155	0.730	192
2131	Chew. & Smok. Tobacco	0.134	0.385	0.619	0.289	0.850	1,114
2141	Tobacco Stemming	-0.117	0.031	0.619	0.133	0.660	2,079
20	All food*	0.030	0.104	0.454	0.074	0.410	316,840
21	All tobacco*	0.150	0.363	0.620	0.255	0.888	20,758
20-21	All food & tobacco*	0.037	0.120	0.464	0.085	0.439	337,598

Note: * = Column values for α , β , η , H, and CR4 are weighted averages using respective sector sales as weights.

Endnotes

1. Economic efficiency encompasses both allocative and technical efficiency. In a dynamic context, productivity gains may accrue due to supranormal profits from market power, in consonance with the Schumpeterian hypothesis. The Demsetz critique states that a price-cost margin may reflect lower marginal costs rather than higher prices due to a greater efficiency by the monopolist (Demsetz, 1973). Of course, there are also plenty of studies that refute the above arguments. In the food industries, only the work of Gisser (1982) incorporates productivity gains.
2. Technically speaking, the *MC* elasticity is the inverse of ε , i.e., the percent change in *MC* given a one percent change in output (see for example, Ferguson, 1979, p. 159). Many studies of oligopoly welfare losses denote ε as the marginal cost elasticity. Under competitive conditions, ε denotes the price elasticity of supply.
3. It is instructive to compare Appelbaum's (1982) conjectural variations elasticity and Clarke and Davis' (1982) collusion parameter. It can be easily shown that, by using the Clarke and Davis parameter (α), the conjectural variations elasticity of firm *i* can be expressed as $\beta_i = s_i + \alpha(1 - s_i)$, where β_i = conjectural variation elasticity of firm *i* and s_i = market share of firm *i*. The weighted average of β_i for *N* firms (using s_i as weights) can be expressed by $\bar{\beta} = H + \alpha(1 - H)$, which is the numerator of equation (1).
4. The Harberger loss represents the social value of output not produced due to monopoly or oligopoly power. There is abundant evidence that Harberger losses underestimate the true welfare losses because they exclude wasteful, rent seeking activities such as lobbying (Tullock, 1967). In a dynamic context, if productivity or efficiency gains occur as a consequence of market power, such gains may offset static deadweight losses (Gisser, 1982). Thus, there is possibility that Harberger or deadweight losses may overestimate the social cost of oligopoly power in a static model. It is beyond the scope of this article to correctly calculate this augmented social costs or to estimate possible welfare gains from induced technological innovations.
5. Census data (e.g., four-firm concentration relative to sales in the data appendix) and previous studies (e.g., Gisser, 1986) suggest that price leadership behavior is possible in many industries which consist of a few large firms and competitive fringe firms. The dominant firms may ignore the pricing behavior of the rest of the leaders (assuming more than one leader), i.e., Cournot condition, or collude among themselves. These two extreme behavioral assumptions provide convenient points of reference for the analysis presented here.
6. For SICs 2048, 2074, 2076, 2084, and 2086, the elasticities reported by Heien and Pompelli (1989) and Gould, Cox, and Perali (1991) were used because of the low statistical significance of the corresponding demand elasticities estimated by Pagoulatos and Sorensen (1986) for those industries.
7. Economists often use aggregate data to construct a measure of the Lerner index known as price-cost margin (PCM) which is commonly defined as $PCM = (sales - cost\ of\ labor - cost\ of\ materials) / sales$ following Collins and Preston (1969). Domowitz, Hubbard, and Petersen (1986) included the change in inventories (ΔI) in the traditional PCM definition to reduce the difference between the value of sales and the value of output. Scherer and Ross (1990) suggest that in order to use the PCM as a close proxy for the Lerner index, researchers should include some measure of capital cost. The definition of Lerner index used in this study is a modified PCM measure that reduces the difference between the value of sales and the value of output as well as includes an opportunity cost of capital.

8. Clearly the model is not applicable to simulate industry-wide perfect collusion ($\alpha = 1$) since industry demand is price inelastic throughout. Likewise, the model to simulate perfect collusion for price leaders ($\alpha^n=1$) is applicable only if the *residual* demand is price elastic. Linear demand curves would provide mathematical solutions for this type of collusion but they usually lead to abnormally high welfare losses (see for example Connor and Peterson's (1994) results).

9. Note that five four-digit SIC categories were merged: (i) poultry and egg processing (SIC=2016 & 2017); (ii) frozen fruit and vegetables and juices (2037 & 2038); (iii) flour and grain milling (2041 & 2045); (iv) bread and bakery (2051, 2052 & 2053); and (v) sugar (2061, 2062 & 2063).

10. Note that the computed collusion parameter ($\hat{\alpha}$) and the estimated weighted conjectural variation elasticity ($\hat{\beta}$) appear to provide a reasonable indication of the degree of collusion in the U.S. food and tobacco manufacturing industries. Appelbaum (1982) estimated the conjectural variation elasticity for the tobacco industry for 1947-1971 at $\hat{\beta}=0.40$, on average, which is close to the ($\hat{\beta}=0.363$) presented in the data appendix. Azzam and Pagoulatos (1990) estimated $\hat{\beta}$ for the meat packing industry at 0.223 while Schroeter (1988) estimated $\hat{\beta}=0.025$ for the beef-packing industry. Our estimate of $\hat{\beta}=0.044$ for the meat-packing industry falls within the range of these two results.

11. Gisser's (1986) assumption that both the leaders and fringe firms have the same supply elasticity implies that both groups of firms have more or less identical technologies which makes it unlikely that a few of them will assume the role of active leaders. Willner (1989) assumed inelastic supply for fringe firms while the leaders' supply was perfectly elastic, i.e., there were technological differences between the leaders and the rival fringe firms.

12. A comparative study of difference of means of two populations is undertaken to test whether they are significantly different from each other (Neter, Wasserman, and Whitmore, 1993, chapter 14). For our purpose, because all the estimates presented in Table 1 came from the same population, a matched sample test procedure is applied and industry sales weighted means were used. Tests using unweighted means or the dollar welfare losses led to very similar results as those reported for the weighted means.