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Abstract:

When competition is tough, the best available technology spreads quickly. Firms which do not implement the least expensive technology are forced to exit, and/or the low cost firm increases its market share. Persistent cost or profit differences require some form of restricted entry, specific factors or oligopolistic coordination. If cost differences mirror oligopolistic coordination, the extent of cost differences should be incorporated in the calculation of the social loss of oligopoly. This paper models an asymmetric oligopoly and adds to the well known demand side loss ("the triangle") the neglected cost side effect ("the staircase") stemming from the non-proliferation of the best technology. We correct for the fact that part of the cost differences may not reflect inefficiency, but instead are attributable to vertical product differentiation. Data for the paper industry in the European Union, in the US and in Japan indicate that cost side welfare loss is much larger than the demand side welfare loss.

JEL.: L13, D43, D61, L61, L73

Keywords: deadweight loss triangle, cost efficiency, vertical product differentiation, oligopoly, paper industry

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Product Quality, cost asymmetry and the Welfare Loss of Oligopoly

Karl Aiginger, Michael Pfaffermayr[1]

1. Introduction

During the last fifty years, the dominant method of measuring the welfare loss of monopoly has been to estimate the deadweight loss triangle. This method led to empirical estimates that the welfare loss was less than 1 % of value added. The primary argument in the claim for much higher losses was the view that all profits ("the rectangle") were welfare losses; the reasoning behind this assertion was that profits should be used to establish or to retain monopoly power and were therefore a waste to society (Posner, 1975; Demsetz, 1984; Tullock, 1997). A third road has been to focus on extra cost components which can be observed in monopolistic industries but are absent in a competitive environment (Cowling and Mueller, 1978).

This article focuses on cost side welfare loss. We claim that the extent of the cost differences prevailing in an industry provides information on the strength of the competition. In a highly competitive environment, firms which do not implement the best available technology are forced to exit the market quickly, and the firm with the lowest costs will increase its market share rapidly. In a cosy oligopoly with entry barriers and/or capacity constraints - and to an even greater extent in one with collusion - firms with different costs can coexist over the medium or long run. Tough competition encompasses the textbook model of perfect competition, in which all firms price at the minimum of average costs, as well as the homogenous Bertrand duopoly model with asymmetric firms, in which the lower cost firm prices just below the costs of the second most efficient firm, and captures the entire market. The cosy oligopoly class begins with the rather innocent static Cournot model and then includes models with varying degrees of collusion. The

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relevance of cost differences in evaluating welfare can be attributed to the fact that a specific part of the welfare which is now lost by consumers, is not regained by producers, due to the sluggish proliferation of the best technology. The cost inefficiency can be depicted as a staircase if firms are ranked according to their unit costs. Cost differences as part of the welfare loss were originally addressed by Dixit and Stern (1982), and Daskin (1991)[2)]. The first derivation of the demand and cost effects from a flexible oligopoly model combined with an empirical estimate using firm data was done by Aiginger, Pfaffermayr (1997).

The claim that all empirically revealed cost differences constitute a welfare loss is exaggerated. We focus in this article on the question whether the empirically observable cost differences could be due to vertical product differentiation. If the higher costs of a firm reflect its investment in higher quality, this specific part of the staircase should not be included in a measure of welfare loss. We permit product heterogeneity in the theoretical model and measure the emprical extent of vertical differentiation with data on the unit value (sales per pound or kilo) of the products. We concentrate on the paper industry, claiming that in this industry, technology is rather easy to purchase in the market. We cover Europe, the US and Japan as three geographical markets. We want to know whether the cost side loss is larger than the demand side effect, and specifically what influence vertical product differentiation has on this cost effect. We label the total cost differences TCD, and the cost side welfare loss - after eliminating the effect of vertical product differentiation - cost staircase proper (CST).

The paper is structured as follows. In Section 2, we present a flexible oligopoly model with vertical product differentiation. We derive the formulas for the demand side loss (deadweight loss triangle, DWT). As in the mainstream literature, this is due to higher (quality adjusted) prices and lower quantity. The cost side effect is due to the insufficient

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2) Dixit, Stern (1982) focus analytically on the welfare effects of trade, and compare 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 and size groups within industries) 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) analyzes 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 and the less efficient firms are not.

use of the best technology. We correct for the effect that vertical product differentiation induces an element of cost heterogeneity, which should not be counted as a welfare loss. Section 3 presents the data. We use firm data for a rather mature and homogeneous product market, namely the pulp and paper industry in the US, Japan and the European Union. Section 4 presents the main results, whereas Section 5 discusses the effects of quality and the robustness of the results. Finally we discuss the merits and limits of our claim that cost differences reflect a lack in competition typical to oligopolistic industries. The last section summarizes, draws tentative conclusions and addresses open questions.

2. Product quality and the welfare loss of oligopoly

Oligopoly and quality: Consider a market served by *N* firms. Each firm produces q_i units of a good which is differentiated in quality, $z_i > 1$. We assume that for consumers the good is homogeneous in the price/quality ratio (p_i / z_i) so that a unique quality adjusted price, p exists. Demand is isoelastic: $p(Q) = AQ^{-\frac{1}{\varepsilon}}$ with $Q = \sum_{i=1}^{N} z_i q_i$, and demand elasticity ε. This implies that higher quality is reflected in a higher willingness to pay and that an increase in quality shifts demand outwards.[3] Given the level of quality we assume constant marginal costs with respect to output, which yields total variable costs of $c_i z_i^{\beta_i}, \beta_i < 1$, different for each firm *i* and increasing in quality. Firms have to invest a fixed amount of capital, $F\frac{z_i}{2}$, in choosing the optimal level of quality (d'Aspremont and Jacquemin, 1988, use similar assumptions for modeling cost reducing R&D competition). This implies that - for a given quality adjusted price - the capital intensity measured in terms of sales $k_i = \frac{Fz_i^2}{2pz_iq_i} = \frac{Fz_i}{2pq_i}$ varies linearly with quality and inversely with quantity. We do not model strategic intertemporal investment decisions, but focus on the equilibrium whereby strategic interaction works by simultaneous quantity and quality competition, with each firm accepting the decisions of the rival firms as given. These assumptions simplify the analysis considerably since quality choice is formally equivalent to investing in a cost reducing technology. The model is similar in form to Sutton's endogenous sunk cost case (Sutton, 1991), but with simultaneous quantity and quality competition, and a fixed industrial structure (i.e. no entry or exit).

3) In this setting quality is best interpreted as durability (Tirole 1988, pp. 100-104, Waterson, 1994, pp. 124-126).

Under these assumptions, the profits of a firm are given by

(1) $$\Pi_i = p(Q)z_i q_i - c_i z_i^{\beta} q_i - F\frac{z_i^2}{2}$$

The best responses arise from the first order conditions:

(2) $$\frac{p-c_i z_i^{\beta_i - 1}}{p} = \frac{p_i - c_i z_i^{\beta_i}}{p_i} = \frac{s_i}{\varepsilon},\; s_i = \frac{z_i q_i}{\sum_{j=1}^{N} z_j q_j} = \frac{z_i q_i}{Q}$$

(3) $$(1-\beta_i)\left(c_i z_i^{\beta_i - 1} q_i\right) = F z_i \text{ or } \frac{p-c_i z_i^{\beta_i - 1}}{p} = 1 - \frac{2k_i}{1-\beta_i},\; k_i = \frac{F z_i^2}{2 p z_i q_i}$$

As in the usual Cournot-model a firms' price cost margin is positively related to its market share s_i and negatively to the elasticity of market demand (quality adjusted). The assumption of product homogeneity in the price/quality relationship formally translates quality differences into "cost differences" (Yarrow, 1985) and it permits the derivation of conditions illustrating the extent to which differences in profits arise from cost differences and from quality differences. The parameter β_i reflects the extent to which an improvement in quality drives up marginal costs. Condition (3) parallels the Dorfman, Steiner (1954) result, stating that the optimal quality level equalizes perceived marginal profits from higher quality goods, and the increase in marginal costs plus quality dependent fixed costs. Note that $\beta_i < 1$ has to hold to ensure the first and second order conditions and to guarantee price cost margins lower than one. If $\beta_i \to 1$ the returns on higher quality are offset more and more by higher marginal costs. So in the presence of fixed costs for quality improvement, firms would be less willing to make such investments . In the limit, costs rise parallel to sales, no firm is willing to invest in quality improvements, and condition (1) can be reduced to the traditional formula with homogenous goods and constant marginal costs. Denoting the Herfindahl index by *H* and aggregating (2) and (3) over all firms leads to

(4) $$\frac{p-\bar{\bar{c}}}{p} = \sum_{i=1}^{N} s_i \frac{p_i - c_i z_i^{\beta_i}}{p_i} = \frac{H}{\varepsilon} \text{ with } \bar{\bar{c}} = \sum_{1}^{N} c_i z_i^{\beta - 1} s_i,$$

(5) $$\frac{p-\bar{\bar{c}}}{p} = 1 - \sum_{i=1}^{n} \frac{2k_i s_i}{1-\beta_i}$$

(6) $$s_i = \left(1 - \frac{2k_i}{1-\beta_i}\right) H \frac{p}{p-\bar{\bar{c}}}$$

Equations (4) and (5) are used in the calculations below; (6) illustrates that the model can be calibrated exactly from firm level data. It can account for the fact that in empirical data, the relationship between profits and market share or concentration is not exactly linear. In our model, the deviation comes from vertical product differentiation.

The deadweight loss triangle: Since quality differences are transformed formally into cost differences, demand side welfare loss (DWT) can be derived in the usual way: The DWT defined by (7) measures the welfare gain from a reduction of the quality adjusted price to the competitive, welfare-maximizing level p^c. As usual, the DWT is measured in percentage of industry sales and approximated linearly. Following Cowling, Mueller (1978, 1981) we have.

(7) $$\mathrm{DWT} = \frac{1}{2pQ}\Delta p \Delta Q = \frac{1}{2pQ}\left(p - p^c\right)\sum_{i=1}^{N} z_i \Delta q_i$$

Using the definition of the quality adjusted elasticity of demand (in absolute terms) $\varepsilon = \left|\frac{d \log(p(Q))}{d \log Q}\right|$ to approximate the quantity change in response to a decrease in the quality adjusted price to p^c, as well as condition (4) to substitute for ε, we can calculate a linear approximation of the corresponding change of quantity:

(8) $$\sum_{i=1}^{N} z_i \Delta q_i = \Delta Q = \frac{\Delta p Q \varepsilon}{p} = \frac{p - p^c}{p - \tilde{\bar{c}}} HQ \text{ using } \varepsilon = \frac{p\tilde{H}}{p - \tilde{\bar{c}}} \text{ from (4) and } \Delta p = p - p^c.$$

In the next step, substitute (7) into (5) and use (1) to derive a generalization of the Cowling - Mueller formula relevant for oligopolistic industries (Aiginger, Pfaffermayr, 1997):

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

The cost "staircase": Proceeding to the cost side, a crucial point is the assumption concerning the reference price (and implicitly the cost level) in the competitive reference scenario. More specifically, this is an assumption about the relation between quality adjusted unit costs, $c_i z_i^{\beta-1} + \frac{F z_i}{2q_i}$, in the active group of oligopolistic firms, versus quality adjusted unit costs in the hypothetically existing competitive group or versus a regulatory regime where firms are forced to set prices to unit costs. Usually a comparison of oligopoly and competitive outcomes is based on the assumption of identical linear costs, homogeneity of demand and pricing at marginal costs $(p^c z_i = c_i z_i^{\beta_i})$[4]. In our model, however, this would imply negative profits due to the fixed costs. In an asymmetric oligopoly with differing product qualities and fixed costs, several scenarios of strategic interaction are possible and it is difficult to define the hypothetical costs which would exist under competition from the actual data pertaining to oligopoly. We follow Dixit and Stern (1982), Daskin (1991) and (Aiginger, Pfaffermayr, 1997) in assuming that in the reference scenario, the hypothetical reference price p^c under competition is revealed by the costs of the most efficient i.e most profitable firm. We modify that assumption firstly by refering to the quality adjusted unit costs of the most efficient firm and secondly by setting the reference price equal to average costs (since marginal pricing would imply losses).

Given an understanding of the reference price, we are able to estimate the cost side welfare loss.[5] This is done by arranging firms in an increasing order of their quality adjusted unit costs, $c_i z_i^{\beta_i - 1} - \frac{F z_i}{2 q_i}$, and then calculating the area between the step function (drawn by the quality adjusted unit costs), and the cost floor. The floor is defined by the most efficient firm and the total height of the "staircase" is the difference between the most efficient and the most inefficient firm in the market.

Figures 1 and 2

Note that this staircase is defined after the elimination of differences in quality: a high cost firm, for example, may nevertheless be efficient if its costs result from the high quality it supplies and the investments it has undertaken to achieve this. The total amount of costs which can be attributed to cost differences and, which in the homogenous case defines the CST, is equivalently given by the difference in profits of the most efficient firm and the market share weighted average profit. We denote it by total cost differences (TCD), since this is the cost difference before correction for the cost of producing quality.

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4) It is an important characteristic of durability models that in general there is no welfare loss from an underprovison of quality in the presence of market power (Waterson, 1994, p.126). This can easily be seen from (3), as this condition states that firms choose the profit maximising quality level by weighting the reduction in quality adjusted variable costs, $\beta_i c_i z_i^{\beta_i - 1} q_i$, against the increase in fixed costs, $F z_i$ independently from market structure.

5) As already mentioned, this is that part of the consumer surplus, which is lost due to a higher price or lower quality, but which is not regained by producers due to their cost inefficiency.

$$(10)\quad \text{TCD} = \left\{\frac{N\left(p-c^*z^{*\beta^*-1}\right)z^*q^*}{pQ} - \frac{Nk^*pz^*q^*}{pQ}\right\} - \sum_{i=1}^{N}\left\{\frac{\left[\left(p-c_iz_i^{\beta_i-1}\right)z_iq_i-k_ipz_iq_i\right]}{pz_iq_i}\frac{pz_iq_i}{qQ}\right\} =$$

$$\left(\frac{\left(p-p^c\right)s^*N}{p} - Nk^*s^*\right) - \sum_{i=1}^{N}\left\{\frac{\left(p-c_iz_i^{\beta_i-1}\right)}{p} - k_i\right\}s_i \text{ using } s_i = \frac{z_iq_i}{Q} \text{ and } s^* = \frac{z^*q^*}{Q}.$$

The first term in (10) describes the total amount of profits that could be regained by consumers if the market switches to the reference scenario (i.e. to the unit price $p^C = c^*z^{*\beta^*-1} + \frac{Fz}{2q^*}$) with all firms using the most efficient technology.[6] From this, the amount actually regained is subtracted, taking into account that firms use an empirically revealed technology and provide the quality they actually supply. Quality adjustment requires that TCD be split into two components. The first one, CST proper, amounts to the welfare loss arising from differences in costs, given that firms provide the same quality as the most efficient firm; the second component is attributable to quality differences and should not be assessed as a welfare loss. This split is shown in (11). Approximating marginal costs linearly around those of the most efficient firm. Due to the symmetry of the reference scenario, $s^* = \frac{1}{N}$ holds, and a bar denotes marketshare weighted averages.

$$(11)\quad \text{TCD} = \frac{1}{p}\sum_{i=1}^{N}\left(c_iz_i^{\beta_i-1} - c^*z^{*\beta^*-1}\right)s_i - \left(k^* - \bar{k}\right) = \frac{c^*z^{*\beta^*-1}}{p}\sum_{i=1}^{N}\left(\frac{c_iz_i^{\beta^*-1}z_i^{\beta_i-\beta^*}}{c^*z^{*\beta^*-1}} - 1\right)s_i - \left(k^* - \bar{k}\right) \cong$$

$$= \frac{c^*z^{*\beta^*-1}}{p}\sum_{i=1}^{N}\left(1 + \frac{c_i-c^*}{c^*} + \left(\beta^*-1\right)\frac{z_i-z^*}{z^*} + \ln z^*\left(\beta_i-\beta^*\right) - 1\right)s_i - \left(k^* - \bar{k}\right) =$$

$$= \left(1 - PCM^*\right)\left(\frac{\bar{c}-c^*}{c^*} + \left(\beta^*-1\right)\frac{\bar{p}-p^*}{p^*} + \ln z^*\left(\beta_i-\beta^*\right)\right) - \left(k^* - \bar{k}\right)$$

The last line in (11) highlights the components of TCD. Let us use the letters A*, B *, C *, D for the four additive terms, where the asterixes for the first three letters indicate that the terms A, B, C in the larger bracket have to be multiplied by *(1 - PCM*)*. The welfare reducing cost inefficiency component consists of A* and C *. A* denotes the difference in the variable costs between the average firm and the most efficient one, $\frac{c-c}{c^*}$, given that all firms produced the lowest quality ($z_i = 1$). C* arises from the possibility that in our model (where β_i is firm specific) the same level of quality may increase marginal costs at a different rate, $\ln z^*\left(\beta_i - \beta^*\right)$. The other components of TCD comprise B* and D and arise

6) Note that we now calculate only the cost side effect, for total surplus, DWT has to be added if the price is lowered.

from quality differences. B* defines the effect of quality on variable costs, D the effect on fixed costs. Having calculated TCD, we can derive the cost effect proper (corrected for quality differences) by subtracting B* and D, which is shown in (12).

$$(12)\quad \text{CST} = \left(1 - PCM^*\right)\left(\frac{\bar{c} - c^*}{c^*} + \ln z_i\left(\beta_i - \beta^*\right)\right) = \text{TCD} - \left(1 - PCM^*\right)\left(\beta^* - 1\right)\frac{\bar{p} - p^*}{p^*} + \left(k^* - \bar{k}\right)$$

The correction for quality differences can go in either direction. It is easy to understand that the correction depends on the quality provided by the most efficient firm, which is defined to be that with the highest profits (in the uncorrected data). If this firm also provides the highest quality (let us call this case "efficiency- quality match"), it is earning the highest profits despite higher variable and fixed costs. If the other firms would provide the same level of quality, higher fixed costs lead to a more pronounced cost lead for the best firm, implying an upward correction of TCD ($CORR_F > 0$). The higher variable costs of providing quality, however, are translated by $\beta_i < 1$ into lower quality adjusted *per unit* of variable costs, implying a downward correction for the staircase ($CORR_V < 0$). The combined effect depends on the relative size of the fixed vs. variable costs of providing quality. If, on the other hand, the firms with the highest profits in the sample provide low quality (no "quality-efficiency" match), the effects move in the opposite direction (the fixed cost effect decreases the CST versus TCD, the variable cost effect increases CST). Therefore, the sign of the quality correction depends in the theoretical model firstly on the quality of the most efficient firm as compared to the average and secondly, on the relative magnitude of variable and fixed costs. Furthermore in the empirical model, the cost data do not always reflect the conditions needed for profit maximization (e.g. firms with higher quality may have lower fixed and lower variable costs).

3. The data and the operationalization of the concept

The balance sheet data for our calculations has been derived from "Standard and Poors Global Vantage Data Bank" and the "PPI's international facts and price book". The first database contains detailed information on approximately 10,000 primarily larger firms in 60 countries. The second source provides data on the 150 largest firms in the pulp and paper industry. It publishes sales for the paper division of diversified firms, whose main activity is within or outside the industry, thereby increasing the number of firms as compared to the data used in Aiginger, Pfaffermayr (1997). For most of the firms, data on nominal sales and on tons produced are available, allowing us to calculate the unit value of the average produced ton. We use this measure as an indicator of the position the firm has in the vertically differentiated market. Paper which can be sold at a higher price is assumed to be qualitatively different from lower priced products according to our model.

We used the European Union (in its present form with 15 countries and referred to as EU15), the USA and Japan to define the geographic dimensions of our markets. National markets, especially in Europe, today seem to be too narrow a concept; most of the larger firms produce and sell in more than one country, specifically within the area of the European Union. We intentionally chose a rather narrow, "well defined", industry with internationally available technology. In order to eliminate short run fluctuations, we took a 5 year average, 1989-1993. Comparing the sales in our sample with information from the "Fortune - 500" statistics, the OECD-ISC and STAN database for industrial analysis shows that we have a reasonable representation of the largest firms. Measuring the coverage on ISIC-3411 production corrected for exports and imports, our sample covers approximately 100% of the industry sales in the US, 82% in the EU15 and 71% in Japan. All in all, our set of data is far from being ideal, but we share this problem with many other empirical studies. What we can do, is test the robustness of our results (see Aiginger, Pfaffermayr, 1997).

A sensitive task is defining a proper measure of costs and profits. We relate costs and profits to sales and define them in a complementary fashion, adding up to unity. Variable costs are defined as the sum of the expenditures on material, wages and interest. If we divide this sum into sales, we attain variable unit costs and as its complement, the gross profit margin. From gross profits we deduct the opportunity costs of capital[7] to calculate a net margin. These costs are the accounting sheet equivalent to the fixed costs in our model. As an alternative we deduct from gross profits the depreciation rate reported in the balance sheet. In this case, depreciation becomes the proxy for the fixed costs in our theoretical model. If the reported depreciation would represent true economic depreciation, the incorporation of depreciation into the definition of costs would be strongly advisable. Reported depreciation rates seldom do this job, however. They are

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7) As a measure of the opportunity cost of invested capital we used the average returns on long-run bonds, amounting to 7.55% in the US, 5.52% in Japan and to 9.29% in the EU, respectively.

heavily influenced by differences in reporting behavior and we do not recommend relying on this second definition. The first profit definition (and by its mirror image the first cost definition) will be the one we prefer.

Fixed costs play a specific role in our model. Technically, fixed costs for providing quality are needed to ensure profit maximization with endogenous quality choice. While we believe the assumption that the provision of higher quality requires a combination of higher variable costs (with variable costs rising less than the price of the product) plus a fixed cost investment in quality, is a fair representation of the real world process, we do not believe that all fixed costs in the paper industry can be attributed to investments in quality. We therefore present calculations which arbitrarily assume that 50 % and 25 % of the fixed costs are investments in quality, in order to evalute the sensitivity of this assumption.

Table 1 summarizes the formulas we used. We define the following symbols:

$c^* = min[c_i]$, $PCM^* = \frac{p - c^* z^{*\beta^* - 1}}{p}$, $PCM^{WM} = \frac{p - \bar{c}}{p}$, $k_C = \frac{RE_C * E}{S}$, $RE_C = 5.52,\ 7.55\ or\ 9.29$ for $C = US, JPN, EU15$

PCM*	=	margin of the most efficient firm
PCM^{WM}	=	weighted mean of margins (over firms, market shares = weights)
S	=	sales
E	=	equity
RE	=	return on bonds
k_C^*	=	capital intensity, most efficient firm
k^{WM}	=	weighted average capital intensity
UV^*	=	unit value, mots efficient firm
UV^{WM}	=	weighted average unit value

8) We found either one of these approaches to be more promising than declaring a "plausible rate for a competitive return". For an alternative, which implements stock market returns, see Cowling and Mueller (1978).

Table 1: Calculation of the welfare loss

Harberger:		
HA:	$\sum_{i=1}^{N} s_i (PCM_i - k_i)^2 \varepsilon_i \,,\; \varepsilon_i = 1$	with $PCM_i - k_i = 0$ if $PCM_i < k_i$
Cowling-Mueller:		
CM:	$\frac{1}{2}\sum_{i=1}^{n} s_i \frac{(PCM_i - k_i)^2}{PCM_i}$	with $PCM_i - k_i = 0$ if $PCM_i < k_i$
Deadweight loss triangle-AP-model, Equation (9):		
AP_{DWT}:	$\frac{1}{2}\frac{(PCM^* - k^*)^2 H}{PCM^{WM}}$	with $PCM_i - k_i = 0$ if $PCM_i < k_i$
Total cost differences, Equation (10)		
AP_{TCD}:	TCD= $PCM^* - k_i - \sum_{i=1}^{n} (PCM_i - k_i) s_i$,	with $PCM_i - k_i = 0$ if $PCM_i < k_i$
Quality adjusted efficiency - "staircase", CST, Equation (12)		
AP_{CST}:	CST=TCD+$CORR_V$+$CORR_F$	
$CORR_V$:	$-(1 - PCM^*)(1 - \beta^*)\left(\frac{UV^{WM} - UV^*}{UV^*}\right)$	$\beta^* = 1 - \frac{2k^*}{1 - PCM^*}$
$CORR_F$:	$k^* - k^{WM}$	

4. Main results: Quality, fixed costs and the CST

Table 2 shows the basic statistics for our data sample and some reference calculations for deadweight triangles. We have 15 firms for Japan, and 34 for the European Union, and 44 for the USA. The Herfindahls are therefore very low. Even the large firms have low market shares, since we permit the relevant markets to include entire geographical areas and the total product market[9]. The average price cost margins according to our first variant (subtracting the opportunity costs of equity) are between 4.7% in Europe and 5.3%

9) Since the relevant market will be narrower the calculations of the demand side welfare loss which allow for oligopoly - as our model does- will be underestimated. Harberger and Cowling and Mueller type estimates are not influenced by this effect.

in the US, with a large dispersion across firms. The variation across firms is smaller in Japan, relative to Europe and the US. The *PCM* in the second variant is even lower, many firms (7 in Europe, 5 in the US and 3 in Japan) have negative average profits over the five year period indicating that the depreciation rates applied in the balance sheets are too large. As mentioned above, we consider the first variant to be our preferred estimate and report the second in our sensitivity analysis.

As a reference calculation, we start with two Harberger-type estimates ($HA_1$and HA_2 for variant 1 and 2). The Harberger style deadweight triangles are small, as usual. They amount to 0.20%, 0.27% and 0.34% for the three blocs, and are therefore of similar size with the lowest value for Japan. Note, that perfect product differentiation (i.e. each firm has a monopoly) is assumed, the DWT is calculated as a market share weighted average and elasticity of *1* is enforced. The Cowling and Mueller estimate (CM) is calculated in the same way, however, with demand elasticity derived from the first order condition. It ranges between 1.25 % (Japan) and 1.69 % (US).

Our approach, which allows for oligopoly, gives estimates between 0.24 % and 0.56 % (see AP_{DWT} in Table 1). The reason why our estimates are lower than CM is that according to the model above, the empirically revealed Herfindahl is used, which is rather low and leads to a downward correction as compared to CM. For a market with so many firms, the assumption of an oligopoly is more preferable than a model in which each firm has a monopoly. Additionally, Europe as the relevant geographic market is more plausible than the individual national markets.

Table 2: Summary statistics, concentration and deadweight loss triangle as a share of total market sales, traditional method, average 1989-1993, SIC 2621-2631, pulp and paper mills

	US	**JAPAN**	**EU15**
Firms	34	15	33
Coverage [a)]	100	71.2	81.7
Herfindahl	0.06	0.05	0.05
Herfindahl (Sample)	0.06	0.07	0.07
Highest PCM(variant 1)	11.5	7.9	13.3
Average market share weighted PCM ((variant 1)	5.3 [b]	4.9 [b)]	4.7 [b)]
Lowest PCM (variant 1)	2.2 [b)]	2.8 [b)]	0.9 [b)]
Highest PCM (variant 2)	11..6	2.6	8.4
Average market share weighted PCM (variant 2)	3.0 [b]	1.1 [b)]	2.2 [b)]
Lowest PCM (variant 2)	0.7 [b)]	0.1 [b)]	0.2 [b)]
Harberger, HA_1	0.34	0.20	0.27
Harberger, HA_2	0.15	0.01	0.10
Cowling-Mueller, CM_1	1.69	1.25	1.43
Cowling-Mueller, CM_2	0.63	0.07	0.48

a) According to ISIC 3411 for production (ISC) and ISIC 341 for exports and imports (STAN), OECD
b) There are a few outliers reporting negative netprofits which are set to 0.
i_C=*7.5 for US, 5.5* for Japan and *9.3* for EU15, respectively. Suscript 1 and 2 refer to varaint 1 and 2 of our profit definition

The extent of the cost differences: For our preferred estimate, the total cost differences (AP_{TCD} in Table 4) amount to 8.60 % of sales in the EU15. They are somewhat smaller in the US (6.23%) and lowest in Japan (2.97 %). All three calculations are significantly higher than the demand effects. If we use the alternative profit definition, AP_{TCD} increases for the US and shrinks for Europe and Japan. This conforms to the rules applied for depreciation in these countries. The US firms try to keep investments and depreciation to a minimum, since they decrease profits and make firms unattractive for investors. In Japan and in Europe, firms try to inflate investment and depreciation, in order to reduce or at least postpone taxes. But in relationship to $AP_{DWT,}$ AP_{TCD} is still by far the larger of the two. Note that AP_{TCD} assumes a homogeneous market. Paper is a rather homogenous product as compared to other products, but of course there are different qualities on the market. Newsprint is much cheaper than tissue, paper can be coated or uncoated, recycled paper can be used in production etc.

Table 3: Unit values (1000 $ per ton)

	high quality 4th Quartile	medium quality	low quality 1st Quartile	revealed quality most efficient firm[a)]
USA	1.74	1.08	0.53	1.05
JAPAN	2.82	1.48	0.96	1.40
EU15	1.87	1.05	0.56	2.23

a) Unit value of the most efficient firm in terms of profits defined by variant

Unit value data: The unit value is defined as sales divided into tons. For a given quality or type of paper it advances towards a price[10]. If the unit value is calculated for a set of differentiated products, it reveals indirectly which qualities are produced. For example, in the larger EU-countries in 1994, the unit value of newsprint lay between 450-841 $ per ton, and the unit value of coated, wood free paper ranged between 937 $ per ton to 1310$ per ton. For each quality, the paper market is rather homogenous. Customers do not care and often do not know where the paper comes from, transport costs are rather low, and the law of one -quality adjusted - price holds approximately. We have unit values for most of the firms and use them as a proxy for $p_i = pz_i$ in equation (12). Table 3 indicates that the medium unit value is slightly higher in Japan (1480 $/ton), than in EU15 and the US (1080 $/t and 1050 $/t, repectively). The unit value of the most efficient firm is slightly below average in the US and in Japan, in the EU15 the unit value of the most efficient firm is missing. We used the average of the two next most efficient firms a proxy, and it is twice as high as the mean. If we would use the unit value of the 5 most efficient firms, qualitatively the result would be the same: it is higher than average, but not to such

10) The PPI-facts and price book reports sales and production of pulp, paper and cut paper for the largest 150 paper firms in the world for 1994 and therefore covers most of the firms in our three markets. Information on production is missing for some firms, however. The unit value has been calculated by dividing the sales of paper into the quantity sold. We corrected paper sales for revenue from cut paper (which usually has a higher unit value) and pulp. We calculated sales of these two products by multiplying the quantities with the average unit value as given in the trade statistics. This gives a corrected unit value which is available for roughly two third of the firms who reported all catogories consistently. From this, we then derived the market share weighted average unit value and that of the most efficient firm. If the latter was missing, we used the uncorrected unit value or that of the 2 next efficient firms as a proxy.

a large extent. If we compare the rankings of efficiency and quality in general by ranking firms according the (quality adjusted) costs and according to our quality proxy we do not see any close relation. This implies that the correction of TCD for quality cannot be predicted, empirical data will show whether CST is larger or smaller than TCD.

The quality correction: Using the unit value data for the calculation of z and combining it with the β revealed by the data (let us call β* and z* the values for the most efficient firm), we can calculate the quality corrected staircase (CST in the model, AP_{CST} in the empirical calculation). As demonstrated above, the correction term subtracted from TCD has two components. The first one ($CORR_V$) corrects for differences in variable costs arising from heterogeneity in quality. It reduces the cost staircase if the most efficient firm provides higher than average quality. The main result is that according to our preferred method, the quality adjusted staircase is larger than the uncorrected staircase for the USA and for Japan, but lower for Europe. The downward correction for Europe is due to the fact that the most efficient firm is specialized in high quality paper, implying a large downward correction in the variable costs, while the fixed costs are corrected upwards only slightly. In the US and in Japan, the most efficient firms produce somewhat below average quality, and the upward correction is slightly positive for both components (remember that the theoretical model would imply opposite directions for the two components).

As a first test of robustness, we use the other profit definition (variant 2, depreciations). The results show that in the US, there is little difference between staircases corrected for quality and uncorrected for staircases, while for Europe, the adjusted staircase is much smaller. In Japan, net profits are so low, that the staircase becomes uncalculable, we have differences in accounting losses and not in profits. This mirrors the high accounting depreciation rates in Japan and the lower variation in net profits. In Europe, the most profitable firms exhibit a very high unit value. Remember that we had to use a proxy, and that using the average of the five most efficient firms, instead of those of the two most efficient firms would have lowered the correction term significantly.

Table 4: Welfare loss in pulp and paper mills.

(AP_{DWT}, AP_{TCD} and AP_{CST} . linear approximation with Cournot competition, average 1989-1993, % of sales,

	ε	revealed ß	AP_{DWT}	AP_{TCD}	AP_{CST} [b)]	$CORR_V$ [c)]	$CORR_F$ [d)]
variant 1 (preferred estimate): cost of equity							
US	0.70	0.86	0.47	6.23	8.83	0.34	2.26
Japan	0.76	0.93	0.24	2.97	4.25	0.32	0.96
EU15	0.64	0.90	0.56	8.60	4.85	-4.41	0.65
variant 2: (robustness check) depreciation							
US	0.70	0.86	0.47	8.60	8.47	0.34	-0.47
Japan	0.76	0.92	0.03	1.55	a)	a)	a)
EU15	0.64	0.85	0.22	6.23	0.87	-5.33	-0.03

a) Quality correction would lead to negative CST
b) AP3=AB2-CORR1-CORR2
c) $CORR_V = -(1-PCM^*)(\beta^*-1)\frac{\bar{p}-p^*}{p^*}$
d) $CORR_F = (k^*-\bar{k})$

5. The influence of quality and the robustness of the estimates

The results show that the influence of quality is not likely to change the extent of the welfare loss dramatically. The cost side component can be corrected upwards or downwards, depending on the position of the most efficient firm in the quality ladder and its fixed costs (see Figures 1 and 2). The reason why the correction is not too large is, that producing higher quality implies higher costs. If the effect of quality on costs and on price were proportional, no correction would be necessary, since costs in relation to sales are not changed. Profit maximizing requires the feasibility of a non-proportional increase, with variable costs increasing less than proportionally and the fixed costs of quality guaranteeing an optimum, in order to make investment in quality improvement attractive. The combined effect of these two components on total unit costs can be and in our case is not too far from a proportionate effect. Therefore, the correction will not be too large if the heterogeneity itself is moderate, as it is in the paper industry.

Nevertheless it is necessary to make this correction and in doing it we learn about the data and the cost structure. The revealed β^* for example indicates the percentage change in variable costs if our quality parameter (and the price) increases by 1 %. The calibrated β^* varies between 0.85 and 0.93 indicating that the variable costs increase slightly less than the price.

Table 5: Robustness of AP_{CST}

		variant 1: opportunity costs of equity			variant 2: depreciation		
		Quality dependence of fixed costs					
	β	100%	50%	25%	100%	50%	25%
US	0.8	8.98	7.85	7.28	8.62	8.86	8.97
	0.9	8.73	7.60	7.04	8.38	8.61	8.73
	1.0	8.49	7.36	6.80	8.14	8.37	8.49
Japan	0.8	4.85	4.37	4.13	-[a)]	-[a)]	-[a)]
	0.9	4.39	3.91	3.67	-[a)]	-[a)]	-[a)]
	1.0	3.93	3.45	3.21	-[a)]	0.23	0.89
EU15	0.8	0.69	0.36	0.20	-[a)]	-[a]	-[a]
	0.9	4.97	4.65	4.48	2.58	2.60	2.60
	1.0	9.25	8.93	8.77	6.20	6.21	6.22

a) Quality correction would lead to negative CST due to overestimation of average depreciation

We tested the robustness of the results several times. We have already reported on the change in the profit definition, substituting the opportunity costs of capital with the reported depreciation. We found inter alia that in Japan profits are so low, that the staircase becomes incalculable; we have differences in accounting losses and not in profits. This illustrates once more that measuring fixed investment costs is not an easy task and, especially, that accounting data on depreciation do no not seem to provide a useful measure.

The next check on robustness was motivated by the fact that in our model the only rationale for fixed costs is that investment in quality needs to be fixed. In Table 5, we test the way the staircase would be changed if, hypothetically, 25 % and 50 % of fixed costs were motivated by investment in quality rather than 100 %. The figures show that the results are rather robust.

The third experiment was to assume counterfactually that the most efficient firm produced either a high or a low quality product (and to vary β^* between 0.8 and 1). We see in Table

5 that for $\beta^* \rightarrow 1$ the fixed cost correction gains dominance (since variable costs and prices move parallel). On the other hand, with declining β^* the importance of quality increases. Most importantly, even these counterfactual assumptions never supply results in which the staircase shrinks towards that of the demand side triangle.[11]

6. Reasons for welfare differences and methodological problems

We claim that cost differences which do not erode quickly reveal a lack of competition. For the paper industry, we began with the assumption that all cost differences shown in the empirical data are due to inefficiency, since the best technology known in the market is not used. We corrected this extreme assumption by addressing the most prominant candidate for cost differences which do not reflect inefficiencies, namely vertical product differences. The effect of the correction is not too great since the production of higher quality paper increases costs and prices to a rather similar extent.

Another important reason for profit differences may be innovation rents. Low cost firms could have invented a superior technique not available to other firms. If some firms possess a superior low cost technique, the other firms cannot supply at that cost level. But, even if this is the case, the question remains as to why this firm does not capture the entire market. With unlimited capacity, it could price its product slightly below the costs of the next best firm. Limits in capacity exist however, diseconomies of scale or the fear of antitrust could play a role. Switching from theory to the real world, we do not see any radical innovation which is owned by the lowest cost firm. The paper industry is an industry in which technology is embodied in machines, and these are supplied by specialized firms to any buyer. We believe that we would assess the importance of innovation to persistent cost differences differently in an industry in which innovation is rapid and where the producers of the product (software industry) carry out their own research.

A somewhat technical reason for cost differences important in capital intensive industries could be that the capacities of some firms are old and written off, therefore contributing to

11) Note, however, that the possibility to test for robustness is limited as we rely on a linear approximation. The larger the counterfactual deviation of β^* is, the larger the approximation error, so that large deviations from the revealed quality (or β^*) lead to unreliable results.

lower accounting costs. Along the same line, it could be inefficient for a firm to invest in a new cost reducing technology if the old capacities are not written off. Both effects should not be too important in our case, since most of the large firms in the paper industry operate many plants (in some cases up to 50 plants), with a mix in the vintages as a result.

In general we cannot exclude the fact that the cost differences shown in the data reveal rents in the sense that the low cost firm owns a specific factor which cannot be copied by others. Examples for such rents range from a location on a specific river (implying optimal transport and low energy costs) to superior managament capacity. But the theory in the last years has shown that rents can and will be transformed into costs, if the competition is tough and not softened by government or firm strategies. The most excellent manager will be lured by other firms and/or can charge a salary (from the old firm or the new one) up to the value of his specific knowledge. The management culture of an excellent firm (e.g. Toyota) will be investigated by the competitors and eventually be copied by less efficient firms; the excellent firm could open new plants or initiate joint ventures. The cheap energy at a specific location can be used in alternative production so that the price is driven up. All these strategies blur the old distinction between rents and costs. The stylized fact that real world profit differences are large and persistent has led to the foundation of a new field in economics ("strategy" or "strategic management"[12]), whose research question asks why profits can differ within an industry over a longer time. Its development nicely shows the thesis and antithesis in this discussion: on the one hand there is something different between sucessful firms and the average (otherwise the profit differences would not persist), but on the other hand, there is no reason why this difference if known, should not be copied rapidly in a tough market (if not, the difference would allow the excellent firm to take over the entire market).

A crucial determinant of the calculation (as well as those in the deadweight triangle literature) is the relation between the actual costs in oligopoly or monopoly relative to the unknown costs in the reference scenario of competition, which by definition does not exist. Claims are made that the costs under monopoly may be lower (due to innovation, see Schumpeter) or that they could be higher (due to inefficiency, see Leibenstein). We assumed that the reference cost and prices under competition could be revealed by the

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12) See Barney (1986), Peteraf (1993), Ghemawat (1991). We are grateful to Marvin Lieberman for proposing to relate our paper to this strand of literature

costs of the most efficient firm. This may be too high or too low. Extra costs of oligopoly, such as advertising, wage rents, or techniques to preserve a monopoly would result in an underestimation[13)]. Concerning Japan, for example, we have the feeling that tough competition could drive the price of paper down to a floor lower than that revealed by our data, increasing the staircase relative to our estimate.[14]

6. Conclusions

We propose adding a cost inefficiency effect to the well known deadweight loss of oligopoly. This second 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, according to unit costs ranging from low to high, creating an illustration which depicts a staircase. While cost differences are usually not included in the welfare loss, this has been done by Dixit, Stern (1982), Daskin (1991) and by Aiginger, Pfaffermayr (1997).

Claiming the total cost differences as welfare loss is a reaction to the neglect of the cost side in the mainstream literature. Of course, there are cost differences which cannot be eliminated even in a competitive environment and therefore cannot be assessed as welfare loss. The most prominent candidate for a cost difference which does not constitute a waste is given in the case of vertical product differentiation. This paper investigates how we can eliminate this effect, first theoretically and then empirically for the paper industry in the triade.

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13) We cannot rule out that part of the cost differences are "strategic costs" of oligopoly such as advertising, expenses to preserve the 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"

14) With many other studies, we share the problem that we are using a specific 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.

We start with a model of a vertically differentiated market in which the demand is homogeneous in the quality adjusted prices. The production of quality involves fixed costs and variable costs. Perhaps contrary to our first intuition, the correction of the total cost differences (TCD) for vertical product differentiation can go in either direction. Firstly it depends on whether or not the more efficient firms also supply higher quality ("quality efficiency match") and secondly, whether the correction for fixed cost differences or for variable cost differences is larger. Thirdly, the effect can be influenced by empricial data not consistent with the predictions of the theoretical model.

The most important empirical results are the following: (1) the uncorrected cost difference (TCD) effect is much larger than the demand side effects, (2) the correction for quality decreases the effect in Europe, since the most efficient European firm produces high quality and the variable cost effect is dominant. The cost staircase proper (CST) is larger in the US and in Japan, where the most efficient firms supply slightly below average quality. (3) The staircases are definitely larger in the US and in Europe than in Japan; this could be due to a rapid diffusion of technology in Japan or by differences in methods of reporting.

The results are quite robust, since the cost differences of active firms are rather large and persistent over time. The exact magnitude, however, depends on conduct, elasticity of demand and the mix of variable and fixed costs and it is important to correct for quality differences. Our results indicate that the staircase might be at least three or four times as large as the DWT and this finding is consistent in the three different markets, namely US, Japan and EU15.[15)]

We do not claim that all the differences in costs across firms reflect welfare losses, quality differences have been explicitly addressed. Cost differences may also be due to the lumpiness of the investment process, from reporting behavior, etc. There may be a component of these differences which mirrors innovation rents, horizontal product differentiation or managerial skills. But the cost differences are large and persistent, so that the cost staircase remains larger than the deadweight loss, even if we overestimate the first

15) It is fascinating that our results for different product markets, a different geographical area and a different time, replicate the flavour 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.

one. And economic theory tells us that under tough competition, cost differences should either erode quickly, or the most efficient firm will gain the entire market.

We propose acknowledging as stylized fact the premise that cost differences are large and do not quickly evaporate over time. This is finding continually greater acceptance in the literature and has given birth to the field of "strategic management". Cost differences, indicate an insufficient pressure to use the least cost technology, they can persist only under some form of output restriction. Since cost differences are a part of the "rectangle" lost by consumers, but not regained by the producers, any total surplus concept forces their incorporation.

The findings have two policy conclusions: firstly, a competition - or an innovation policy, which promotes the diffusion of the best practice, will increase welfare, maybe even more than a competition policy targeted at lower prices and higher output. Secondly, competition policy should be aware that the non-proliferation of the best technology may be due to a collusive arrangement. In industries with persistent cost differences, firms should take the burden to explain the reason for the non-proliferation of the lowest cost technique.

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Figure 1:

Deadweight loss, staircase and quality adjustment in an oligopoly with 5 firms:
The "quality-efficiency match with" $CORR_V$ dominating $CORR_F$ so that CST <TCD

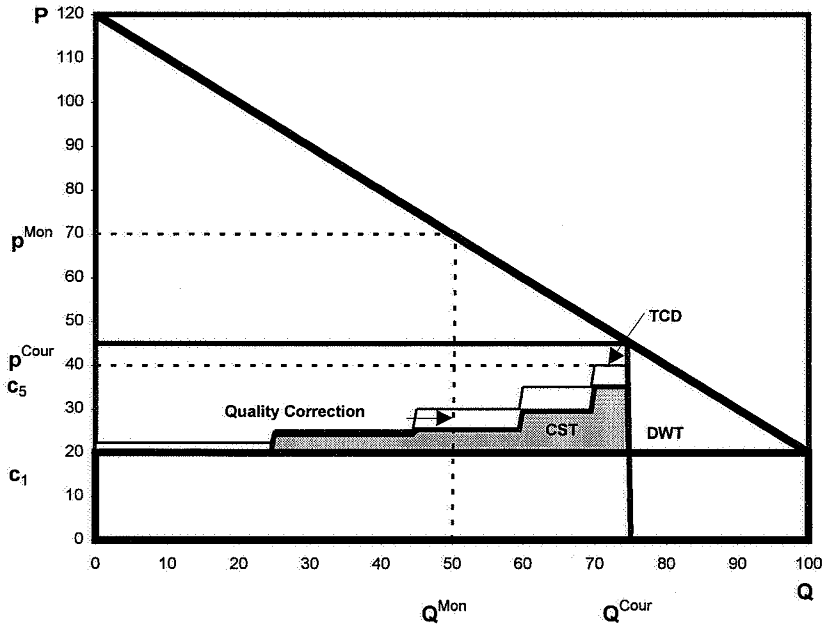
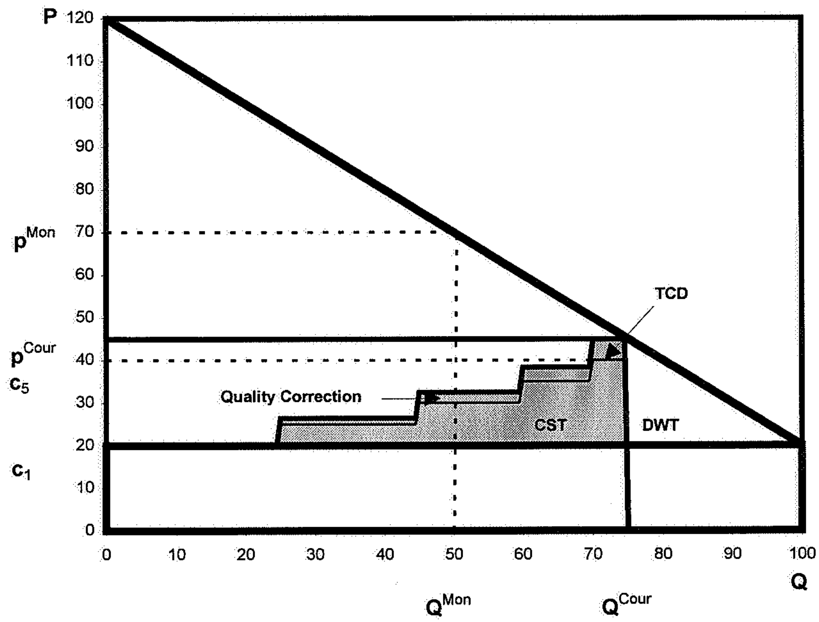


Figure 2:

Deadweight loss, staircase and quality adjustment in an oligopoly with 5 firms: No "quality-efficiency match with" $CORR_V$ dominating $CORR_F$ so that CST > TCD



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