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LOOKING AT THE COST SIDE OF "MONOPOLY"*

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Welfare loss under oligopoly is defined as that part of consumer surplus which is lost and not regained by higher profits. In a model with asymmetric firms, this implies that the total welfare loss consists of the deadweight loss triangle plus a cost side inefficiency effect, due to the fact that in imperfect markets not all firms utilize the lowest cost technique. Using a flexible CV-model we calculate these effects empirically for two relatively homogeneous industries (pulp/paper and cement). The deadweight loss triangles are shown to be smaller than the cost difference effect ("the staircase") for these industries.

I. INTRODUCTION AND PLAN OF THE PAPER

IN THE LAST fifty years the dominant method to measure the welfare loss of monopoly has been to estimate the deadweight loss triangle. This method led to empirical estimates that the welfare loss was so negligible that, "if this estimate is correct, economists might serve a more useful purpose if they fought fires or termites instead of monopoly" (Stigler [1966, p. 34]). The main way to claim much higher losses has been to view all profits as losses; the reasoning behind this view is that profits must be used to establish or to retain monopoly power and are therefore a waste to society (Posner [1975]). A middle way has been to focus on extra cost components[1] which can be observed in monopolistic industries but are absent in a competitive environment (Cowling and Mueller [1978]).

This article focuses on the cost side of monopoly power, especially on differences in firms' costs, as signs of inefficiency or waste, which are (partly) due to a monopolistic market structure. If firms can potentially produce at different costs in an oligopolistic market, the toughness of competition (Sutton [1992]) determines the cost differences between active firms, and their persistence. If there are entry barriers and firms make

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[1] Sometimes these costs are called strategic costs of monopoly power, sometimes we speak about rents transformed into costs. Advertising and wage premia (perhaps due to unionization) are examples of these extra costs. Willner [1989] and Willner and Ståhl [1992] among others have pointed out that the low estimates of welfare loss may also be due to bad approximation and mismeasurement.

profits arising from market power, less efficient firms could stay in market. This represents a welfare loss as, in the absence of capacity constraints, their output could be produced at lower costs by the more efficient firms. Cost differences as part of the welfare loss have been addressed by Dixit and Stern [1982], and Daskin [1991]. However, a comparison of the relative size of the two components of welfare loss is not available so far[2].

The paper is structured as follows. In Section II, we present a flexible oligopoly model which will be used for the calculation of welfare losses on the demand side (deadweight loss triangle, DWT). On the cost side, we measure how large the cost difference is between actual costs and those which would exist if all firms used the most efficient technology (cost staircase, CST). And we relate our definition of welfare losses to the definition in the literature. Section III presents the data. We use firm data for two rather homogeneous product markets; namely, the pulp and paper industry and the cement industry in the European Union. Section IV presents the main results. In Section V, we test the robustness of our findings. Section VI discusses the merits and limits of our claim, that cost differences reflect a lack in competition typical for oligopolistic industries. In the last section, we draw tentative conclusions and address open questions.

The main innovation of the paper is the derivation of potential welfare losses of monopoly power in a consistent and flexible oligopoly model for the supply side, as well as for the demand side. We derive conditions under which the cost side inefficiency will theoretically be greater than the deadweight loss triangle, and compare the relative magnitude of the two components empirically for two industries for the European Union. The paper industry is characterized by intensive international competition, while less competition can be anticipated in the cement industry, due to greater transport costs. The tentative assumption that the European Union is the relevant market seems to be better for the pulp and paper industry than to assume national markets, but it is not fully justified for the cement industry.

[2] The first article focuses analytically on the welfare effects of trade, and compares general versus partial equilibrium results. Daskin [1991] presents a conceptual framework as well as empirical estimates for the overall—demand side and cost side—welfare loss using grouped industry data (US, 4-digit SIC industries, size groups) and stressing the dependence of the results on the price elasticity of demand. His estimate of roughly 6–10% of the combined welfare loss in his most plausible scenario is higher than the estimates in most previous studies. Holt [1982] analyses the welfare loss in a linear oligopoly model with asymmetric firms. He comes to the conclusion that the welfare loss arising from market power may be higher if the efficient firms are ready to enter, but the less efficient ones are not. Freyer [1992] points to a tougher competition policy in the US and UK in the early years of this century as encouraging consolidation. We thank an anonymous referee for this reference.

II. A MODEL FOR ESTIMATING WELFARE LOSSES

In this section, we present a flexible conjectural variation oligopoly model, in which firms' costs vary, and firms may also have different conjectures regarding their rivals' behavior. The conjectural variation model has been criticized for its ad-hoc assumptions concerning the conduct of firms, its lack of a game-theoretical foundation, and the pressing of dynamics into a static model (see, for example, Friedman [1983]). However, as Dockner [1992] and Cabral [1995] have pointed out, the conjectural variation model can be given a consistent theoretical foundation, if it is considered to be the reduced form of a dynamic game.[3] Our first step is to calculate the usual welfare loss on the demand side. This results in some sort of deadweight loss or Harberger triangle (DWT), although in our case, for a flexible oligopoly model, rather than for a monopoly model. As a second step, we support the case that the cost differences between firms are additional components of inefficiency. If we arrange the firms in an order according to their unit costs (starting with the most efficient and ending with the least efficient firm) we arrive at a step function, which can be illustrated as a "cost staircase" (CST). Together, the demand side deadweight loss triangle and the "cost staircase" are our estimate of total welfare loss under oligopoly.

DWT under oligopoly: Consider a market served by N firms each producing q_i units of a homogeneous good. Demand is given by $p(Q)$ with $Q = \sum_{i=1}^{N} q_i$ and elasticity of demand ε. We have unit (and marginal) costs of c_i, different for each firm i. Furthermore, we denote the Herfindahl Index of concentration by H and the elasticity of the conjectural variation by $\alpha_i = \frac{d\,log(Q-q_i)}{d\,log(q_i)}$. Aggregating the first order conditions for profit maximization over all firms using the market shares as weights gives a generalized version[4] of the Cowling and Waterson equation (Cowling and Waterson [1976], Clarke and Davies [1982]).

(1)
$$\frac{p-\bar{c}}{p} = \frac{\sum_{i=1}^{N}\alpha_i s_i + H - \sum_{i=1}^{N}\alpha_i s_i^2}{\varepsilon} = \frac{\tilde{H}}{\varepsilon} \text{ with}$$
$$\bar{c} = \sum_{1}^{N} c_i s_i,\ s_i = \frac{q_i}{Q},\ \tilde{H} = H + \sum_{i=1}^{N}\alpha_i s_i(1-s_i)$$

[3] Dockner [1992] derives a conjectural variations equilibrium as the steady state of a subgame perfect (closed loop) Nash-equilibrium in a non-cooperative differential game with adjustment costs. This model gives a theoretical foundation for negative conjectural elasticities and so explicitly excludes the possibility of collusion. Cabral [1995] formulates a supergame and shows that the Nash-equilibrium with the highest joint profits is equivalent to a conjectural variations equilibrium with strictly positive conjectural elasticity depending on the discount factor. Thus the static conjectural variations approach is justified if it is interpreted as a long-run solution or reduced form of a dynamic game.

[4] The generalization goes in two directions. First, we allow conjectures about rivals' behavior, then we allow these conjectures to differ between firms.

The price cost margin is proportional to the Herfindahl index, adjusted for the influence of conjectures. The adjustment is positive if conjectures are more collusive than in the Cournot case, the adjustment term declines with the numbers of firms and their asymmetry in size.

In the first step, we use this result to obtain the demand side welfare loss (DWT). The DWT generally is defined by (2), where p^c is the price of the competitive reference scenario, which will be specified below. The DWT is usually measured in percentage of sales and approximated linearly (2′), following Harberger [1954].

$$\text{(2)} \qquad \text{DWT} = \frac{1}{pQ}\int_{p^c}^{p} q(\tau)d\tau - \frac{p-p^c}{p}$$

$$\text{(2′)} \qquad \text{DWT} = \frac{1}{2pQ}\Delta p \Delta Q = \frac{1}{2pQ}(p-p^c)\Delta Q$$

Using the definition of the demand elasticity (in absolute terms) $\varepsilon = \left|\frac{\Delta Q/Q}{\Delta p/p}\right|$ to approximate the quantity change in response to a decrease in price to p^c, as well as condition (1) to substitute for ε, we get a linear approximation of the corresponding change of quantity:

$$\text{(3)} \qquad \Delta Q = \frac{\Delta p}{p} Q\varepsilon = \frac{p-p^c}{p-\bar{c}}\tilde{H}Q \text{ using } \varepsilon = \frac{p\tilde{H}}{p-\bar{c}} \text{ from (1) and } \Delta p = p - p^c.$$

In the next step, substitute (3) in (2′) to derive a generalization of the Cowling and Mueller formula:

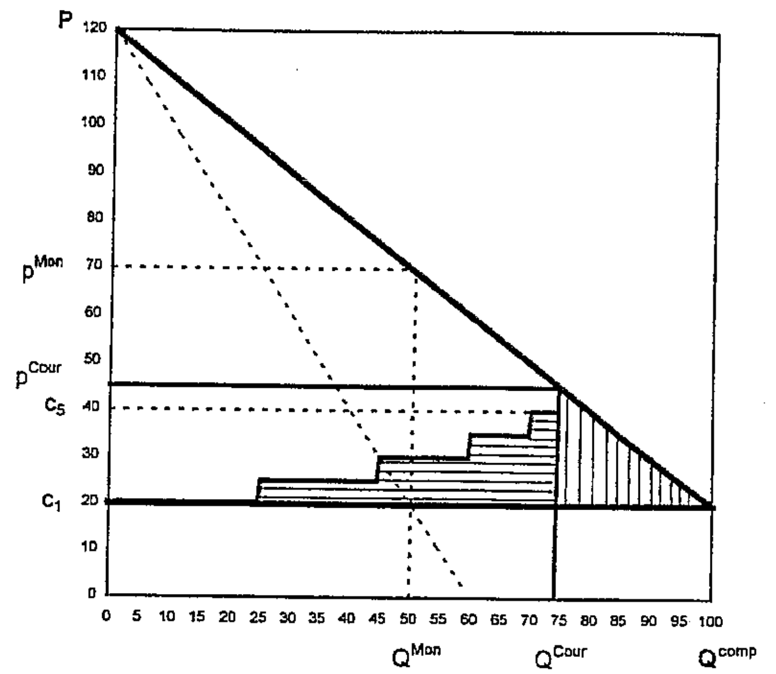
$$\text{(4)} \qquad \text{DWT} = \frac{1}{2}\left(\frac{p-p^c}{pQ}\right)\Delta Q = \frac{1}{2}\left(\frac{p-p^c}{p}\right)\frac{p-p^c}{p-\bar{c}}\tilde{H}$$

As an alternative to (4), which we will use below, we can derive ε from the first order condition of the most efficient firm. In the case analyzed below the reference price corresponds to the marginal costs of the most efficient firm, i.e. $p^c = c^*$, and $\Delta p = p - c^*$:

$$\text{(3′)} \qquad \Delta Q = \frac{p-c^*}{p} Q\varepsilon = Q(s^* + (1-\alpha^*)s^*) \text{ using } \varepsilon = \frac{p(s^* + (1-\alpha^*)s^*)}{p-c^*}.$$

$$\text{(4′)} \qquad \text{DWT} = \frac{1}{2}\left(\frac{p-p^c}{pQ}\right)\Delta Q = \frac{1}{2}\left(\frac{p-p^c}{p}\right)(s^* + (1-\alpha^*)s^*)$$

In equation (3′) and (4′) c^* denotes the marginal cost of the most efficient firm, s^* its market share and α^* its conjectural elasticity. Compared to the DWT for the monopoly model, $\text{DWT} = \frac{1}{2}\left(\frac{p-p^c}{p}\right)$, DWT under oligopoly is much smaller than even the small monopoly triangle. The triangle shrinks with lower concentration and a more aggressive behavioral mode (lower elasticity of perceived demand and higher $\tilde{H}$). Here, we additionally have a partly countervailing factor $(p-p^c)/(p-\bar{c})$ which is greater than one,



Demand: $p(Q) = 120 - Q$, marginal costs: $c^* = c_1 = 20, c_2 = 25, c_3 = 30, c_4 = 35, c_5 = 40$

cost staircase

deadweight triangle

Figure 1
Deadweight loss and "staircase" in a linear Cournot-oliogopoly with 5 firms.

since in general, the reference price p^c is lower than the weighted average costs under oligopoly[5]. Figure 1 gives an illustration for 5 firms and linear demand.

A crucial point is now to make an assumption about the reference price. This is an assumption about the relation between average costs in the active group of oligopolistic firms versus costs in the hypothetically existing competitive group. Usually a comparison of monopoly and competition is based on the assumption of identical cost functions in these two market forms[6]. In an asymmetric oligopoly this is not an option. Joint profit maximization allows firms with different costs to coexist under a broad range of circumstances; Cournot strategies transfer differences in efficiency into market shares. The homogeneous Bertrand model with

[5] Note, we refer to the average of unit costs across firms.

[6] Only under identical cost functions is the deadweight loss a comprehensive measure of the difference in total surplus between monopoly (or oligopoly) and competition. If costs are lower under a monopoly, a gain in productive efficiency has to be traded off against the welfare loss due to the monopoly pricing rule; if costs are higher under a monopoly, productive inefficiency and allocative inefficiency are two additional components of total welfare loss.

constant marginal costs, allows profits for the most efficient firm supplying the entire market, amounting to the cost differential with respect to the second most efficient firm. On the other hand, if all firms were equating prices and marginal costs, and entry were driving down the market price to the minimum of average costs, we could see no differences in unit costs. If we follow Sutton's hierarchy of markets with increasing competitiveness, we see that cost differences are more likely to occur for less competitive market structures.[7] We follow Dixit and Stern [1982] and Daskin [1991] in assuming that in the competitive case, costs and therefore the reference price p^c will be equal to the cost of the most efficient firm active in our asymmetric oligopoly (firm with the lowest marginal costs, c^*). This is the most plausible choice if we define the reference scenario as the long run equilibrium of a competitive market with free entry or a Bertrand competition in homogeneous goods. Here all firms have to use the most efficient technology otherwise they exit, any residual differences revealed by data have to be rents to a specific factor like managerial skills (firms with suboptimal management are eventually challenged by takeovers). We will return to this point in Section VI.

The cost "staircase": Given an understanding about the reference price it is relatively easy to estimate the cost side welfare loss. It is that part of the consumer surplus, which is lost due to the higher price, but not regained by producers due to cost inefficiency. This is done by arranging firms in increasing order of their c_i's, and then calculating the area between the step function, drawn by the unit costs, and the cost floor, which is defined by the most efficient firm. This area looks like a "staircase": the stairs have different length according to the individual firms' production volume q_i. The height of each stair is the cost difference between two neighboring firms (firms are arranged according to unit costs). The total height of the "staircase" is the difference between the most efficient and the most inefficient firm in the market.

Formally the "staircase" is defined (in relation to sales) as

$$(5) \qquad \text{CST} = \frac{(p-p^c)Q}{pQ} - \frac{1}{pQ}\sum_{i=1}^{N}\Pi_i = \frac{p-p^c}{p} - \sum_{i=1}^{N}\frac{p-c_i}{p}s_i = \frac{p-p^c}{p} - \frac{p-\bar{c}}{p}$$

[7] On the empirical side there are many reasons why unit costs can be different between firms in the short run. There can be economies of scale, so that larger firms have lower unit costs. Some firms may have less efficient reserve capacities, which they use in periods of high demand. Regarding to the first possibility, we defend roughly constant costs in the model by the fact that steep economies of scale in a rather homogenous market would quickly eliminate the smaller firms. The second fact which was addressed in Rees [1993] and raised by Michael Waterson in a discussion with the authors is potentially interesting if the information on efficiency on the level of individual plants is available. In our method of calculating ex post costs by balance sheet data, the inefficiency of the older plants will not influence the data too much, since the data probably do not include depreciation for the old occasionally used plants.

Equation (5) is simple and instructive. The cost side deadweight loss is the price difference between oligopoly and the reference price minus the average margin of all firms with higher marginal costs than the reference price (both are measured relative to p). This leads to the question, why some firms have lower costs. The Schumpeterian view, popular in models of international trade, is that some firms innovate and achieve a cost advantage for some limited time. In this case, cost differences may not be seen as inefficiency, but as the consequence of progressive, innovating firms. We feel that the Schumpeterian view explains a very important part of the international competitive game. We do not believe, however, that it is specifically important for the industries we have chosen: the paper industry as well as the cement industry are rather mature industries in which access to the latest technology is relatively free. Product innovation is not too important, process innovation is embodied in plants and machinery supplied by global producers. Own research is relatively low, and cost differences are relatively stable and persistent over years. These facts lead us to the view, that innovation based cost differences may not be too large in these industries.

Whatever the reason for these cost differences, the question why the cheapest firm does not capture the entire market must be addressed. It could be diseconomies of scale or some exogenously given capacity constraint, like in the case hydroelectric power generation or in mining firms. The second reason is less likely in the industries chosen. Diseconomies of scale existing on the plant level can often be circumvented at the firm level if a firm builds different plants at different locations or just add one module to existing ones. Many large paper and cement companies operate more than one plant at various locations, many paper mills have several large machines running concurrently at one site. Voluntary output restriction—intended to maximize profits on an oligopolistic market in a cooperative or a collusive regime—remains the most plausible reason. In this case it is again better to incorporate cost differences into the welfare loss, even if some of them reflect returns on innovation and are less critical than other rigidities.

Relation of the model to the literature: Our calculations of the DWT have in principle the same initial approach to defining monopoly power as Harberger [1954] and Cowling and Mueller [1978]. Both papers stick to the monopoly model, and use a linear approximation. They arrive at the same formula (4) (setting $\tilde{H} = 1$ and $p^c = \bar{c}$). In making this operational, Harberger [1954] uses "outside" information to defend that $\varepsilon = 1$ may not be a bad approximation. However, this elasticity is not compatible with profit maximization, which implies $PCM = 1/\varepsilon$. Therefore, whenever data reveals that $PCM < 1$ (or equivalently a cost share is larger than 0), ε cannot be equal to one. Cowling and Mueller [1978] circumvent these problems by estimating ε from the first order condition for profit maximization in a monopoly, demonstrating that the welfare loss amounts to $\pi/2$ (half of profits, independent of the demand elasticity). This is consistent with profit maximization. However, Cowling and Mueller [1978] have the problem that the demand elasticity implied in their empirical data appears improbably high.[8] Our innovations are to derive the DWT explicitly from a flexible oligopoly model, and to add the cost staircase to arrive at a total welfare loss. How important the addition of the second component is will be judged on the theoretical level and on the empirical level.

III. THE DATA AND THE OPERATIONALIZATION OF THE CONCEPT

We use balance sheet data derived from "Standard and Poors Global Vantage Data Bank" for our empirical research. The database contains detailed information on about 10,000 primarily larger firms in 60 countries. We use the European Union in its present form with 15 countries as the geographic dimension of our market. National markets seem today to be a too narrow concept; most of the larger firms produce and sell in more than one country, especially within the area of the European Union. We intentionally choose rather narrow, "well defined", homogeneous industries, since we are testing a homogeneous model. The pulp and paper industry is used to exemplify an industry engaged in intensive international trade, whereas the cement industry is faced with limited geographical competition. In order to eliminate short run fluctuations, we have taken a 5 year average, 1989–1993. Data for 15 firms in the paper industry, and 17 in the cement industry are available. We know from other sources that there are many more firms producing in the two markets, but comparing "Fortune - 500" statistics with the firms in the data bank shows that we have a representation of the largest firms. Our sample covers 45% of industry sales in the pulp and paper industry, and 94% in the cement industry[9]. All in all, our set of data is far from

[8] They acknowledge the problem (in Cowling and Mueller, [1981]) and explicitly derive the conclusion that under oligopoly the problem will be mitigated (smaller DWT and smaller implied elasticities), although their calculations still refer to the monopoly model and to the demand side only.

[9] The lower degree of representation for the paper industry is partly due to the existence of holding companies. Robustness calculations were made (see chapter 5), which include the holding companies. In general the missing firms are comprised of several groups: small firms, diversified firms, and firms missing by accident. The absence of smaller firms does not hurt too much, because the performance measure, as well as the Herfindahl, is most heavily influenced by larger firms. The diversified group is a specific problem. If a firm is producing for different product markets, we would like to disaggregate the sales. Including the total sales of the diversified firms would result in an upward bias, excluding the sales of the diversified firms, on the other hand, would incur a downward bias. The latter problem may be mitigated by the fact that some of the firms in our narrow sample may have out of industry sales, also. The third group which is omitted includes those firms which did not report consistently, which changed their scope of activities, were involved in mergers, or went bankrupt.

being ideal, but we share this problem with many other empirical studies. What we can do, is to test the robustness of our results.

A sensitive task is defining a proper measure of profits. We define costs as the sum of expenditures on material, wages and interest, and divide these expenses into sales to calculate unit costs. This provides us with a gross concept of the margin (the difference between sales and costs is divided by the sales). It forms an upper bound, neglecting the opportunity cost of equity, as well as depreciation. While this is not the only approach used in the literature, it is quite a common starting point. We then search for proxy opportunity costs of equity, hopefully ones under competition. We know from the theory of international competition, and from empirical studies in European countries, that apparel industries in particular are currently confronted with fierce competition by low cost countries. The data verify these observations. Therefore, we select returns on equity in apparel industries as one way of attaining a proxy for opportunity costs of equity, amounting to 18.24%. Alternatively we used the average returns on long-run ECU-bonds, amounting to 9.29%, as a measure of the opportunity cost of invested capital[10]. We will label the three proxies with $k = 1, 2, 3$, and present the empirical estimates for opportunity cost to be zero ($AP1_1$), to be 9.29% ($AP1_2$), and 18.24 ($AP1_3$).

Table I summarizes the formulas we used. We define the following symbols:

$$c^* = min[c_i],\ PCM^* = \frac{p - c^*}{p},\ PCM^{WM} = \frac{p - \bar{c}}{p},\ PCM_k^L = \frac{RE_k^* E}{S},$$

$RE_k = 0, 9.26$ or 18.24 for $k = 1, 2, 3$

PCM^*	= margin of the most efficient firm
PCM^{WM}	= weighted mean of margins (over firms, market shares = weights)
S	= sales
E	= equity
RE	= returns on equity in apparel or returns on ECU-Bonds
PCM_k^L	= long run competitive price cost margin under k=3 alternative assumptions on the opportunity costs of invested equity capital

We start the models presented here with two Harberger type (H_1-H_3) estimates. Harberger type means that perfect product differentiation is assumed (monopoly of each firm) and that the deadweight loss triangle is calculated as a weighted average of the DWT's caused by each firm. Additionally, $\varepsilon = 1$ is assumed. Then we present three Cowling and

[10] Either of these approaches seemed to us more promising than the declaration of a "plausible rate for a competitive return". For an alternative, which implements stock market returns, see Cowling and Mueller [1978].

TABLE I
CALCULATION OF THE WELFARE LOSS

Harberger:

H_k: $\sum_{i=1}^{n} s_i(PCM_i - PCM_k^L)^2 \varepsilon_i, \varepsilon_i = 1$ with $PCM_i - PCM_k^L = 0$ if $PCM_i < PCM_k^L$

Cowling-Mueller:

CM_k: $\frac{1}{2}\sum_{i=1}^{n} s_i(PCM_i - PCM_k^L)$ with $PCM_i - PCM_k^L = 0$ if $PCM_i < PCM_k^L$

Deadweight loss triangle-linear approximation, Equation (4):

$AP1_k$: $\frac{1}{2}\frac{(PCM^* - PCM_k^L)^2[\alpha + (1-\alpha)H]}{PCM^{WM} - PCM_k^L}$ with $PCM_i - PCM_k^L = 0$ if $PCM_i < PCM_k^L$

Efficiency-"staircase", Equation (5)

$AP2_k$: $PCM^* - PCM_k^L - \sum_{i=1}^{n}(PCM_i - PCM_k^L)s_i$, with $PCM_i - PCM_k^L = 0$ if $PCM_i < PCM_k^L$

Mueller type models (CM_1-CM_3), which means that we still assume the monopoly model, calculate the market share weighted DWT, but use the implied estimate of ε, which is consistent with the theoretical model. What follows, is the estimation of our oligopoly model, with consistent implied elasticity, called $AP1_k$, (DWT with linear approximation; letters according to the initials of the authors of this paper) and our estimation of the cost side effect $AP2_k$.

Additionally, we derive upper and lower bounds of the DWT by calculating the minimal and maximal CV-parameter consistent with the data.

IV. THE MAIN RESULTS

The Harberger estimates in Table II are 0.44% for the paper industry and 0.93% for cement, if we assume the opportunity cost to be zero. They amount to 0.06%, resp. 0.09%, if we assume the reference opportunity cost for equity to be 18.24%. This replicates the extremely small welfare losses in all Harberger-type studies. The results are likely to be overestimations, since the model assumes perfect product differentiation and thus monopoly of each of the 15 (17) firms. On the other hand, the enforced elasticity of 1, is clearly at odds with the monopoly model plus a PCM of 8.95% in the paper industry and 12.95% in the cement industry. Only elasticities of 5 and 10 are consistent with the monopoly formula. The Cowling and Mueller results are 4.48% for paper and 6.48% for cement, for the zero

TABLE II
DEADWEIGHT LOSS TRIANGLE AS A SHARE OF MARKET SALES, TRADITIONAL METHOD, AVERAGE 1989–1993, % SALES

	SIC 2621-2631 *Pulp and paper mills*	*SIC 3241* *Cement*
Firms	15	17
Herfindahl	0.11	0.17
Highest PCM	17.51	30.55
Average market share weighted *PCM*	8.95	12.95
Lowest *PCM*	3.06	6.90
Harberger, H_1 ($RE = 0$)	0.44	0.93
Harberger, H_2 ($RE = 9.29$)	0.18	0.25
Harberger, H_3 ($RE = 18.24$)	0.06	0.09
Cowling-Mueller, CM_1 ($RE = 0$)	4.48	6.48
Cowling-Mueller, CM_3 ($RE = 9.29$)	2.67	4.04
Cowling-Mueller, CM_2 ($RE = 18.24$)	1.11	1.81

opportunity cost estimation; and 1.11% versus 1.81% for opportunity costs of 18.24%. Now the elasticity is automatically consistent with the model, however the monopoly assumption is still unrealistic. The implied elasticity is rather large, as compared to what economists consider to be a sensible price elasticity. This is the problem recognized by Cowling and Mueller [1981] for this style of analysis.

For our method we consider $AP1_2$ and $AP2_2$ with $\alpha = 0$ in Table III as our favorite estimates for the two components of the total welfare loss. This means we interpret the results for the medium opportunity cost of capital, for Cournot conduct and the linear approximation. All these choices will be changed in the next section. The demand side welfare loss

TABLE III
WELFARE LOSS IN OLIGOPOLY, $AP1_2$ AND $AP2_2$, AVERAGE 1989–1993, % OF SALES, LINEAR APPROXIMATION

	α	ε	DWT	CST	TOTAL
			$AP1_2$	$AP2_2$	$AP1_2 + AP2_2$
Pulp and paper mills	-0.13[a]	—	0.00	7.93	7.93
	0.00	2.11	1.85	7.93	9.78
	0.33[a]	7.54	6.63	7.93	14.56
Cement	-0.20[a]	—	0.00	7.66	7.66
	0.00	2.07	2.56	7.66	10.22
	0.42[a]	6.36	7.87	7.66	15.53

[a] The lower and upper bound of α is defined by (6) and (7) below, respectively.

(DWT in the version of AP_1) is 1.85% for paper and 2.56% for cement. These numbers are comparable to other studies. The supply side welfare loss (CST in the version of AP_2), 7.93% for paper and 7.66% for cement, is considerably larger. The combined loss is 9.78% resp. 10.22% for this version. The main results are the following two: the cost staircase is definitely greater than the deadweight loss and the total welfare loss is larger in the cement industry than in the paper industry. The first tendency is due to the fact that the cost differences are rather large, while the industries analyzed are far from having a monopoly.[11] The second result, the higher DWT in the cement industry can be attributed to the higher margin in the cement industry. It is perhaps, slightly overestimated, since transport costs are more important and regional markets may exist in this industry.

V. ROBUSTNESS, RELATION TO LITERATURE, LIMITATIONS

We checked the robustness of the two main results by changing concepts and models along several lines. All tests which are not published here are available from the authors at request.

Robustness and approximation: To assess the accurateness of the linear approximation we additionally calculated the demand side DWT with constant elasticity of demand[12] (Table IV). The constant elasticity approach gives comparable results for small and intermediate elasticities, but estimates a higher DWT for larger elasticities, as expected.

Robustness and conduct: The results in Table III, IV, and V provide also calculations for the upper and lower bounds for the conjectural variation parameter. The more collusive the markets are, the higher the deadweight triangle. For the upper bound of feasible α, the DWT equals or comes near to the CST; for low values, DWT approaches zero. The lower bound of α can easily be found from (1) and the condition that individual and average price cost margins have to be positive. With this lower bound the average firm will break even, but some less efficient firms will not. Our lower bound estimates thus rest on a too small α and the zero lower bound of the

[11] More formally, condition (8a′) in the appendix states a sufficient condition for the CST to be larger than the DWT namely that the price cost margin of the most efficient firm is more than twice the weighted average. The most efficient firm in both, the pulp and paper and the cement industry exhibits a price cost margin slightly below this benchmark.

[12] With constant elasticity of demand, the demandside DWT can be calculated directly from (2):

$$AP1'_k : \frac{1}{pQ}\int_{c^*}^{p} K\tau^{-\varepsilon}d\tau = [\frac{1}{1-\varepsilon}][1-(1-(PCM^* - PCM_k^L))^{1-\varepsilon}]$$

and

$$\frac{1}{pQ}\int_{c^*}^{p} K\tau^{-\varepsilon}d\tau = ln(\frac{1}{1-(PCM^* - PCM_k^L)}] \text{ if } \varepsilon = 1$$

TABLE IV
WELFARE LOSS IN AN OLIGOPOLY:
ROBUSTNESS FOR ALTERNATIVE OPPORTUNITY COSTS AND NON LINEARITY

			Linear Approximation					*Linear Approximation*					*Constant elasticity*	
	α[a]	ε	DWT	CST	TOTAL	α[a]	ε	DWT	CST	TOTAL	α[a]	ε	DWT	TOTAL
			$AP1_1$	$AP2_1$	$AP1_1 + AP2_1$			$AP1_3$	$AP2_3$	$AP1_3 + AP2_3$			$AP1'_1$	$AP1'_1 + AP2'_1$
Pulp and	−0.13[a]		0.00	8.55	8.55	−0.13	—	0.00	6.96	6.96	−0.13	—	0.00	8.55
paper mills	0.00	1.26	1.92	8.55	10.47	0.00	5.08	2.14	6.96	9.10	0.00	1.26	2.22	10.77
	0.45	5.71	8.76	8.55	17.31	0.15	10.90	4.59	6.96	11.55	0.45	5.71	13.83	22.38
											−0.03	1.[b]	1.74	10.29
Cement	−0.20		0.00	17.59	17.59	−0.20	—	0.00	7.18	7.18	−0.20	—	0.00	17.59
	0.00	1.29	6.01	17.59	23.60	0.00	4.61	2.69	7.18	9.87	0.00	1.29	7.89	25.48
	0.31	3.27	15.27	17.59	32.86	0.20	9.26	5.40	7.18	12.58	0.31	3.27	26.21	43.80
											−0.04	1[b]	5.90	23.49

[a] The lower and upper bound of α is defined by (6) and (7) below, respectively.
[b] Here, the elasticity is exogenously assumed to be 1 and the consistent α is derived.

TABLE V
WELFARE LOSS IN AN OLIGOPOLY,
PULP AND PAPER: ROBUSTNESS WITH RESPECT TO THE MISSING FIRMS

		Scenario 1					Scenario 2					Scenario 3		
α[a]	ε	DWT	CST	TOTAL	α[a]	ε	DWT	CST	TOTAL	α[a]	ε	DWT	CST	TOTAL
		$AP1_2$	$AP2_2$	$AP1_2+AP2_2$			$AP1_2$	$AP2_2$	$AP1_2+AP2_2$			$AP1_2$	$AP2_2$	$AP1_2+AP2_2$
−0.04	—	0.00	10.97	10.97	−0.06	—	0.00	7.93	7.93	−0.04	—	0.00	3.40	3.40
0.00	1.62	1.42	10.97	12.39	0.00	1.07	0.94	7.93	8.87	0.00	0.37	0.33	3.40	3.73
0.14	7.54	6.63	10.97	17.60	0.37	7.54	6.63	7.93	14.56	0.78	7.54	6.63	3.40	10.03

[a] The lower and upper bound of α is defined by (6) and (7) below, respectively.
Scenario 1: $PCM - PCM_2^L$ of the missing firms is 0%: 20 missing firms with size corresponding to sample average, $H = 0.04$
Scenario 2: missing firms are a replication of firms in the sample, $H = 0.06$
Scenario 3: $PCM - PCM_2^L$ of the missing firms: 13.26% (most efficient firm): 20 missing firms with size corresponding to sample average, $H = 0.04$

DWT is somewhat too low. The upper bound for α is derived from the fact that DWT is bounded from above by the DWT which would be observed under monopoly of the most efficient firm. Formally we have

$$(6) \qquad \frac{p-\bar{c}}{p}=\frac{\alpha+(1-\alpha)H}{\varepsilon}\geq 0 \Leftrightarrow \alpha \geq \alpha_{LOW}=-\frac{H}{1-H}$$

$$(7) \qquad \mathrm{DWT}_{max}=\frac{1}{2}\left(\frac{p-p^c}{p}\right)\geq \frac{1}{2}\left(\frac{p-p^c}{p}\right)\frac{p-p^c}{p-\bar{c}}\tilde{H} \Rightarrow \alpha \leq \alpha_{HIGH}$$

$$= \left[\frac{PCM^{WM}-PCM_k^L}{PCM^*-PCM_k^L}-H\right]\frac{1}{1-H} \text{ since } \tilde{H}=H+\alpha(1-H)$$

A specific level of α implies a specific market elasticity of demand, the theoretically feasible upper bounds[13] yield values for ε, which are higher than most economists would think as reasonable. We conclude that for realistic conduct parameters, CST is larger than DWT.

Robustness and opportunity costs: We presented the results for opportunity costs equal to the riskless return, alternatively for the returns realized in the apparel industry. Again, CST is much larger than DWT for all realistic α and ε, and the welfare loss in the cement industry is larger than that in the paper industry.

The relevant market: A problem always present in industrial organization is the proper specification of the market. We have some firms which produce other products jointly with paper resp. cement, and we also have diversified conglomerates and/or holding companies, whose activities are centered in the paper and cement industry, but which produce for different product markets, also. We added holding companies and diversified companies, but this did not change the essence of the results.

The missing firms: In the pulp and paper industry we have a coverage in terms of sales of less than 50 %. We have to demonstrate that this does not change our main results. The "Fortune - 500" statistics indicate that our sample includes nearly all of the larger firms. We had calculated the Herfindahl from the firms in our sample, since we do not know the size distribution of the missing firms[14]. To test the influence of market size and firm asymmetry we reestimated the DWT and the CST for the paper industry under three assumptions about the missing firms. In Table V,

[13] The assumption of a constant α across firms, however introduces some error and does affect the DWT as the monotone relationship between margins and market shares as implied by (1) does not exactly hold for our data. From (1) and (4) we see that the DWT is somewhat underestimated if conduct is more collusive than Cornout and the α_i's are positive. In general the error also depends on the distribution of marginal costs (Clarke and Davies [1982]) and from (5) we see that the CST remains unaffected by this assumption.

[14] To the extent that holding companies and diversified firms exist, we additionally do not know the exact market size.

scenario 1 assumes that all the missing firms have the margin of the least efficient firm in our sample, Scenario 3 that all have the margin of the most efficient firm. Scenario 2 assumes that the missing firms replicate the sample firms (in size and cost heterogeneity) in a way that total sales correspond to total EU-sales. The effect of the missing firms on the demand side is primarily to decrease the Herfindahl, if firms are smaller than under our three assumptions (which is probably true) this effect is stronger than shown by our assumption. The results of the exercise demonstrate that our estimates are quite robust. The CST is larger than the DWT under plausible assumptions about the CV-parameter; it ranges between 3.40% and 10.97%. The already small DWT shrinks.

VI. COST ASYMMETRIES AND WELFARE LOSS: DISCUSSING OUR APPROACH

The essential feature of our theoretical approach is our claim that cost differences between firms reveal a lack in competition. Given that product differentiation is not too important in the analyzed markets, our data show that an efficient technique apparently available in the market is not used by all firms. Our empirical estimates then indicate that this effect is large and outweighs the demand side deadweight triangle. We now discuss the limits to the claim that any cost differences revealed by data will constitute a welfare loss.

The first objection parallels the discussion of productive efficiency versus allocative efficiency in monopoly. Our "staircase" is unambiguously a welfare loss, as long as it is located between the floor of the competitive price and the ceiling of the oligopolistic price. If the "height" of the total staircase exceeds the span between this floor and this ceiling, so that the most efficient firm has lower costs than a "potentially existing" competitive crowd, then the evaluation becomes more complicated. We may have an "efficiency gain" of oligopoly, at least for the most efficient firms. This must be traded off against the demand side loss. Nevertheless even in that case the data indicate[15] that there exists a best technology (maybe available only due to oligopolization), which is not used, so that at least a potentially higher productive efficiency is lost.

[15] Under the assumption of product homogeneity we could say that the data reveal that technologies with different efficiency are in actual use. If product heterogeneity is present, it could be that different unit costs reflect vertical or horizontal product differentiation. This aspect was stressed by an anonymous referee, for which we are very grateful. Nevertheless we believe that this tendency may be limited specifically in our industries (see later). On the theoretical level the effect is limited since vertical product differentiation implies usually that a higher value has to be bought by higher costs (if these effects are parallel, the unit costs do not change). In the case of horizontal product differentiation demand must be very different in the submarkets to allow different unit costs.

We already addressed the possible existence of innovation rents in section II. Furthermore, note that even under competition there may be cost variance coming from differences in managerial ability. These rents are however continuously challenged by takeover threats. An argument specifically relevant for two capital intensive industries like paper and cement may be that firms are stuck in specific technologies. If a major process innovation opens a low cost technology, in the short run old plants and new plants competing at different costs may be the result of an optimal replacement strategy and not of inefficiency. In a strictly competitive market the low cost firms however should gain market shares quickly increasing the pressure for rapid installment of the new technology. The same holds true for concentrated industries with significant, but exhausted scale economies, like pulp and paper and cement, engaging in price competition. In the medium and long run less efficient firms have to adopt the new technology or drop out of the market as fierce competition and entry drive profits down to zero. In this competitive world firms are forced to produce at the minimum efficient scale guaranteeing a feasible and efficient industry configuration (Panzar [1989]) without significant differences in unit costs. In a coordinated market in contrast, market shares may remain stable e.g. by the threat that next time another firm will install a low cost technique. Coordination seems plausible since there was no dramatic change in the technology of the industries investigated and our data (we use firm data) do not reveal any change in the industry configuration.

We infer cost differences from differences in price cost margins. This approach relies crucially on the law of one price. Consequently the product must be homogeneous, and the market international. To account for problems with heterogeneity we intentionally chose two industries with mature and rather homogeneous products. However, what is relatively homogeneous from a cross section perspective is never homogeneous for the branch experts. The paper market splits into a market of newsprint, printing and writing, tissue and packaging[16]. Most of these product lines are not substitutable in consumption or in production. The price differences are however relatively small, usually less than 1 : 2 between the cheapest type and the most expensive, and prices are rather similar across

[16] Printing and writing paper may be disaggregated in woodfree and non woodfree paper, each again into coated and uncoated. Packaging paper may be subdivided into kraftliner and board. More information about the structure and heterogeneity of the paper industry is provided in an appendix, which is available on the JIE website.

countries[17]. Even price spans of this mild kind would impose a problem for our approach, if differences in price cost margins would reflect to a large extent product differentiation. Two arguments indicate that this should not be the case. Firstly, experts in the paper technology report that higher values (prices per ton) have to be bought by higher costs (investment costs and material costs). Production of woodfree printing paper, for example, is more expensive than production of newsprint. Secondly, most firms in our sample are not specialized in one submarket, but own plants producing different quality and types of paper.

There are also arguments as to why our approach may underscore the efficiency loss. If the "staircase" is very flat even the most efficient firm is less efficient than the potential competitive group. Consequently, our reference price is too high, and the cost inefficiency is underscored. This can especially be the case, if there are extra costs of oligopoly, such as advertising, wage rents, or monopoly preserving techniques[18].

With many other studies, we share the problem that we are using a partial equilibrium model. General equilibrium considerations tend to reduce the efficiency losses derived from partial equilibrium models (as shown in Holt [1982]). Hopefully this effect will not be too predominant in our specific mature industries. The estimates could be changed if we knew more about these firms' fixed costs (Martin [1993], Aiginger and Pfaffermayr [1997]).

[17] The most comprehensive information about relative homogeneity across different industries is to calculate the unit value (sales per weight) of exports. Homogeneous industries will have a low variation of export prices across countries, and within the industry. The standard deviation of the export prices across the fifteen EU countries is 0.413 for paper and 0.171 for cement. It is 2.499 for shoes, 7.423 for power engines, 23.194 for computers. The difference between subcategories (total EU exports, within variation) is again low. On the cement market the trade statistics differentiates into two submarkets (SITC 6624 and SITC 6623), the price difference is less than 1:2 namely 0.181\$/weight to 0.344. In the pharmaceutical market the unit values of the subindustries differ between 0.036 and 0.439, in the machine industry between 3.468 and 90.918. Thus in a hierarchy of industries ranked according to heterogeneity paper and cement will be placed at the low end. Comparing these price differences with that in price cost margins (amounting to 5.7:1 in the pulp and paper industry and 4.4:1 in the cement industry) indicates that the main source of variability in profits is not product heterogeneity but cost differences.

[18] We cannot rule out that part of the cost differences are "strategic costs" of oligopoly like advertising, expenses to preserve oligopoly etc. If these costs differ widely across firms then the cost increasing tendency of monopoly (stressed vigorously in the papers of Cowling and Mueller) may be (partly) reflected in our staircase. Yarrow [1985, p. 529] refers to the possibility that collusive solutions to the price- output subgame produce intensive competition in the earlier stages of the game " . . . leading to a transformation of monopoly rents into costs".

VII. CONCLUSIONS

We propose to add a cost inefficiency effect to the well known deadweight loss of oligopoly. The new component is the inefficiency arising from the fact that a low cost technique exists, but this technique does not spread rapidly across firms. Graphically, we can rank the firms, from low to high unit costs, creating an illustration which depicts a staircase. Cost differences between active firms are addressed in the literature on the production frontier, but not in the discussion on welfare losses due to monopoly. We apply our model to two rather mature industries in the European Union, one assumed to be very competitive due to intensive international competition (paper), and one supposed to be concentrated on limited geographical markets.

Empirically, our estimates for the cost side inefficiency are definitely larger than those for the demand side loss. This result is quite robust, since the cost differences of active firms are rather large and persistent over time. The exact magnitude depends on conduct, elasticity and the opportunity costs of capital, too, but in our favorite estimates, the "staircase" is 7.93% for paper and 7.66% for cement, while the demand side loss is 1.85% resp. 2.56%. This indicates that the staircase might be four or three times as large as the DWT. We carefully tested the robustness of our results by changing the concept for the opportunity costs, the range of firms included, and the conjectures about rivals. The results seem to be very robust.[19]

We have to acknowledge the limits of our approach. We share with many studies the fact that balance sheet data do not report economic profits, and data for some firms is missing. We are confident that the European Union is the relevant geographic market for the paper industry, for cement this is clearly not the case (though firms conquer ever larger market areas by acquiring existing or building new plants). The theoretical model used may not be fully appropriate, though we have tried to use a rather flexible one. It is a partial equilibrium model and we have assumed identical conjectures across firms in the empirical analysis. The results depend on the crucial assumption of how costs under an existing oligopoly relate to the unknown costs of a non existing competitive market. We do not claim that all the differences in costs across firms reflect welfare losses and that our concept focusing on rather mature, homogeneous industries can easily be employed to analyze other industries. Cost differences may come from innovation, from the lumpiness of the investment process, from

[19] It is fascinating that our results for different product markets, a different geographical area and a different time, replicate the flavor of the earlier results: the deadweight loss is less than 1% for our estimates along the Harberger line, and between 1% and 6% along the Cowling and Mueller line. Concepts seem to determine more about the demand side DWT than the data.

product heterogeneity not fully reflected in costs, from reporting behavior, etc. But, the cost differences are large and persistent, so that the cost staircase remains larger than the deadweight loss even though we might have overestimated it.

In future work, we would like to extend the concept to a wider range of industries. We would like to calculate different individual conjectural elasticities which are consistent with the market shares of the individual firms. On the conceptual level, methods are needed to show which part of the staircase comes from product differentiation, or product innovation.

We propose acknowledging as a stylized fact, that cost differences are large and do not quickly evaporate over time, even in mature and rather homogeneous industries. Some part of these differences may mirror innovation rents, product differentiation or managerial skills, but cost differences specifically in the analyzed industries indicate an insufficient pressure to use the best cost technology. The persistent presence of cost differences can exist only under some form of output restriction. Cost differences therefore should be included into a wider concept of welfare loss due to oligopoly. Empirically, the cost staircase seems to be much larger than the deadweight triangle. If this result can be replicated in further studies it also has two important policy conclusions: firstly, a competition or an industrial policy which promotes the diffusion of the lowest cost technique or the best practice may increase social welfare more than a competition policy targeted only at lower prices and higher output; secondly, competition policy should not only focus on the average level of profits in an (homogeneous) industry, but accept the variation of profits across firms as a tentative indicator of lack of competition.

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APPENDIX: ON THE RELATIVE SIZE OF THE DEADWEIGHT LOSS TRIANGLE AND OF THE STAIRCASE

We compare the cost side welfare loss (5) with demand side (4) welfare loss. Acknowledging that the elasticity of demand not only can be derived from the aggregate Cowling and Waterson equation, but also from the first order profit maximizing condition for the most efficient firm (see (4)), we obtain a condition in which the cost "staircase" is larger than the linearly approximated deadweight loss triangle:

$$\text{(8a)}\qquad \text{CST-DWT} = \frac{p-p^c}{p} - \frac{p-\bar{c}}{p} - \frac{1}{2}\left(\frac{p-p^c}{p}\right)(s^* + \alpha^*(1-s^*))$$

$$= \left(\frac{p-p^c}{p}\right)\left(1 - \frac{s^*+\alpha^*(1-s^*)}{2}\right) - \frac{p-\bar{c}}{p} > 0 \Leftrightarrow$$

$$\frac{p-p^c}{p} > \left(\frac{2}{2-s^*-\alpha^*(1-s^*)}\right)\left(\frac{p-\bar{c}}{p}\right)$$

$$= \left(\frac{2}{1+(1-\alpha^*)(1-s^*)}\right)\left(\frac{p-\bar{c}}{p}\right)$$

Additionally, we can derive an upper bound for the linearly approximated DWT, yielding a simplified, however only sufficient, version of (6a) using $s^* + \alpha^*(1-s^*) < 1$ because $s^*, \alpha^* < 1$:

$$\text{(8a')}\qquad \frac{p-p^c}{p} > 2\left(\frac{p-\bar{c}}{p}\right) \Rightarrow \text{CST} > \text{DWT}$$

Condition (8a) indicates that the supply side deadweight loss, i.e. the cost "staircase" is more important than the usual deadweight loss triangle, if cost asymmetry is large. Since we know that the first term on the right hand side in (8a) is bounded from above by 2 (the case of joint profit maximization with production in the most efficient plant, i.e. α^* converging to 1), a sufficient, however, not necessary condition for CST to be larger than the DWT is that the price cost margin of the most efficient firm is more than double the (market share weighted) average price cost margin[20]. This condition, however, is very restrictive, as it uses collusive behavior as benchmark of comparison. In the Cournot case, with $\alpha_i = 0$, (8a) is modified to

$$\text{(8a'')}\qquad \text{CST} > \text{DWT, if } \frac{p-p^c}{p} > \left(\frac{2}{2-s^*}\right)\left(\frac{p-\bar{c}}{p}\right)$$

[20] An alternative condition, sufficient for the truth of the reverse case (DWT > CST) can also be derived using (8a'):

$$\text{(8b)}\qquad \text{CST} = \frac{p-p^c}{p} - \frac{p-\bar{c}}{p} < \frac{p-p^c}{p}(1-\tilde{H}),\ \text{using } \frac{p-p^c}{p} > \frac{p-p^c}{p}\tilde{H} \text{ from (6a) and (4)}$$

$$\text{(8c)}\qquad \text{DWT} > \frac{p-p^c}{2p}\tilde{H},\ \text{since } p^c < \bar{c}$$

Combining (8b) and (8c) gives the sufficient, however, not necessary condition

$$\text{(8d)}\qquad \text{CST} < \text{DWT if } 1-\tilde{H} < \frac{1}{2}\tilde{H} \text{ or } \frac{2}{3} < \tilde{H}$$

which states that demand side welfare loss is likely to be higher than the "staircase", if concentration is sufficiently high and/or conduct is not aggressive.

For example, if the market share of the most efficient firm is 50%, the Cournot Case (8a′) requires the price cost margin of the most efficient firm to be 1.5 times higher than the average price cost margin.

We conclude that on the theoretical level the staircase may be smaller or larger than the demand side loss. Our empirical investigations have shown that concentration is far less than the critical Herfindahl Index required by the condition presented above. But in the end the relation between DWT and CST is and has to be an empirical question. In our data the latter is far larger.

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