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Deadweight Loss in Oligopoly: A New Approach*

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I. Introduction

Ever since Harberger's [18] pioneering article, researchers have attempted to estimate the welfare loss resulting from the exercise of market power. Despite nearly four decades of work in this area, however, surprisingly few researchers disagree with Harberger's finding that deadweight loss is quite small. While many dispute his claim that deadweight loss in manufacturing amounts to only about 0.1% of GNP, few estimates exceed more than 1–3% of the value of output.¹ Some of the higher estimates, moreover, include losses of a broader nature than the purely allocative losses on which Harberger focuses.

In this paper I use a generalization of a recent model of oligopoly to estimate the magnitude of deadweight loss in the U.S. manufacturing sector. While the exact magnitude of the losses depends on several parameters, the estimates indicate that deadweight loss may be considerably higher than earlier work suggests, ranging from roughly 6–10% of the value of shipments if demand is inelastic to over 20% if demand is elastic.

The theoretical model used to derive the empirical estimates below is an explicit model of oligopoly, rather than an extension of the basic model of monopoly on which Harberger bases his work. While much of the existing work in this area extends Harberger's basic framework, the predominance of oligopolistic market structures in many industries justifies an approach based on a model of oligopoly. The particular model I use is flexible enough to allow for the exercise of different degrees of market power in different industries. Moreover, unlike most previous empirical work in this area, the model allows for differences in both costs and conduct among firms within any particular industry.

Section II provides a brief (and deliberately selective) review of the literature designed to motivate the particular approach I have taken. (For a more complete review, see Scherer and Ross [25].) In section III, I develop the theoretical model used to estimate deadweight loss in an industry. The theoretical model extends and generalizes the oligopoly models of Dixit and Stern [14] and Clarke and Davies [4], which trace their lineage to work of Cowling and Waterson [8]. Section IV adapts the theoretical model for use with available data on U.S. manufacturing, and section V presents and discusses empirical estimates of the model. A brief conclusion follows.

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1. Kamerschen [20] and Cowling and Mueller [5] are two notable exceptions.

II. A Brief (and Selective) Review of the Literature

Much of the work in this area stems from Harberger's well-known deadweight loss triangle. In its simplest textbook form, the intuition behind Harberger's analysis is straightforward: Firms' decisions to set price above marginal cost reduce consumer surplus and increase firms' profits relative to their levels in a competitive environment. The difference between the increase in producer surplus and the reduction in consumer surplus represents pure deadweight loss rather than redistribution from consumers to producers.

If demand is linear and long-run marginal costs are constant—and equal for the monopolist and the hypothetical competitive industry—the deadweight loss for a monopolist (DWL) is given by

$$DWL = (1/2)(\Delta p)(\Delta q),$$

where $\Delta p = p_m - p_c$ and $\Delta q = q_m - q_c$ denote the deviations from competitive pricing and output that result from the monopolist's exercise of market power. (Subscripts m and c denote monopoly and competition, respectively.)

Harberger and others then rewrite DWL in terms of observable variables. Letting η denote the absolute value of demand elasticity, we can rewrite DWL as

$$DWL = (1/2)\pi^2\eta/R,$$

where π is the monopolist's excess profits and R is the firm's revenue. Using this framework and several empirical assumptions, Harberger [18] estimates that deadweight loss in the U.S. manufacturing sector was on the order of 0.1 percent of GNP in the late 1920s.

Many later researchers, while using the same basic model, criticize Harberger's empirical assumptions. Much of their criticism focuses on his assumption that $\eta = 1$ for all industries, his failure to account for the interdependence of Δp and Δq (through the demand function), and his estimation of excess profits. (For summaries of some of this work, see Waterson [33], Clarke [3], and Scherer and Ross [25].)

Cowling and Mueller [5; 6] and Cowling, Stoneman et al. [7] attempt to correct for these problems—and others—and suggest that welfare losses are considerably higher than had been suggested by Harberger.² Although Cowling and Mueller estimate welfare losses attributable to individual firms rather than industries, they ultimately derive their estimates of allocative losses by starting from the same basic theoretical structure as Harberger; i.e., they look at a “welfare loss triangle” whose area is $(1/2)(\Delta p_i)(\Delta q_i)$ for an individual firm i [5, 729]. Given their other assumptions, such estimates of welfare loss reduce to simple functions of the firm's excess profits.

Holt [19], however, points out that such “Lerner equation loss estimates,” as he calls them, are appropriate only for a monopoly with linear demand and constant costs. They are inappropriate estimates for the welfare loss from the exercise of market power in an oligopoly. In particular, he criticizes Cowling and Mueller's focus on individual firms and shows that the summation of

2. Cowling and Mueller also look at a broader range of losses than those considered in most of the earlier literature, including, e.g., losses due to advertising. In this section, I focus on their approach to allocative loss only. In a recent paper, Shinjo and Doi [29] apply Cowling and Mueller's approach to estimate welfare losses in Japan. Among their other findings, they conclude [29, 252] that “aggregate WL [welfare loss] as a percent of national income is found similar to the order of magnitude reported for the U.S. and European countries.”

such estimates across all firms in an industry does not lead to an accurate estimate of welfare losses for the industry.³ In general, Holt notes [19, 289] that “[t]he precise relationship between industry profits and welfare losses depends on the number of firms, the nature of cost asymmetries, and the source of monopoly power in the industry.” (See also Schmalensee [26].)⁴

Masson and Shaanan [21] also argue that it is more appropriate to model the industry rather than the firm.⁵ They acknowledge, however, that they do so at the cost of losing individual firm differences. In particular, their analysis precludes consideration of differences in firms’ costs.

Recent papers by Gisser [15], Dickson [11], Daskin [10], and Willner [35] model the industry rather than individual firms using a dominant-firms model, while Dickson and Yu [13] use a more general model to estimate welfare losses in Canadian manufacturing.

The model outlined below also considers welfare loss at the industry level, thereby avoiding aggregation problems inherent in a firm-level approach. The model is more general than the dominant-firms models noted above, however, allowing a broader range of oligopoly solutions. In addition, the model is flexible enough to allow for cost asymmetries among firms *within* an industry. Finally, unlike Dickson and Yu’s model, the model below allows for different behavior among firms within an industry.

III. The Theoretical Model

In this section I develop the theoretical model to be used to estimate deadweight loss in an industry. Since the model derives from a model in Dixit and Stern [14] (henceforth D-S), I first summarize the salient features of their model.⁶ To do so, first define the following notation:

- X = total industry output;
- n = the number of firms in the industry;
- x_i = output of firm i ($i = 1, 2, \dots, n$);
- $s_i = x_i/X$ = the market share of firm i ; and
- c_i = marginal cost of firm i .

Any particular firm’s marginal costs are assumed to be constant at some level, but the level may vary across firms. Industry demand is assumed to be isoelastic: $X = Kp^{-\eta}$, where K is a constant and η is the absolute value of demand elasticity.⁷

3. For a symmetric n -firm Cournot oligopoly with constant costs and linear demand, for example, he shows that the summation of firm-level welfare loss estimates of the sort suggested by Cowling and Mueller will overstate welfare loss estimates for the industry by a factor of n .

4. Cowling and Mueller might well acknowledge these points, including the difficulty in aggregating welfare costs across firms; see Cowling and Mueller [5], especially pp. 745–6. They argue, however, that their estimates of “relative cost of monopoly for each firm” [5, 739] are still meaningful.

5. For an interesting discussion of the aggregation problems inherent in a firm-level approach, see Masson and Shaanan [21, 521]. They reiterate some of the points made by Holt [19] and Schmalensee [26] and provide a clear comparison of their work and that of Cowling and Mueller.

6. Clarke and Davies [4] present the same model. Since Dixit and Stern explicitly suggest the application to deadweight loss, I refer to the model as the D-S model. The two pairs of authors apparently developed the same basic model concurrently.

7. For much of the theoretical development in Clarke and Davies [4] and Dixit and Stern [14], marginal cost curves need not be horizontal and demand need not be isoelastic. Following Dixit and Stern, I make these assumptions, relatively common ones in this area, to get tractable expressions for consumer surplus, producer surplus, and welfare loss. Dickson and Yu [13], whose work also derives from the same basic model, do not assume constant marginal costs. As

Firm i chooses its optimal output to maximize its profits, given its conjectures about the change in output by other firms in response to a change in x_i . Dixit and Stern—as well as Clarke and Davies—parameterize firm i 's conjectures as follows:

$$dx_k/dx_i = \alpha(x_k/x_i), \quad k \neq i;$$

i.e., firm i assumes that the percentage change in other firms' outputs will be directly proportional to the percentage change in its own output.⁸ The absence of any subscript on α reflects the Dixit-Stern/Clarke-Davies assumption that all firms have the same proportional conjectures about all other firms in their industry.⁹ Although α is constant for all firms in an industry, it may vary across industries. While D-S focus their attention on values of α between $\alpha = 0$, the Cournot conjecture, and $\alpha = 1$, perfectly collusive conjectures, there is no inherent need to constrain α to exceed 0.¹⁰

Given this structure, D-S solve for the equilibrium values of the endogenous variables, including market price, p , and the firms' market shares, s_i ($i = 1, 2, \dots, n$). Graphically, the equilibrium is depicted in their Figure 1, which I have reproduced below, where

$$c^* = \min_i(c_i)$$

denotes the marginal cost of the lowest-cost firm. Total industry output is OX , and the progressively higher "steps" correspond to the lower price-cost margins of higher-cost firms.

In this model, Figure 1 is the oligopoly counterpart of the standard textbook graph illustrating Harberger's deadweight loss for a monopoly. Using the usual Marshallian measures of surplus, the welfare loss for the industry is the difference between the loss in consumer surplus and the gain in producer surplus resulting from the exercise of market power. As Dixit and Stern point out, however, the firms' unequal costs make it necessary to specify a standard against which to compare the oligopoly equilibrium. If we take $p = c^*$ (and the associated output on the industry demand curve) as our standard for comparison, the area marked "DWL" in Figure 1 gives the welfare loss due to oligopoly.¹¹

noted in the text below, however, their approach implies a monotonic (positive) relationship between firms' margins and market shares within an industry, which is inconsistent with the data for many industries.

8. Similar parameterizations of conjectures are common in this and related literature. See, e.g., Dickson [12], Cubbin [9], Sleuwaegen [31], and Dickson and Yu [13].

9. Dixit and Stern and Clarke and Davies make this assumption in large part for the sake of mathematical simplicity and tractability, especially in deriving some of their comparative statics results. Clarke and Davies briefly discuss some of the issues and problems involved in a more general parameterization of conjectures. In the theoretical extension that I develop below—and in its empirical application—I weaken the assumption that α is constant for all firms in the industry.

10. Dixit and Stern note [14, 126] that "[c]ases of $\alpha < 0$ are also conceivable, working towards 'accommodating' behaviour on part of other firms, an example being where they adjust their outputs to keep price constant." For a discussion of the relationships among values of the conjectural variation elasticity, the nature of competition, and the appropriate measure of concentration, see Dickson [12]. (Dickson [12] defines firm i 's conjectural variation elasticity as $(dX/X)/(dx_i/x_i)$; i.e., the proportional change in the numerator includes the change in firm i 's output. Given that definition, each firm's conjectural variation elasticity would be 0 in perfect competition, e.g., since each firm assumes that a change in its own output has no effect on total market output.)

11. Although Cowling and Mueller [5] focus on the estimation of welfare loss for individual dominant firms, they mention in passing an approach that seems strikingly similar to the one in Dixit and Stern, which I modify below: "If a policy were adopted forcing the most efficient size or organisational structure upon the entire industry, the welfare loss under the existing structure would have to be calculated using the profit margin of the most efficient *firm and the output of the entire industry*, rather than the profit margins of the individual firms and their outputs." ([5, 744], emphasis in original) They also point out [5, 729] that "we shall obtain welfare loss estimates by individual firms from their price/cost

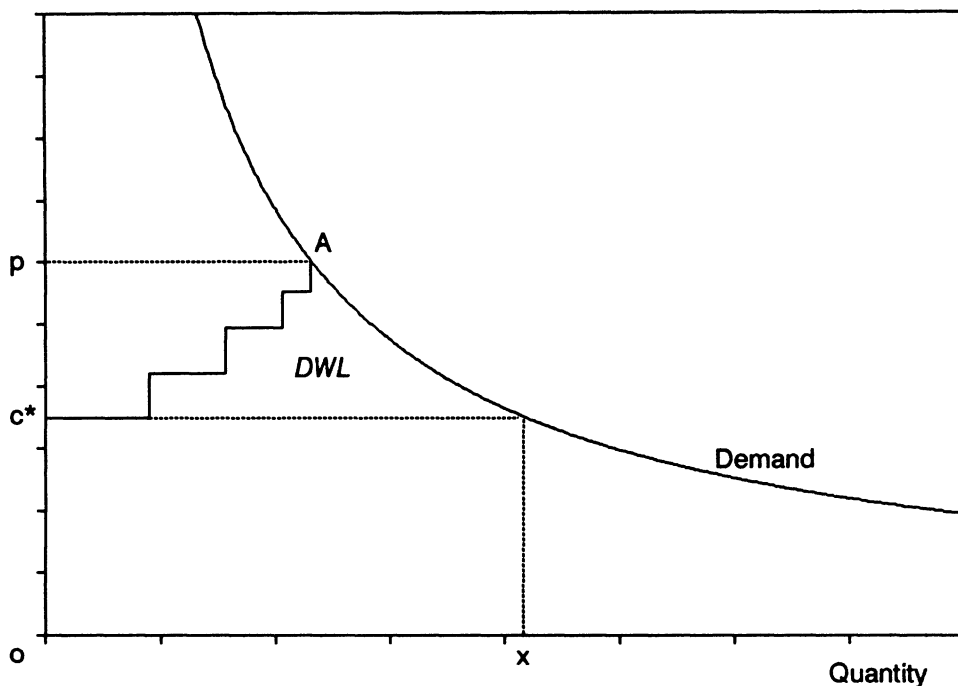


Figure 1.

The Dixit-Stern/Clarke-Davies model, however, has an unfortunate implication. Their assumption that α is the same for all firms in the industry implies a monotonic relationship between price-cost margins and market shares [14, 128]. (See also the discussion of my equation (2) below.) Low-cost firms *necessarily* have high market shares (and high price-cost margins) in the model, and vice versa for high-cost firms. In fact, we rarely observe such a monotonic relationship between price-cost margins and market shares for all firms in any given industry.¹²

To remedy that discrepancy between theory and fact, I extend the D-S model by allowing firms in an industry to have different conjectures; α , therefore, is indexed by i .¹³ Formally, the industry's inverse demand function is given by $p(X)$, and firm i 's conjectures can be written as

$$dx_k/dx_i = \alpha_i(x_k/x_i) \quad \text{or} \quad dx_k/x_k = \alpha_i(dx_i/x_i) \quad \text{for all } k \neq i.^{14}$$

margins. These estimates indicate the amount of welfare loss associated with a single firm's decision to set price above marginal cost. . . . To the extent other firms also charge higher prices, because firm i sets its price above marginal cost, the total welfare loss associated with firm i 's market power exceeds the welfare loss we estimate."

12. For a related observation, see Stylized Fact 4.12 (and supporting references) in Schmalensee [28, 984]: "Within particular manufacturing industries, profitability is not generally strongly related to market share."

13. For empirical evidence on the variation of conjectures within an industry, see, e.g., Gollop and Roberts [17], Slade [30], or Rogers [24].

14. Although this parameterization of firm i 's conjectural variation elasticity is sufficient to remove the monotonic relationship between firms' market shares and price-cost margins, an anonymous referee has pointed out that the conjectural variation elasticity could be even more general. Specifically, firm i might have different conjectures about different firms, so we would have to write the conjectural variation elasticity as α_{ik} , where $\alpha_{ik} \equiv (dx_k/x_k)/(dx_i/x_i)$ is *not* necessarily equal to α_{ij} for $j \neq k$. From an empirical point of view, that more general formulation of conjectural variation elasticities necessitates estimation of many more parameters; as noted below, the available data are already quite limited. For a brief discussion of some of the theoretical issues involved in such a parameterization of conjectural variation elasticities, see Clarke and Davies [4, 280].

Firm i then chooses x_i to maximize its profits, given by

$$\pi_i = p(X)x_i - c_i x_i - \text{fixed costs.}$$

The firm's first-order condition is then

$$d\pi_i/dx_i = p + x_i p' [1 + \sum_{k \neq i} (dx_k/dx_i)] - c_i = 0,$$

which, after some algebraic manipulation, can be written as¹⁵

$$p\{1 - [\alpha_i + (1 - \alpha_i)s_i]/\eta\} = c_i. \quad (1)$$

In terms of firm i 's price-cost margin, $m_i \equiv (p - c_i)/p$, we can write (1) as

$$m_i = (p - c_i)/p = (1/\eta)[\alpha_i + (1 - \alpha_i)s_i]. \quad (2)$$

Ceteris paribus, therefore, a firm with a relatively low α_i will tend to produce a higher quantity and have a higher market share than a firm with identical costs but higher α_i . Once α_i is allowed to vary across firms in the industry, there need not be a monotonic relationship between firms' price-cost margins (m_i) and their market shares (s_i).¹⁶ The largest firms in an industry are not always the most efficient.

Figure 1 is now helpful in adapting Dixit and Stern's algebraic calculation of consumer surplus, producers' profits, and the resulting deadweight loss. Calculation of producer surplus is straightforward:

$$\begin{aligned} \sum \pi_i &= \sum (p - c_i)x_i \\ &= R \sum [(p - c_i)/p](x_i/X) \\ &= R \sum m_i s_i \end{aligned} \quad (3)$$

since $R = pX$ and $X = \sum x_i$.¹⁷

15. Omitting the explicit index $k \neq i$ for convenience in all the summations below, the first order condition implies $p + x_i p' [1 + \sum (dx_k/dx_i)] = c_i$. We can then write the left side of the latter equality as

$$\begin{aligned} &p + x_i(p/p)(X/X)p'[1 + \sum (dx_k/dx_i)] \\ &= p + p(x_i/X)(X/p)p'[1 + \sum (dx_k/dx_i)] \\ &= p\{1 - (s_i/\eta)[1 + \sum (dx_k/dx_i)]\} = p\{1 - (s_i/\eta)[1 + \sum \alpha_i(x_k/x_i)]\} \\ &= p\{1 - (s_i/\eta)[1 + \alpha_i \sum x_k/x_i]\} = p\{1 - (s_i/\eta)[1 + \alpha_i(\sum x_k/X)/(x_i/X)]\} \\ &= p\{1 - (s_i/\eta)[1 + \alpha_i(1 - s_i)/s_i]\} = p\{1 - s_i/\eta - \alpha_i(1 - s_i)/\eta\} \\ &= p\{1 - [\alpha_i + (1 - \alpha_i)s_i]/\eta\}, \end{aligned}$$

the left side of equation (1) in the text.

16. In terms of Figure 1, as we "climb the steps" from c^* to p , the horizontal length of the steps may get shorter or longer. For the model in which α_i is the same for all firms in the industry, Dixit and Stern derive an equation that is identical to my equation (2) except that they have no subscript on α . (See their equation (9).) In that case, m_i and s_i do rise and fall together.

17. Using equation (2) in the text, we can rewrite the right side of (3) as

The reduction in consumer surplus is given by the area under the demand curve between c^* and p . For $\eta \neq 1$, that area is given by

$$\begin{aligned} \int_{c^*}^p K u^{-\eta} du &= [K/(1-\eta)] u^{1-\eta} \Big|_{c^*}^p = [K p^{1-\eta}/(1-\eta)] [1 - (c^*/p)^{1-\eta}] \\ &= [R/(1-\eta)] [1 - (c^*/p)^{1-\eta}] = [R/(1-\eta)] [1 - (1-m^*)^{1-\eta}] \end{aligned} \quad (4a)$$

where m^* is the price-cost margin of the lowest-cost firm. For $\eta = 1$, the lost consumer surplus is given by

$$\begin{aligned} \int_{c^*}^p K u^{-1} du &= K \cdot \ln(u) \Big|_{c^*}^p = K \cdot \ln(p/c^*) \\ &= R \cdot \ln(p/c^*) \quad \text{since, if } \eta = 1, R \equiv pX = pKp^{-1} = K \\ &= R \cdot \ln[1/(1-m^*)]. \end{aligned} \quad (4b)$$

Deadweight loss is then given by the difference between the appropriate expression in either (4a) or (4b) and the expression in (3). The next section explains how I use (3) and (4) to estimate deadweight loss in an industry from data given in the *Census of Manufactures*.

IV. Empirical Adaptation of the Theoretical Model: Sample and Data Considerations

In an attempt to apply the theoretical model above to a wide range of industries, I use the 1977 *Census of Manufactures* [32] (henceforth the Census) as the basic source of data on U.S. manufacturing industries at the four-digit S.I.C. level. Unfortunately, the more recent 1982 Census does not provide the data that are necessary to calculate price-cost margins for firms of different size.¹⁸

Even the 1977 Census does not provide data on *individual* firms' market shares or price-cost margins, as apparently required by equations (3) and (4). Instead, the Census aggregates data for five groups of firms. Rather than provide individual market shares, the Census provides data on four concentration ratios: the four-firm ($CR4$), eight-firm ($CR8$), 20-firm ($CR20$), and 50-firm ($CR50$) concentration ratios. Thus we can extract information on combined market shares of various "ranks" of firms: $CR4 = \sum_{i=1}^4 s_i$ = the combined share of the first four firms, or first rank; $CR8 - CR4 = \sum_{i=5}^8 s_i$ = the combined share of the next four firms (firms 5–8), or rank; and so on for rank 3 (firms 9–20), rank 4 (firms 21–50), and rank 5 (firms 51– n).

In fact, equation (3) does not require information on individual shares or price-cost margins; it requires a share-weighted average of individual firms' price-cost margins, which *can* be computed from Census data. For the first rank, for example, we can compute a market share-weighted average of the four firms' price-cost margins, M_1 , directly (more on the actual definition of the price-cost margin below.) We can write M_1 as

$$(R/\eta) [\sum \alpha_i s_i + H - \sum \alpha_i s_i^2],$$

where $H \equiv \sum s_i^2$ is the Herfindahl index of concentration. For the model in which α_i is the same for all firms in the industry, the latter expression simplifies to $(R/\eta)[H + \alpha(1-H)]$. (Dixit and Stern [14], equation (15)). Dickson and Yu [13] use a clever adaptation of the latter expression in their estimation of welfare loss in Canadian manufacturing, but their model implies a (positive) monotonic relationship between firms' market shares and price-cost margins.

18. That omission is particularly curious in light of the fact that the 1982 *Census* does, for the first time, provide data on the Herfindahl index for different industries.

$$M_1 = \sum_{i=1}^4 s_i m_i / \sum_{i=1}^4 s_i = (1/CR4) \left(\sum_{i=1}^4 s_i m_i \right),$$

so we can use Census data on $CR4$ and M_1 to calculate $\sum_{i=1}^4 s_i m_i$ as $M_1 \cdot CR4$. Similarly, we can use Census data for the other four ranks to calculate their contribution to producer surplus without knowing individual firm shares or margins.

Equation (4), which requires knowledge of m^* , the highest price-cost margin among firms in the industry, does require some empirical assumptions. For all five ranks, I assume equal margins *within* each rank, although margins do typically differ across ranks. For ranks 1 and 2, e.g., I assume that

$$\begin{aligned} m_1 &= m_2 = m_3 = m_4 = M_1 \quad \text{and} \\ m_5 &= m_6 = m_7 = m_8 = M_2, \end{aligned}$$

where M_1 and M_2 can be computed from Census data.¹⁹ For the sake of estimating equation (4) above for any industry, that assumption is sufficient, given any particular value of η . For some of the discussion in the next section, further assumptions about η are required; I discuss those assumptions in the text below.

For each rank, I use Census data to calculate M_i as

$$\begin{aligned} &[VS_i - \text{payroll}_i - (\text{cost of materials})_i \\ &\quad - (\text{cost of capital})(\text{average book value of depreciable assets})_i \\ &\quad - \text{depreciation}_i - (\text{rental payments})_i] / VS_i \end{aligned}$$

where VS = value of shipments. The Census provides data for VS ; payroll, and cost of materials for each rank within each four-digit industry. Since the Census does not disaggregate book value of assets, depreciation, or rental payments by rank—it just provides totals for the industry—I prorate those variables according to their market shares. In the empirical estimation of equations (3) and (4), I try three alternative values for the cost of capital: 5%, 10%, and 15%.²⁰

The sample includes all four-digit industries for which the 1977 Census reports data, with two general exceptions: (i) I exclude all industries that include “nec” (not elsewhere classified) or “miscellaneous” in their titles, and (ii) I exclude 10 industries for which the Census uses different rankings for data on concentration and data on payroll and cost of materials. The “full” sample that remains has 363 four-digit industries.

19. In preliminary work, I also considered an alternative set of assumptions; viz., that the top four firms have equal conjectural variation elasticities and unequal market shares given by the one of the distributions of shares suggested in Schmalensee [27] and Micheleni and Pickford [22]. Those alternative assumptions, however, imply that the top four firms have different price-cost margins. Moreover, equation (2) in the text indicates that those margins then depend critically on our assumption about the value of η : Different values of η , combined with Census data that make it possible to calculate M_1 , may then cause the identity of the lowest-cost firm—and with it, the estimates of estimates of deadweight loss—to change. (From (2), a low value of η implies a large dispersion of m_1 , m_2 , m_3 , and m_4 , whose weighted average equals M_1 ; the value of M_1 is unaffected by assumptions about η , since we calculate it directly from Census data. For low enough assumed values of η , therefore, the implied price-cost margin for the largest firm, m_1 , may become the highest in the industry—and, therefore, the benchmark for calculations of deadweight loss—even if M_1 is considerably lower than M_2 , M_3 , M_4 , and M_5 .)

20. In principle, we might like to use different risk-adjusted costs of capital for each industry. For present purposes, however, I am primarily interested in the order of magnitude of the estimates of deadweight loss, so this estimation approach should suffice.

Table I. Deadweight Loss as Percentage of Value of Shipments—No Restrictions on η

Table IA Full Sample: 363 Industries				Table IB Sample Censored Using Weiss/Pascoe Screen (257 Industries)			
η	Cost of Capital			η	Cost of Capital		
	5%	10%	15%		5%	10%	15%
0.25	6.33%	6.22%	6.12%	0.25	6.61%	6.50%	6.39%
0.50	7.59%	7.35%	7.14%	0.50	7.80%	7.56%	7.34%
1.00	10.43%	9.90%	9.42%	1.00	10.44%	9.90%	9.43%
1.50	13.77%	12.89%	12.10%	1.50	13.46%	12.58%	11.80%
2.00	17.77%	16.45%	15.28%	2.00	16.96%	15.66%	14.51%
2.50	22.63%	20.75%	19.10%	2.50	21.02%	19.21%	17.62%
3.00	28.60%	26.02%	23.77%	3.00	25.76%	23.33%	21.21%
5.00	74.69%	66.19%	58.93%	5.00	55.25%	48.41%	42.66%

V. Empirical Results

Tables I and II report deadweight loss in U.S. manufacturing as a percentage of value of shipments for alternative values of demand elasticity (η), weighting each industry by its value of shipments. For any particular value of η , deadweight loss is relatively insensitive to the value chosen for the cost of capital.

Table IA reports estimates for the full 363-industry sample. For $\eta \leq 1$, deadweight loss is roughly 6–10% of the total value of shipments. As expected, deadweight loss increases with η . For large enough values of η , in fact, deadweight loss becomes a very high percentage of the value of shipments.²¹

The estimates in Table IA, however, may be misleading for two reasons. First, S.I.C. codes, while convenient for empirical purposes, do not necessarily correspond perfectly to true economic markets [25]. As a consequence, concentration ratios reported by the Census may be too high or too low. In an attempt to exclude some of the industries for which the definitions are particularly inappropriate, I compared reported (Census) and adjusted values of $CR4$ given in Weiss and Pascoe [34], who adjust reported values to correct for several potential sources of over- or under-inclusion in the S.I.C. definitions. In Table IB, I exclude all industries for which the reported and adjusted values of $CR4$ differ by more than 25% of the adjusted $CR4$ or five percentage points, whichever is greater.²² Comparing Tables IA and IB suggests that such exclusions increase (re-

21. There is less than total unanimity about the appropriate value of elasticity in such empirical work, and there are surprisingly few empirical studies that report estimates of demand elasticity for a cross section of industries. For a sample of 46 food and tobacco industries in the U.S., Pagoulatos and Sorensen report uniformly inelastic demand [23, 241]: “The values range from a high of .756 for cigars to a low of .008 for flavoring extracts and syrups in our sample.” Shinjoi and Doi justify their focus on $\eta = 1$ by noting [29, 248] that “it is based on the findings that the price elasticities estimated from industry time series data [for Japan] tend to cluster around 1.0 [fn. omitted].” Empirical estimates reported in Allen [1, 103] suggest that η might be as high as 2 for certain industries in the manufacturing sector.

22. Two examples may clarify the rule: If the reported $CR4$ is 42% and the adjusted $CR4$ is 34%, the industry would not be excluded even though the two numbers differ by more than five percentage points, since $42 - 34 = 8$ is less than 25% of 34 ($.25 \times 34 = 8.5$). If the reported $CR4$ is 6% and the adjusted $CR4$ is 10%, the industry would also not be excluded even though $|6 - 10| = 4$ exceeds 25% of the adjusted $CR4$, since the difference between the two numbers is less than five percentage points.

Table II. Deadweight Loss as Percentage of Value of Shipments—Restrictions Imposed on η^*

Table IIA Full Sample: 363 Industries				Table IIB Sample Censored Using Weiss/Pascoe Screen (257 Industries)			
η^*	Cost of Capital			η^*	Cost of Capital		
	5%	10%	15%		5%	10%	15%
0.25	6.33%	6.22%	6.12%	0.25	6.61%	6.50%	6.39%
0.50	7.59%	7.35%	7.14%	0.50	7.80%	7.56%	7.34%
1.00	10.43%	9.90%	9.42%	1.00	10.44%	9.90%	9.43%
1.50	13.76%	12.88%	12.10%	1.50	13.46%	12.58%	11.80%
2.00	17.17%	15.94%	14.84%	2.00	16.92%	15.64%	14.50%
2.50	20.12%	18.59%	17.23%	2.50	20.17%	18.59%	17.18%
3.00	22.58%	20.84%	19.28%	3.00	22.82%	21.01%	19.37%
5.00	26.62%	24.92%	23.31%	5.00	27.18%	25.45%	23.82%

*In Tables IIA and IIB, η was set equal to the minimum of (i) the value indicated in the table and (ii) the maximum value possible for each industry, as determined by restrictions on the conjectural variation elasticities. See text for further discussion of limits on η .

duce) our estimates of deadweight loss for $\eta \leq 1$ ($\eta > 1$), but the magnitude of the change in the estimates is relatively small for $\eta \leq 3$. Even for $\eta = 5$ in Table IB, deadweight loss remains rather high.

At least some of the estimates in Tables IA and IB may also be misleading because we have imposed no restrictions on η . It seems reasonable, however, to impose the restriction that no firm's α_i exceed 1; i.e., no firm's conjectural variation elasticity is greater than a monopolist's would be. Although the α_i 's do not appear explicitly in equation (3) or (4), the link among m_i , α_i , and η , together with the restriction $\alpha_i \leq 1 \forall i$, does lead to a restriction on η , which does appear in (4): Solving equation (2) for α_i ,

$$\alpha_i = (\eta m_i - s_i)/(1 - s_i), \quad (5)$$

so $\alpha_i \leq 1 \Rightarrow \eta \leq 1/m_i \forall i$.

Table IIA reports estimates of deadweight loss for the entire 363-industry sample when we impose the restrictions on η implied by $\alpha_i \leq 1 \forall i$. For each industry, I set η equal to the value given in the leftmost column of Table IIA or $\min(1/m_i)$, whichever was *smaller*. Since $\min_{m_i > 0}(1/m_i)$ exceeds 1 for all industries in the sample, $\alpha_i \leq 1$ is not a binding constraint for $\eta \leq 1$, and the first three rows of Table IIA are identical to the corresponding rows of Table IA. For higher values of η , however, $\alpha_i \leq 1$ becomes a binding constraint for more and more industries, so the entries in the bottom rows of Table IIA are lower than the corresponding entries in Table IA. For $\eta = 3$ and especially for $\eta = 5$, the entries in Table IIA are much lower.

Finally, Table IIB reports the results of imposing both the Weiss/Pascoe industry screen and the restriction that all firms' conjectural variation elasticities be less than or equal to 1. As expected, the first three rows of Table IIB are identical to the corresponding rows in Table IB. Moreover, there is very little difference between the entries in Tables IIA and IIB, which suggests that the restrictions on α_i are more important quantitatively than the restrictions on the industries included in the sample.

Table III. Top Five Industries, Ranked by Dollar Value of Deadweight Loss

SIC – Industry Name	CR4	DWL as % of Total DWL	Cumulative % of Total DWL
3714 – Motor vehicle parts, accessories	62.2%	6.33%	6.33%
3721 – Aircraft	58.5%	6.32%	12.65%
3711 – Motor vehicles and car bodies	93.4%	4.26%	16.90%
3861 – Photographic equip. and supplies	72.2%	3.46%	20.36%
3353 – Aluminum sheet, plate, and foil	72.0%	3.04%	23.40%

Some researchers have noted that firms' tendency to collude is higher the more inelastic is demand [2, 217]. That tendency *might* seem to be inconsistent with the results reported in Tables I and II, in which deadweight loss increases with elasticity. Moreover, equation (5) above might seem to imply a positive relationship between elasticity and firms' tendency to collude, since $\partial\alpha_i/\partial\eta = m_i/(1 - s_i) > 0$.

Recall, however, that η and the α_i 's are exogenous in the theory above—as are η and α in Clarke and Davies [4] and Dixit and Stern [14]—and market shares and price-cost margins (s_i and m_i) are endogenous. In the empirical application, the endogenous variables s_i and m_i are observable, while the exogenous variables η and α_i are unobservable. Equation (5), therefore, is not a *behavioral* relationship linking firms' tendency to collude to demand elasticity. Instead, it gives the value of a firm's α_i we can infer from the observable values for m_i and s_i along with a hypothesized value of η . Since m_i and s_i are “fixed” by the data, the positive sign on $\partial\alpha_i/\partial\eta$ has the following interpretation: Given values of m_i and s_i are consistent with a high hypothesized value of demand elasticity only if α_i is high. Equation (5), therefore, along with theoretical restrictions on α_i , puts limits on how high the hypothesized value of η can be.

To see why deadweight loss increases with η in Tables I and II, consider equations (3) and (4) along with Figure 1. Equation (3) shows that the empirical estimate of producer surplus is not affected by a change in η . The invariance of producer surplus is also evident from Figure 1 if we imagine drawing a demand curve through point A that is more elastic than the demand curve shown. Such a demand curve reveals, however, that the lost consumer surplus *does* increase with η : A more elastic demand curve would be above the demand curve shown for all quantities to the right of point A, and the point x , the quantity demanded if price were c^* , would be further to the right in Figure 1. Since producer surplus is invariant with respect to η and lost consumer surplus increases with η , deadweight loss increases with η .²³

While it is not evident from Tables I and II, a small number of industries account for a very large fraction of the total welfare loss. If $\eta = 1$ and the cost of capital = 10%, for example, Table IIB indicates that total deadweight loss for the censored sample of 257 industries is 9.90% of the total value of shipments. As Table III indicates, however, the top five industries, ranked by

23. Readers who are bothered by this result may object that the optimal markup for a monopolist decreases as η increases, which is certainly true. In the empirical estimation of deadweight loss above, however, the actual markups are given by the data. Higher hypothetical values of η have no implications for the actual markups observed; they do imply greater reductions in output from the level that would have been produced at $p = c^*$. The same positive relationship between estimated deadweight loss and demand elasticity appears in Harberger's expression for the deadweight loss from monopoly: “Thus, the dead-weight welfare loss from monopoly rises as a quadratic function of the relative price distortion . . . and as a linear function of the demand elasticity” [25, 662]. For a given value of the relative price distortion (p/c^* in our case), deadweight loss increases with η .

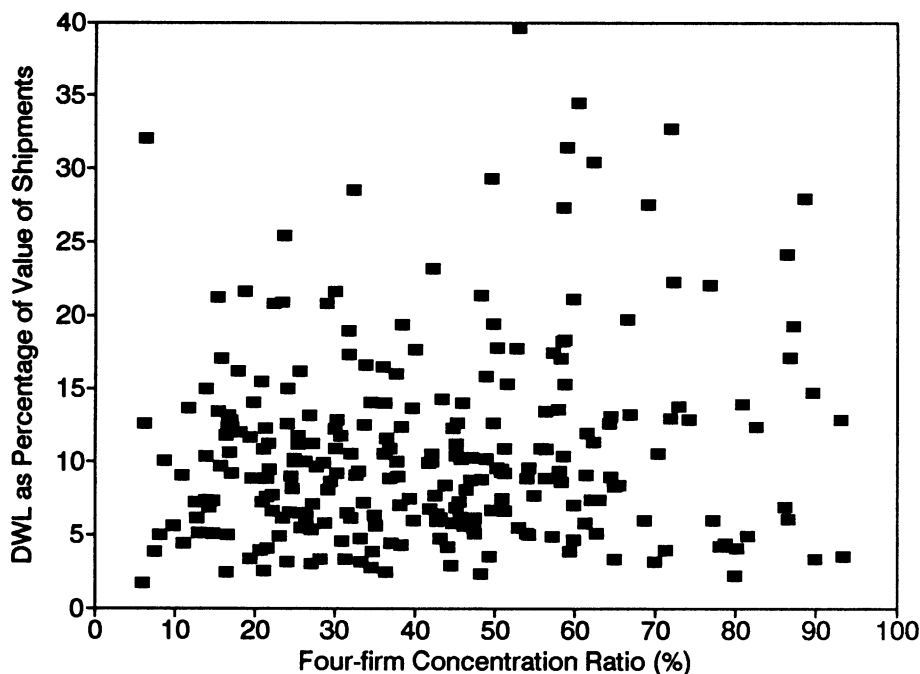


Figure 2.

dollar value of deadweight loss, account for nearly a quarter of the total deadweight loss in the sample.

All five industries in Table III have high four-firm concentration ratios,²⁴ so it is natural to wonder if deadweight loss, expressed as a percentage of an industry's value of shipments (DWL/VS), is correlated with the industry's concentration. As it turns out, that correlation is quite small. For $\eta = 1$ and a cost of capital of 10%, for example, Figure 2 shows a scatter diagram of DWL/VS against $CR4$ for the 257 industries in the censored sample.²⁵ Needless to say, the graph does not suggest a tight-fitting relationship. The regression of DWL/VS against $CR4$ (with both expressed as percentages) is as follows:

$$DWL/VS = 9.240 + .0380(CR4),$$

(1.93)

where 1.93 is the t statistic for the null hypothesis that the true coefficient on $CR4$ is 0. The estimated coefficient is marginally significant in a statistical sense (5% level), but its magnitude is quite small: A ten-percentage-point increase in $CR4$ (from 30% to 40%, e.g.) is associated with an increase of less than .4 percentage points in DWL/VS (from 10.38% to 10.76% when $CR4$ increases from 30% to 40%, e.g.). These results are not necessarily inconsistent with Table III, which lists the top industries ranked by dollar value of DWL , not DWL/VS . For industry 3711, e.g., DWL/VS was only 3.57%; the dollar value of DWL was high because the industry's shipments were so large.

24. The 93.4% four-firm concentration ratio for industry 3711, however, undoubtedly overstates the true degree of concentration in the industry, since the Census reports domestic concentration ratios.

25. Because many points overlap, the graph seems to show fewer than 257 points.

The above estimates of deadweight loss are considerably higher than many estimates in the existing literature.²⁶ Part of that difference undoubtedly stems from the assumption that all firms have constant marginal cost (albeit at different levels for different firms). That assumption is particularly significant for the firm with the lowest marginal cost (c^*), since that firm serves as a benchmark in my calculation of deadweight loss.²⁷ While the assumption of constant marginal cost is admittedly a strong one—suggesting perhaps that these estimates of deadweight loss serve as an upper bound—there are no available empirical estimates for the elasticity of marginal cost for a broad range of industries. The assumption of constant marginal cost, moreover, while controversial, has a long history in this literature, extending as far back as Harberger's original work.²⁸

VI. Summary and Conclusions

Using a generalization of a recent model of oligopoly, I have estimated the magnitude of welfare loss for a broad cross section of U.S. manufacturing industries. Unlike previous empirical work in this area, the model is flexible enough to allow for both cost asymmetries and unequal conjectural variation elasticities among firms in an industry. For the sample considered, the evidence suggests that deadweight loss is roughly 6–10% of the value of shipments if demand is inelastic or unit elastic; losses may be considerably higher if demand is elastic. Much of the deadweight loss, however, is accounted for by just a few industries.

The estimates are subject to all the usual caveats that apply in this area. In particular, the study relies on S.I.C. classifications, which are imperfect proxies for true economic markets, and *Census of Manufactures* accounting data. Even the censored sample, which excludes industries for which adjusted concentration ratios differ significantly from the reported ratios, provides only rough approximations of true markets. In relying on Census data, of course, I have lots of company. Indeed there seems to be no reliable, alternative, publicly-available source of data on a broad cross section of industries. With these caveats in mind, the study indicates that deadweight losses may be considerably higher than much of the earlier literature would suggest.

26. Many researchers in this area, however, including Harberger, report welfare losses in *manufacturing* as a percentage of *GNP*, rather than as a percentage of the value of shipments in manufacturing. Scherer and Ross note [25, 664] that “[d]istortions attributable to monopoly also exist in sectors other than manufacturing. . . . The manufacturing sector originated about one-fourth of U.S. GNP in the period studied by Harberger and one-fifth in the 1980s. To arrive at an economy-wide welfare loss estimate, figures derived for manufacturing alone must be inflated—perhaps by as much as a factor of 3 or 4.” At least some of the lower estimates reported in the literature, therefore, are not directly comparable to those reported in the text above.

27. Cf. Dickson and Yu [13], whose estimates of welfare loss depend on several parameters, including ϵ , the elasticity of the industry's marginal cost. For high or infinite values of ϵ , some of their estimates of DWL/GNP are comparable to—and in some cases, dramatically higher than—those reported in the text above. (Moreover, Dickson and Yu report welfare losses in Canadian manufacturing as a percentage of Canadian GNP, not as a percentage of manufacturing shipments. See fn. 26 above.)

28. For two rather different views on the subject, cf. Willner [35, 604–605], who claims, “It could even be considered a stylized fact that large corporations have horizontal marginal costs [fn. om.]. We therefore find Gisser's assumption of equally elastic and positively sloping supply schedules [for dominant firms and the competitive fringe] ad hoc and weakly motivated;” and Gisser [16, 611], who responds that “it seems that there is neither compelling empirical evidence, nor a priori reasons, supporting the argument that the marginal costs of the leaders are more elastic than the marginal costs of the small firms.”

References

1. Allen, Bruce T. *Managerial Economics*. New York: Harper & Row, 1988.
2. Carlton, Dennis W. and Jeffrey M. Perloff. *Modern Industrial Organization*. Glenview, Ill.: Scott, Foresman, 1990.
3. Clarke, Roger. *Industrial Economics*. New York: Basil Blackwell, 1985.
4. ——— and Stephen W. Davies, "Market Structure and Price-Cost Margins." *Economica*, August 1982, 277–87.
5. Cowling, Keith and Dennis Mueller, "The Social Costs of Monopoly." *Economic Journal*, December 1978, 727–48.
6. ——— and ———, "The Social Costs of Monopoly Power Revisited." *Economic Journal*, September 1981, 721–5.
7. ———, Paul Stoneman, John Cubbin, Graham Hall, Simon Domberger, and Patricia Dutton. *Mergers and Economic Performance*. Cambridge: Cambridge University Press, 1980.
8. ——— and Michael Waterson, "Price-Cost Margins and Market Structure." *Economica*, August 1976, 267–74.
9. Cubbin, John, "Apparent Collusion and Conjectural Variations in Differentiated Oligopoly." *International Journal of Industrial Organization*, June 1983, 155–163.
10. Daskin, Alan J. "Price Leadership and Welfare Losses in U.S. Manufacturing: Comments, Corrections, and Extensions." Unpublished mimeo, January 1987.
11. Dickson, Vaughan, "Price Leadership and Welfare Losses in U.S. Manufacturing: Comment." *American Economic Review*, March 1988, 285–87.
12. Dickson, V.A., "Conjectural Variation Elasticities and Concentration." *Economics Letters*, 1981, 281–85.
13. ——— and Weiqiu Yu, "Welfare Losses in Canadian Manufacturing Under Alternative Oligopoly Regimes." *International Journal of Industrial Organization*, June 1989, 257–67.
14. Dixit, Avinash and Nicholas Stern, "Oligopoly and Welfare: A Unified Presentation with Applications to Trade and Development." *European Economic Review*, September 1982, 123–43.
15. Gisser, Micha, "Price Leadership and Welfare Losses in U.S. Manufacturing." *American Economic Review*, September 1986, 756–67.
16. ———, "Price Leadership and Welfare Losses in U.S. Manufacturing: Reply." *American Economic Review*, June 1989, 610–13.
17. Gollop, Frank M. and Mark J. Roberts, "Firm Interdependence in Oligopolistic Markets." *Journal of Econometrics*, August 1979, 313–31.
18. Harberger, Arnold C., "Monopoly and Resource Allocation." *American Economic Review*, May 1954, 77–87.
19. Holt, Charles A., Jr., "On the Use of Profit Data to Estimate the Social Cost of Monopoly Power in an Oligopoly." *Journal of Economics and Business*, 1982, 283–89.
20. Kamerschen, David R., "An Estimation of the 'Welfare Losses' from Monopoly in the American Economy." *Western Economic Journal*, Summer 1966, 221–36.
21. Masson, Robert T. and Joseph Shaanan, "Social Costs of Oligopoly and the Value of Competition." *Economic Journal*, September 1984, 520–35.
22. Michelini, Claudio and Michael Pickford, "Estimating the Herfindahl Index from Concentration Ratio Data." *Journal of the American Statistical Association*, June 1985, 301–05.
23. Pagoulatos, Emilio and Robert Sorensen, "What Determines the Elasticity of Industry Demand?" *International Journal of Industrial Organization*, 1986, 237–50.
24. Rogers, Robert P., "The Measurement of Conjectural Variations in an Oligopoly Industry." *Review of Industrial Organization*, Spring 1989, 39–65.
25. Scherer, F. M. and David Ross. *Industrial Market Structure and Economic Performance*, third ed. Boston: Houghton Mifflin, 1990.
26. Schmalensee, Richard, "Is More Competition Necessarily Good?" *Industrial Organization Review*, 1976, 120–21.
27. ———, "Using the H-Index of Concentration with Published Data." *Review of Economics and Statistics*, May 1977, 186–93.
28. ———. "Inter-Industry Studies of Structure and Performance," in *Handbook of Industrial Organization*, Vol. 2, edited by Richard Schmalensee and Robert D. Willig. Amsterdam: North-Holland, 1989.
29. Shinjo, Koji and Noriyuki Doi, "Welfare Loss Calculation for Japanese Industries." *International Journal of Industrial Organization*, June 1989, 243–56.
30. Slade, Margaret E., "Conjectures, Firm Characteristics, and Market Structure: An Empirical Assessment." *International Journal of Industrial Organization*, December 1986, 347–69.
31. Sleuwaegen, Leo, "On the Nature and Significance of Collusive Price Leadership." *International Journal of Industrial Organization*, June 1986, 177–88.

32. U.S. Bureau of the Census. *1977 Census of Manufactures*. Washington, D.C.
33. Waterson, Michael. *Economic Theory of the Industry*. Cambridge: Cambridge University Press, 1984.
34. Weiss, Leonard W. and George A. Pascoe, Jr. *Adjusted Concentration Ratios in Manufacturing, 1972 and 1977*. Washington, D.C.: Federal Trade Commission, 1986.
35. Willner, Johan, "Price Leadership and Welfare Losses in U.S. Manufacturing: Comment." *American Economic Review*, June 1989, 604–09.