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Product Quality, Cost Asymmetry and the Welfare Loss of Oligopoly

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ABSTRACT *When competition is tough, firms which do not implement the least expensive technology are forced to exit, or the low cost firms are able to increase their market share. Persistent cost or profit differences require some form of restricted entry, specific intangible assets or oligopolistic co-ordination. If technology or skills is easy to transfer but it is not transferred because of collusion, we have to add a cost side effect ('the staircase')— stemming from the non-proliferation of the best technology- to the well-known demand side loss ('the triangle'). This paper presents a model with vertical product differentiation and develops a method which disentangles cost differences coming from vertical product differences and those coming from other sources. Data for the paper industry in the EU, in the US and in Japan indicate that cost differences are large. If at least some part of them comes from oligopolistic co-ordination, then the welfare loss of oligopoly is much larger than the usually measured demand side welfare loss.*

Key words: Dead-weight loss triangle; Cost efficiency; Vertical product differentiation; Oligopoly; Paper industry.

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

1. Introduction

During the last 50 years, the dominant method of measuring the welfare loss of monopoly has been to estimate the dead-weight loss triangle. This method led to empirical estimates that the welfare loss is less than 1% of value added. Following the arguments we put forward in Aiginger and Pfaffermayr (1997a), we add a cost side component to the measurement of the welfare loss,[1] claiming

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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 or the firm with the lowest costs will increase its market share rapidly. In an oligopoly with entry barriers and/or capacity constraints—and to an even greater extent in one with collusion—firms with different costs can co-exist 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 Bertrand duopoly model with constant marginal costs differing across firms, in which the lower cost firm prices just below the costs of the second most efficient firm and captures the entire market. The oligopoly class starts from the rather innocent static Cournot model and then includes models with varying degrees of collusion. In all these models the market share depends to some degree on cost efficiency. The source of the cost differences is not explained. In static models cost asymmetry is assumed, in dynamic models the question comes up why the differences do not evaporate over time. One possibility consistent with profit maximisation is that the investment in the low cost technique is not individually profitable, because it would destroy a system of collusion based on a historical cost structure. From the point of the society the cost differences are a loss, since some part of the welfare, which is lost by consumers under oligopoly, is not regained by producers, due to the sluggish proliferation of the best technology.

The general technique to derive the demand and cost effects from a flexible oligopoly model has been presented in Aiginger and Pfaffermayr (1997a). This paper proceeds a step further and modifies the claim that all empirically revealed cost differences constitute a welfare loss, by developing a method which can eliminate cost differences coming from vertical product differentiation. If the higher costs of a firm reflect its investment in higher quality, this specific part of the costs differences should not be included in a measure of welfare loss. We again concentrate on the paper industry, claiming that in this industry, technology is rather easy to purchase in the market, and estimate quality by the unit value of the products sold. We cover Europe, the US and Japan as three geographical markets. We want to know whether the cost differences remain larger than the demand side effect, after eliminating the effect of vertical product differentiation.

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 (dead-weight loss triangle, DWT), for total cost differences TCD and for cost differences proper (the cost stair case, CST), remaining after taking product differentiation into account. Section 3 presents the data, Section 4 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.

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:

$$p(Q) = AQ^{-\frac{1}{\varepsilon}} \text{ with } Q = \sum_{i=1}^{N} z_i Q_i,$$

and elasticity ε. This implies that higher quality is reflected in a higher willingness to pay and that an increase in quality shifts demand outwards.[2] 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,

$$F \frac{z_i^2}{2},$$

in choosing the optimal level of quality (d'Aspremont and Jacquemin (1988), use similar assumptions for modelling cost reducing R&D competition). This implies that—for a given quality adjusted price—the capital intensity measured in terms of sales

$$k_i = \frac{F z_i^2}{2 p z_i q_i} = \frac{F z_i}{2 p q_i}$$

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).

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

$$\Pi_i = p(Q) z_i q_i - c_i z_i^{\beta_i} q_i - F \frac{z^2_i}{2} \tag{1}$$

The best responses arise from the first order conditions:

$$\frac{p - c_i z_i^{\beta_i - 4}}{p} = \frac{p_i - c_i z_i^{\beta}}{p_i} = \frac{s_i}{\varepsilon / s_i} = \frac{z_i q_i}{\sum_{j=1}^{N} z_j q_j} = \frac{z_i q_i}{Q} \tag{2}$$

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

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 and Steiner (1954) result, stating that the optimal quality level equalises 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

$$\frac{p - \bar{\tilde{c}}}{p} = \sum_{i=1}^{N} s_i \frac{p_i - c_i z^{\beta_i}{}_i}{p_i} = \frac{H}{\varepsilon} \text{ with } \bar{\tilde{c}} = \sum_{1}^{N} c_i z^{\beta-1}{}_i s_i \text{ or} \tag{4}$$

$$\frac{p-\bar{\tilde{c}}}{p} = 1 - \sum_{i=1}^{N} \frac{2k_i s_i}{1-\beta_i} \tag{5}$$

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

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 Dead-Weight 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-maximising level p^c. As usual, the DWT is measured in percentage of industry sales and approximated linearly, leading to the an extended formula of the type derived by Cowling and Mueller (1981), and adapted by Aiginger and Pfaffermayr (1997a) for oligopolistic industries. Using the definition of the quality adjusted elasticity of demand (in absolute terms)

$$\varepsilon = \left| \frac{\mathrm{d} \log(p(Q))}{\mathrm{d} \log Q} \right|$$

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 have (see Aiginger and Pfaffermayr (1997b) for details)

$$\text{DWT} = 1/2 \left(\frac{p-p^c}{pQ}\right) \Delta Q = 1/2 \left(\frac{p-p^c}{p}\right)\left(\frac{p-p^c}{p-\bar{\bar{c}}}\right) H \qquad (7)$$

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,

$$c_i z_i^{\beta-1} + \frac{Fz_i}{2q_i},$$

in the active group of oligopolistic firms, vs. quality adjusted unit costs in the hypothetically existing competitive group or *vs.* 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 ($p^c z_i = c_i z_i^{\beta_i}$).[3] 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 and Pfaffermayr (1997a), 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 referring to the quality adjusted unit costs of the most efficient firm and secondly by setting the reference price equal to average costs (since marginal cost pricing would imply losses).

Given an understanding of the reference price, we are able to estimate the cost side welfare loss.[4] This is done by arranging firms in an increasing order of their quality adjusted unit costs,

$$c_i z_i^{\beta_i-1} - \frac{Fz_i}{2q_i},$$

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. 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 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. Quality adjustment requires the TCD to 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 (8) using a linear approximation of marginal costs around those of the most efficient firm.[5] Due to the symmetry of the reference scenario,

$$s^\star = \frac{1}{N}$$

holds, and a bar denotes marketshare weighted averages.

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

$$\text{CST} = \text{TCD} - (1 - PCM^\star)(\beta^\star - 1)\frac{\bar{p} - p^\star}{p^\star} + (k^\star - \bar{k}) \qquad (8)$$

The first line in (8) highlights the components of TCD. Let us use the letters A*, B*, C*, D for the four additive terms on the r.h.s., where the asterixes for the first three letters indicate that the terms A, B, C in the larger bracket have to be multiplied by $(1 - PCM^\star)$. 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,

$$\frac{\bar{c} - c^\star}{c^\star},$$

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, $\ln z^\star(\beta_i - \beta^\star)$. The other component of TCD comprises B* and D and arises from quality differences. B* defines the effect of quality on variable costs, D the effect on quality dependent fixed costs. Having calculated TCD, we can derive the cost effect proper (corrected for quality differences) by subtracting B* and D.

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 ($\text{CORR}_F > 0$). 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 ($\text{CORR}_V < 0$). 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 *vs.* 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 quality dependent costs. Furthermore, in the empirical model, the cost data do not always reflect the conditions needed for profit maximisation (e.g. firms with higher quality may have lower fixed and lower variable costs).

3. The Data and the Operationalisation of the Concept

The balance sheet data for our calculations has been derived from *Standard and Poors GlobalVantage 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 and Pfaffermayr (1997a). 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 EU (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 EU. In order to eliminate short run fluctuations, we took a 5-year average, 1989–93. Comparing the sales in our sample with information from the 'Fortune-500' statistics, and OECD databases shows that we have a reasonable representation of the large firms. Measuring the coverage for the industry ISIC-3411, 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 Section 5).

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[6] to calculate a net margin. These costs are the accounting sheet equivalent to the fixed quality dependent costs in our model.

Fixed costs, that is, cost components depending on quality but not on quantity, play a specific role in our model as the relative size of the cost components drives the decisions of firms between upgrading quality or enhancing quantity. Note that this type of fixed costs also exists in long run, so the fixed costs concept used essentially means that the same quality dependent cost components do not vary with the amount of the produced quantity even in the long run when capital can be flexibly adjusted. 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 not only a usual assumption of models with vertical differentiation but also a fair representation of the real world process.

4. Main Results: Quality, Fixed Costs and the CST

Table 1 shows the basic statistics for our data sample and some reference calculations for dead-weight triangles. We have 15 firms for Japan, 33 for the EU and 34 for the US using the 4-digit SIC-industry as the relevant market. 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.[7] The average price cost margins are between 4.7% in Europe and 5.3% in the US, with a large dispersion across firms. The variation across firms is smaller in Japan, relative to Europe and the US.

As a reference calculation, we start with a Harberger-type estimate (HA) (Harberger, 1954). The Harberger style dead-weight 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 for the demand side loss between 0.24 and 0.56% (see AP_{DWT} in Table 3). 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. The total cost

Table 1. Summary statistics, concentration and dead-weight loss triangle as a share of total market sales, traditional method, average 1989–93, 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	11.5	7.9	13.3
Average market share weighted PCM	5.3[b]	4.9[b]	4.7[b]
Lowest PCM	2.2[b]	2.8[b]	0.9[b]
Harberger, HA[c]	0.34	0.20	0.27
Cowling–Mueller, CM[d]	1.69	1.25	1.43

[a] According to ISIC 3411 for production (ISIC) 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.

[c] HA: $\sum_{i=1}^{N} s_i (PCM - k_i)^2 \, \varepsilon_i \; \varepsilon_i = 1.$

[d] 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 $PCM_i < k_i$ and, $k_i = \frac{i_c {*} E_i}{S_i}$.

Table 2. 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, for EU 15 average of second and third most efficient firm

differences (AP_{TCD} in Table 3) 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. The correction for quality differences make use of the unit values of production.

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.[8] The unit value of the most efficient firm is slightly below average in the US and in Japan (see Table 2). In the EU15 the unit value of the most efficient firm is missing. We used the average of the two next most efficient firms and that of the next five firms as a proxy, the first one is twice as high

Table 3. Welfare loss in pulp and paper mills, AP_{DWT}, AP_{TCD} and AP_{CST}. Linear approximation with Cournot competition, average 1989–93, % of sales

	ε	Revealed β	AP_{DWT}[a]	AP_{TCD}[b]	AP_{CST}[c]	$CORR_V$[d]	$CORR_F$*
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

[a] $AP_{DWT}\ \frac{1}{2}\frac{(PCM^{\star}-k^{\star})^2\,H}{PCM^{WM}}$

[b] $AP_{TCD}\ PCM^{\star}-k_i-\sum_{i}^{N}(PCM_i-k_i)s_i$

[c] $AP_{CST} = AP_{TCD}+CORR_V+CORR_F$

[d] $CORR_V = (1-PCM^{\star})(1-\beta^{\star})\left(\frac{UV^{EM}-UV^{\star}}{UV^{\star}}\right),\ \beta^{\star} = 1-\frac{2k^{\star}}{1-PCM^{\star}}\,UV^{\star}$

denotes the unit value of the most efficient firm, UV^{WM} weighted average unit value.

[e] $CORR_F = (k^{\star}-\bar{k})$ with $PCM_i-k_i = 0$ if $PCM_i < k_i$ and $k_i = \frac{RE_i^{\star}E}{S}$

and *WM* denoting the market share weighted mean.

as the mean, the second nearer to but still above the mean. The results for the three areas and furthermore those for the individual firms show that the efficiency and quality in general do not seem to be closely related. This implies that the correction of TCD for quality can go into either direction, and 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 (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 the quality adjusted staircase is larger than the uncorrected staircase for the USA (8.83%) and for Japan (4.25%), but lower for Europe (4.85). The downward correction for Europe is due to the fact that the most efficient firm is specialised 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).

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 reason why the correction is not too large is, that producing higher quality implies higher costs. The correction may go in either direction depending on fixed costs and on the quality produced by the most efficient firm. Profit maximising requires that we model this with variable costs increasing less than proportionally and quality dependent fixed costs. This cost structure makes investment in quality improvement attractive and it guarantees an optimum. 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. 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.

Data are unreliable in several respects. There are two extreme reactions to this problem. One is to dismiss empirical evidence from accounting data altogether (for a rather extreme position see Fisher and McGowan)[8], the other is to take them seriously or even literally. An intermediate position is to check the robustness of the results by variations in the concepts, definitions, tests etc. (Schmalensee, 1989). We do this in Aiginger and Pfaffermayr (1997b), where we report only three robustness checks.

As an alternative to our cost concept, we deduct from gross profits the depreciation rate reported in the balance sheet in the first test of robustness.[9] In this case, depreciation becomes the proxy for the quality dependent fixed costs in our theoretical model. If the reported depreciation would represent true economic

Table 4. Robustness of AP_{CST}

	B	Opportunity costs of equity quality dependent			Depreciation quality dependent		
		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.

depreciation, the incorporation of depreciation into the definition of costs would be strongly advisable. Reported depreciation rates seldom do this job, however. They are heavily influenced by differences in reporting behaviour. The result is that in the US, there is little difference between staircases corrected for quality and uncorrected for staircases, while for Europe, the adjusted staircase with the second profit definition is much smaller. In Japan, net profits are so low, that the staircase becomes incalculable, we have differences in accounting losses and not in profits (see Aiginger and Pfaffermayr, 1997b).[10]

The next check was to 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 in Table 4 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 4 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 Cost Differences and Methodological problems

We claim that cost differences which do not erode quickly should be added to the welfare loss of oligopoly. We corrected this extreme assumption by addressing the most prominent candidate for cost differences which do not reflect inefficiencies, namely vertical product differences. The effect of the correction is not too large since the production of higher quality paper increases costs and prices to a rather similar extent. What we will do now is (1) to search for other, non-welfare reducing reasons for cost differences, (2) to discuss which models of competition and oligopoly are consistent with the results and (3) to recall seminal problems arising in the comparison of oligopoly and competition.

There are at least two alternatives to explain persistent cost differences, which do not involve oligopolistic co-ordination, each of them consisting of various strands of literature. One alternative is to interpret cost differences as innovation premia or to maintain that innovation is a complex process so that firms differ substantially in their ability to adopt a new technology, or to claim that imitating firms may even have to go through many of the same design and development activities as the innovator. The first part of this explanation may be called Schumpeterian explanation, the second and third come from Nelson (Nelson, 1991). An alternative explanation is to focus on managerial skills or that the low cost firm owns specific intangible assets 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 management 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) could be analysed 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.[12]

On the other hand, if we maintain that these sources of cost differences are persistent, the question remains as to why the low cost 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. This leads to the question which model of competition and which model of oligopoly is consistent with persistent cost differences and a stable pattern of market shares (without giving up profit maximisation). In the standard model of competition with many firms, freely available technology, free entry all firms have the same cost curves and produce at the same point. But there are also models where firms have different, upward sloping marginal cost curves and price at marginal costs. The marginal firm has zero profit, the non marginal firms have positive profits. This is not the standard type model of competition, but a 'price taking plus heterogeneity type'. But entry is not free and technology is private, so its long run persistence has to be questioned (and the difference in the average costs may be considered as a welfare loss). Among the oligopoly models the static Cournot models start with the cost heterogeneity as an assumption, showing its compatibility with profit maximisation. In the long run the question of entry arises and why firms do not use the best technology. We think that a plausible story could be told in a supergame setting. After by some historical reasons an oligopoly has been established (a collusive price has been agreed upon), in which costs are different across firms, each firm could increase short or medium term profits by switching to the best technology, but this would endanger the stability of the system. If all firms switch to the best technology a Bertrand or Cournot non cooperate game might be played. This is of course only one possible story, but it shows that it could be individually profitable not to use the best technology, while this would be beneficial from the society's point of view.[13]

There are two questions which had been important in the measurement of welfare losses of monopoly since its beginning. If there are economies of scale, monopoly could have an productivity advantage, which could offset the allocative loss. Secondly, if innovation needs extra profits for financing it could be that cost curves are lower due to process innovation. In accepting that the unknown hypothetical price under competition (reference price) equals the costs of the most efficient firm in our sample—after correcting for quality differences—we followed the standard procedure, but are open to critique.[14]

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 with technology embodied in machines, and these are supplied to any producer by specialised firms. We would assess the importance of innovation for persistent cost differences differently in an industry in which innovation is rapid and where the firms carry out their own research (software industry).

6. Conclusions

The measurement of welfare losses under oligopoly has been dominated by the estimation of the dead-weight triangle, which originates from the fact that less output is higher priced relative to a hypothetical competitive market (demand side effect, dead-weight loss). If, however oligopolitic co-ordination allows cost differences between firms to persist, which under competition would evaporate, we have to add a cost side effect (cost staircase).

This paper shows that for the paper industry in the USA, in Japan and in Europe the total cost differences (TDC) among firms are large. We develop a method which allows to eliminate one source of cost differences, which is not welfare reducing, namely vertical product differentiation. Doing this on the theoretical level and on the empirical level we show that the remaining 'cost staircase proper' (CST) is still much larger than the demand side effect. Taking the data seriously and identifying all the remaining cost differences as inefficiency we would conclude that the cost side welfare loss is at least three times if not ten times larger than the demand side loss. We mitigate the well known unreliability of empirical data to some extent by presenting several test of robustness.

On the conceptual level at least two alternative explanations for cost differences exist. One is that cost differences come from innovation rents (being of the Schumpeterian or the Nelson–Winter type), another is that they come from Ricardian rents or specific factors (managerial skills, firm specific learning). We take the first one as a very likely source for persistent cost differences and tried to minimise its impact by concentrating on a mature industry, in which process innovation is embodied in machines available at the market and not many drastic product innovations occur. We would not recommend to apply the model without specification for the software industry or biotechnology. Explaining persistent cost differences by specific factors and rents is also appealing and it is summarised in the booming strategic management literature. However, there are also arguments that rents can be transformed into factors for which competitions arises at least in the long run and if competition is tough.

The minimum result is that cost differences are an important stylised fact even after allowing for the effect of vertical product differentiation, and analysing a mature industry in relative homogeneous economic areas as we did. Insofar as the cost differences come from oligopolistic co-ordination they should be included in an estimate of the social loss. If at least half of the empirically revealed cost differences come from this source—as we find reasonable for a mature industry—the cost side effect is larger than the demand side loss. Research should focus on the reasons for the slow dissemination of best technology, and policy encouraging the proliferation of tangible and intangible innovations could increase welfare maybe more than or at least additional to traditional competition policy.

Notes

1. In the literature, 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). The claim that cost differences may constitute a welfare loss has been made prior to Aiginger and Pfaffermayr (1997a) by Dixit and Stern (1982) and by Daskin (1991).
2. In this setting quality is best interpreted as durability (Tirole, 1988: 100–104; Waterson, 1994: 124–26).
3. 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: 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, Fz_i independently from market structure.
4. 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.
5. Formally, we have

$$\text{TCD} = \left(\frac{(p-p^c)s^\star N}{p} - NK^\star s^\star\right) - \sum_{i=1}^{N}\left\{\left(\frac{p-c_i z_i^\beta - 1_i)}{p} - k_i\right\} s_i\right.$$

$$= \frac{c^\star z^{\star\beta^\star-1}}{p}\sum_{i=1}^{N}\left(\frac{c_i z^{\beta^\star-1} z_{ii}^{z\beta} - \beta^\star_i}{\frac{c^\star z^{\star\beta^\star-1}}{p}} - 1\right) s_i - (k^\star - \bar{k}) \approx \frac{c^\star z^{\star\beta^\star-1}}{p} \star \sum_{i=1}^{N}$$

$$\left\{1 + \frac{c_i - c^\star}{c^\star} + (\beta^\star - 1)\frac{z_i - z^\star}{z^\star} + \text{In} z^\star(\beta_i - \beta^\star) - 1)\right\} s_i - (k^\star - k)$$

assuming symmetry in the reference scenario,

$$s^\star = \frac{1}{N},$$

and using

$$s_i = \frac{z_i q_i}{Q}$$

and

$$s^\star = \frac{z^\star q^\star}{Q}.$$

6. 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.
7. Since the relevant market will be narrower (especially narrower than the SIC-4-digit) the Herfindahl may be underestimated, and consequently the DWT, which allows for oligopoly—as our model does, too. Harberger as well as Cowling and Mueller-type estimates are not influenced by this effect.

8. 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. 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.
9. Note that we do not include both opportunity costs of equity and depreciation of the same time to proxy quality dependent fixed costs. The reason is that we would get negative profits for many firms. This implies that in the robustness test either depreciation relative to sales is equal across firms or, that opportunity costs of equity over sales are constant across firms.
10. This mirrors the high accounting depreciation rates in Japan and the lower variation in net profits. The US firms try to keep investments and depreciation to a minimum, since these items decrease profits and make firms unattractive for investors. In Japan and in Europe (with exception of UK whose reporting behaviour is more in line with US practices), firms try to inflate investment and depreciation, in order to reduce or at least postpone taxes. Remember that the relation between financial and tax accounting differs across countries, too. But in relationship to AP_{DWT}/AP_{CST} is still by far the larger of the two.
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.
12. The stylised 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'), whose research question is 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 successful 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. See Barney (1986), Peteraf (1993) and Ghemawat (1991). We are grateful to Marvin Lieberman for proposing to relate our paper to this strand of literature.
13. Traditional pre-game theoretic game theory stressed that collusion is more difficult to organise, if firms have different costs. This prediction is no objection against the supergame story, since the supergame refers to the incentives to destabilise an existing collusion scheme, however firms agreed on the starting point of the scheme (the candidate equilibrium). Another story could be transaction cost based, firms do not switch to the low cost technique because transaction costs are high. The welfare evaluation of this depends then on the exact type of the transaction cost, if the main part is due to mobility barriers, government regulation, red tape, managerial slack we we would be inclined to asses them as loss, if transaction costs are of the more objective type like delivery lags, uncertainty, etc., then there is no feasible alternative to reduce cost differences and we would not speak of a loss to society.
14. One defence could be to cite the opinion of more than 100 researchers in industrial organisation, who rejected the opinion that costs were lower under oligopoly by a wide margin (see Aiginger, Mueller and Weiss, 1998).

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