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CONDUCT, STRUCTURE AND RELATIVE WELFARE LOSSES IN QUANTITY-SETTING DUOPOLY*

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NO. 205

WARWICK ECONOMIC RESEARCH PAPERS

DEPARTMENT OF ECONOMICS

UNIVERSITY OF WARWICK
COVENTRY

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May, 1982

*We thank numerous colleagues at our home institutions and at The International Institute of Management Berlin for helpful comments and suggestions. We are pleased to acknowledge partial financial support for research underlying this paper from the Centre for Industrial Economic and Business Research at the University of Warwick (now reconstituted as The Centre for Research in Industry, Business and Administration).

ABSTRACT

Since the pioneering study of Harberger, monopoly welfare loss has received much attention in the literature. However, no attempt has been made explicitly to incorporate oligopolistic interaction. In this paper we postulate a specific social welfare function and solve directly for the level of welfare (net surplus) under various duopoly equilibria. Our approach departs from the long-standing tradition in industrial economics in which performance (profit) is explained by structure (concentration). We look directly at welfare, and concentration is found jointly with prices, outputs and profits as part of a solution determined by preferences, behaviour (conduct) and technology. Numerical analysis and computer graphics are employed to generate estimates of welfare loss under each oligopoly solution concept, relative to the social optimum, across plausible ranges of underlying cost and demand parameters.

1. Introduction

Since the pioneering work of Harberger (1954) welfare losses due to monopoly have received much attention in the literature. Recently published estimates put these at 7-13 per cent of gross corporate product in the U.S. and 3-7 per cent in the U.K. (Cowling and Mueller, 1978). These are much larger numbers than Harberger's 'less than one-tenth of one per cent of GNP', though the whole issue remains controversial (see Littlechild, 1981; Cowling and Mueller, 1981). The empirical analyses typically assume linear demand and constant costs. On these assumptions it can easily be shown that the monopoly loss will be exactly 25 per cent of the level of welfare (net surplus) obtaining under a social optimum characterised by zero profit and marginal-cost pricing, irrespective of demand and cost conditions.[1/] This is a maximum figure in that it assumes monopoly pricing behaviour, whereas many previous studies have assumed limit pricing. On the other hand it takes no account of the costs of securing monopoly positions, analyzed by Posner (1975) and others, or of the possibility of reduced technical efficiency etc. in markets where competitive pressure is lacking.

This paper is concerned with the extent to which welfare losses may be attenuated by inter-firm rivalry in oligopolistic markets. So far as we are aware, this has not been considered in the literature to date, although Cowling (1976) and Cowling and Waterson (1976) have derived the relation

$$\frac{p - c}{p} = \frac{H\,(1 + \lambda)}{\eta_p},$$

where p = price, c = marginal and average cost, H is the Hirschman-Herfindahl index of seller concentration, η_p is the industry elasticity of demand and they interpret $\lambda = {}^{dX}/_{dx_i}$ as summarizing firms' expectations concerning the response of rivals to their own output decisions. Thus they relate the Lerner index of monopoly $^{(p-c)}/_p$ to the degree of oligopolistic interaction λ. However alternative oligopoly solutions other than Cournot are not considered explicitly.

Our method is to postulate a specific welfare function and solve for the level of welfare (net surplus) under various combinations of conduct and structure. By 'conduct' we mean alternative conjectural variations determining the way in which the oligopoly game is played. 'Structure', in our terms, embraces both the number of firms (which is fixed at two throughout the present analysis) and also consumer preferences and production technology, as summarised in the parameters of the relevant demand and cost functions.

We focus on quantity-setting duopoly and employ numerical analysis and computer graphics to examine the welfare losses both for given modes of conduct across alternative plausible structures, and given structure under different patterns of conduct, all relative to the social optimum.

This approach departs from a long-standing tradition in industrial economics in which performance (profit) is explained in terms of structural characteristics, notably the level of seller concentration. Our approach differs both in that we look directly at welfare and, in addition, concentration is found jointly with prices, profits and outputs, as part of an equilibrium determined by preferences, behaviour and technology. The traditional approach overlooks this endogeneity. Thus, causal relationships are inferred from equilibrium conditions, such as the Cowling-Waterson relationship. A systematic relationship between concentration and welfare, if it exists, may nevertheless be important to know, not least as a practical aid in the determination of priorities for antitrust agencies. Our analysis permits us to observe such a structure-performance mapping, or alternatively will show whether a given structure (concentration level) may correspond to several states of conduct/performance.

Section 2 draws on recent work by Bramness (1979), Dixit (1979), Ulph (1980), and others providing a unifying framework within which alternative conjectural-variations equilibria may be compared with each other and with the social optimum. Our primary concern is not with the relative merits of the alternative models as oligopoly solution concepts: the 'arbitrariness' or 'correctness' of firms' conjectures and so forth. Rather we focus on the social value of the outcomes produced by alternative behavioural postulates which exist in the literature. Section 3 reports the results of our numerical analysis, showing indices of social welfare for different types of oligopolistic interaction under variation in the degree of product homogeneity, and cost and demand asymmetries. The implications of our analysis for antitrust policy are spelled out along with our conclusions in Section 4.

2. Alternative Conjectural Variations Equilibria

We consider quantity-setting duopoly and assume constant marginal costs c_1, c_2. The utility function is assumed quadratic:

$$U = x_o + \alpha_1 x_1 + \alpha_2 x_2 - \frac{1}{2}(\beta_1 x_1^2 + 2\gamma x_1 x_2 + \beta_2 x_2^2) \tag{1}$$

with α_i, β_i, $\gamma > 0$ and $\beta_1 . \beta_2 \geq \gamma^2$.

x_1, x_2 are the duopolists' outputs and x_o is the composite output of the rest of the economy, assumed competitive.

First order conditions for consumers' equilibrium yield linear inverse demands:

$$\left.\begin{aligned} p_1 &= \alpha_1 - \beta_1 x_1 - \gamma x_2 \\ p_2 &= \alpha_2 - \beta_2 x_2 - \gamma x_1 \end{aligned}\right\} \tag{2}$$

γ captures cross-price effects between the competing firms and may be interpreted as a measure of product differentiation. By definition we require that x_1, x_2 are substitutes in an oligopoly, hence $\gamma > 0$. The products are perfect substitutes when both $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2 = \gamma$. In our numerical analysis the homogenous product case is for convenience treated as $\beta_1 = \beta_2 = \gamma = 1$. Absolute demand advantages for either firm may be captured in a higher value of α_i. Writing $\alpha_i - c_i = \Theta_i$, the duopolists' profit functions are respectively

$$\left.\begin{array}{ll} & \Pi_1 = \theta_1 x_1 - \beta_1 x_1^2 - \gamma x_1 x_2 \\ \text{and} & \Pi_2 = \theta_2 x_2 - \beta_2 x^2 - \gamma x_1 x_2 \end{array}\right\} \qquad (3)$$

Equilibrium conditions for the social optimum, pure monopoly and various oligopoly solutions are set out in equations 4-10 in table 1. The social optimum maximises net surplus: $U - (c_1 x_1 + c_2 x_2)$. Equilibrium is characterised by marginal-cost pricing by both firms, and is the benchmark for subsequent welfare comparisons; in the absence of fixed costs equilibrium will result in zero profits being earned. The Cournot, Bertrand, and Stackelberg solutions are familiar and require no comment.

Market share maximisation, or the maintenance of a given market share, has been proposed as the way oligopolists will formulate their strategy in practice, and casual empiricism lends this view plausibility. A true equilibrium must ensure that compatible market shares are chosen; i.e. must simultaneously satisfy both the reaction functions (7). With symmetric cross-price effects, implicit in our specification of the utility function, it turns out that market share equilibrium coincides with collusive behaviour leading to joint profit maximisation.[2/] Thus, (7) are also first-order conditions for a maximum of industry profits:

$$\Pi_1 + \Pi_2 = \theta_1 x_1 + \theta_2 x_2 - \beta_1 x_1^2 - \beta_2 x_2^2 - 2\gamma x_1 x_2.$$

With a quadratic welfare function the market share/collusion equilibrium will, like pure monopoly, always generate exactly half the output rate and three quarters the net surplus obtaining at the social optimum, irrespective of demand and cost parameter values. Thus, denoting the social optimum outputs by (x_1^o, x_2^o) and comparing (4) and (7), it is obvious that $(\frac{1}{2}x_1^o, \frac{1}{2}x_2^o)$ solve (7). Now at the social optimum

$$U^o = \theta_1 x_1^o + \theta_2 x_2^o - \frac{1}{2}(\beta_1 (x_1^o)^2 + 2\gamma x_1^o x_2^o + \beta_2 (x_2^o)^2) .$$

Recognising that $\Pi_1^o = \Pi_2^o = 0$ in equilibrium and substituting $\theta_1 x_1^o = \beta_1 (x_1^o)^2 + \gamma x_1 x_2$, $\theta_2 x_2^o = \beta_2 (x_2^o)^2 + \gamma x_1 x_2$ from (3) yields

$$U^o = \theta_1 x_1^o + \theta_2 x_2^o - \frac{1}{2}(\theta_1 x_1^o + \theta_2 x_2^o) \tag{14}$$

Obviously

$$U^o = \frac{1}{2}(\theta_1 x_1^o + \theta_2 x_2^o)$$

whereas, substituting for x_1^{ms}, x_2^{ms} from (12) and (13),

$$U^{ms} = \theta_1 \frac{x_1^o}{2} + \theta_2 \frac{x_2^o}{2} - \frac{1}{2} (\theta_1 \frac{x_1^o}{2} + \theta_2 \frac{x_2^o}{2}) \tag{15}$$

$$= (1 - \frac{1}{4})U^o .$$

The concept of rational conjectures equilibria (RCE) has recently been discussed by Ulph (1980), Perry (1982), Bresnahan (1981) and others. The essential requirement is that, for a rational conjectural equilibrium, each firm's conjectures concerning the rival's reactions are correct. In our framework a local RCE implies that each firm has effectively predicted the slope of its rival's reaction function in the neighbourhood of equilibrium.

To capture local RCE completely we first obtain general reaction functions by differentiating (4) and setting to zero:

$$\left.\begin{aligned} \partial\Pi_1/\partial x_1 &= \Theta_1 - 2\beta_1 x_1 - \gamma x_2 - \gamma x_1 k_1 = 0 \\ \partial\Pi_2/\partial x_2 &= \Theta_2 - 2\beta_2 x_2 - \gamma x_1 - \gamma x_2 k_2 = 0 \end{aligned}\right\} \quad (16)$$

where $k_i = dx_j/dx_i$ as conjectured by firm i. The equilibrium so defined will not be unique; 'correct' conjectures provide the uniqueness. Suppose firm 2 changes output from its equilibrium value by an infinitesimal amount dx_2. Then dx_1 is found from (16) :

$$dx_1 = -\gamma/(2\beta_1 + \gamma k_1)dx_2 \ .$$

Therefore, if firm 2's conjecture is to be correct, we require

$$k_2 = -\gamma/(2\beta_1 + \gamma k_1) \ . \quad (17)$$

Similarly, firm 1's conjecture must be

$$k_1 = -\gamma/(2\beta_2 + \gamma k_2) \ . \quad (18)$$

Equations (16)-(18) are four equations in four unknowns, (x_1, x_2, k_1, k_2), so that it is possible to solve for the equilibrium conjectures and output. Ulph considers both interior and boundary optima; the equilibrium conditions (8) in table 1 are for an interior solution with positive profit.[3/]

Our dominant firm solution may be thought of as an extension of Stackelberg's follower-leader solution concept. Follower j is thought of as the aggregate of a competitive fringe of sellers. Leader i maximises Π_i over residual demand (market demand minus fringe supply) and costs. Fringe supply is governed by marginal-cost pricing hence Π_i is maximised subject to $dx_j/dx_i = -\gamma/\beta_j$. The dominant firm is distinguished by a Bertrand reaction function, the fringe by a social optimum. The outcome may be regarded as quasi rational conjectural equilibrium, in that the dominant firm's conjecture is correct while the individual fringe suppliers are price takers.[4/]

Inspection of table 1 shows that the extent of product differentiation, captured in the parameter γ, bears importantly on the equilibrium outcomes. Thus with homogenous products ($\gamma = \beta_1 = \beta_2 = 1$ in our case) the Bertrand, RCE and dominant-firm equilibria all converge on the social optimum, since $(2 - \gamma^2/\beta_1\beta_2) = 1$ (Bertrand, dominant-firm), and $\delta = 0$ (RCE) respectively. Conversely, as γ goes to zero and there are no cross-price effects (i.e. complete product differentiation) the Cournot, Bertrand, RCE and Stackelberg outcomes converge on the market share/collusion position; in all cases the reaction functions reduce to

$$\Theta_1 = 2\beta_1 x_1$$

and $$\Theta_2 = 2\beta_2 x_2 .$$

In effect we are no longer dealing with a duopoly; interaction vanishes as the firms are now monopolists serving disjoint demands. Notice, however, that x_1 and x_2 are both positive and the outcome differs from the pure monopoly case in table 1. This refers to the homogenous products case where only one firm exists. Hence Π_i is maximised subject to $x_j = 0$. Clearly, constraining x_j to zero under complete product differentiation would involve more than merely that firm i has a monopoly.

Each of the foregoing equilibria is depicted in figure 1. R_1M_1, R_2M_2 are the familiar Cournot reaction functions. Along each firm's equilibrium locus marginal cost equals perceived marginal revenue and a stable equilibrium exists at C. R_1N_1, R_2N_2 are the social-optimum 'reaction functions', where respectively firm 1's, 2's marginal cost equals price. Market share reaction functions are the loci M_1Q_1, M_2Q_2. The market share equilibrium MS at their intersection necessarily belongs to the <u>set of efficient profit points</u>: the curve M_1M_2, which is the locus of points of tangency of the duopolists' iso-profit curves. As we have seen, MS is also the joint-profit-maximising equilibrium. The Stackelberg outcomes S1, S2 occur at points of tangency between i's iso-profit curve and j's (Cournot) reaction function. Likewise, the dominant-firm equilibria may be found as points of tangency between the dominant-firm's iso-profit curve and the fringe's socially-optimal reaction-function, D1

(D2) . In the homogenous products case we could legitimately identify the end-points M1, M2 of the Cournot reaction functions as the pure monopoly outcomes for firms 1 and 2 respectively; marginal revenue equals marginal cost with x_2 , x_1 respectively equal to zero.[5/]

Bramness (1979) has delimited the area where kinked-demand-curve equilibria can arise within the framework we are using. Firm i believes that if x_i is increased x_j will increase equiproportionately, but that if x_i is decreased, x_j will stay unchanged. Then its 'equilibrium locus' is the whole zone between its Cournot and market-share reaction functions. The intersection of these zones for firms 1 and 2 covers the whole area where kinked-demand-curve equilibria can arise and is the shaded area in figure 1.

3. Welfare Comparisons

Our aim is to examine the extent of welfare losses in duopolistic markets, and how these vary according to

(i) alternative modes of interaction (conduct), and

(ii) alternative competitive states (structure) as captured in the underlying cost and demand parameters.

In respect to (ii), and with ultimate antitrust-policy implications in mind, we focus in particular on the way welfare losses behave as the degree of product differentiation increases (γ falls), and as one firm enjoys progressively larger cost- or demand-advantages (e.g. c_i/c_j falls or α_i/α_j increases). As any of these happen, competition is reduced in some sense, and we would expect an increase in the shortfall in welfare from the socially-optimal level. Our interest is in the gradient of the relationship between welfare and competition; in whether this relationship dominates or is dwarfed by the impact of alternative modes of conduct on welfare, for a given competitive state; and in whether variations in competitiveness bear on different behaviour patterns uniformly or differentially, i.e. whether the welfare ranking of alternative behavioural outcomes is preserved as the degree of competitiveness varies.

These questions are tackled with the aid of numerical analysis. For specified parameter values we solve for equilibrium prices, outputs, profit, implied elasticities, net surplus (absolute and relative to the social optimum) and level of concentration (as measured by the Herfindahl index.[6/]) This output is also available in graphic form and figure 2 is an example. The contours of our social welfare function are elipses centred on SO , with zero or infinite slope as they intersect the social-optimum reaction functions. The example given features mildly asymmetric demand and costs, with $\gamma = 0.75$.[7/] Since products are not homogenous M_1, M_2 cannot be considered pure monopoly outcomes. Otherwise, as we would expect, market share (joint profit-maximisation) generates least net surplus. Dominant-firm equilibria cause least reduction in welfare from the social optimum, other outcomes tending to cluster inbetween.

With eight solution concepts and seven parameters to consider the number of possible permutations is large. However, not all make economic sense. Thus, product homogeneity is implausible where there are cost or demand asymmetries, and vice versa. For this would imply non-optimising behaviour by at least one firm or by consumers; if costs are asymmetric one or both firms must be inefficient, and if demands differ consumer preferences are irrational. On the other hand, where there is product differentiation, costs and demand may be either symmetric or asymmetric. For differentiation can arise either from both firms incurring extra costs to secure customer allegiance, or from one firm doing so. Finally, it could be argued that leader-follower behaviour, as under Stackelberg and dominant-firm equilibrium, is plausible only where one firm has a cost or demand advantage. Otherwise the assumption of leader-follower roles is arbitrary. In addition, we may discount Stackelberg and dominant-firm equilibria under which the leader is at a cost or demand disadvantage on grounds of total implausibility.

In presenting our results we first consider the special case of homogenous products. We then examine separately the impact on the welfare rankings of variations in the degree of differentiation (γ) cost asymmetry (c_1/c_2) and demand asymmetry (α_1/α_2). Although, as we have said, not all of the implied combinations make sense, it is helpful to get some feel for the "partials" of welfare with respect to the parameters in this way. Next we consider joint variations in the parameters, focussing our attention on what we consider to be the most plausible or interesting combinations. In particular, we consider cases of low, medium and high product differentiation in conjunction with correspondingly low, medium and high degrees of cost disadvantage for one firm (firm 2) accompanied by a concomitant demand advantage. This is tantamount to extending our analysis to incorporate product quality and selling effort as decision variables to the firm, albeit for the special case where an x% cost differential secures the same percentage absolute demand advantage.

Homogenous Products

Table 2 confirms the earlier analytical result that with homogenous products socially optimal behaviour results not only from explicit marginal-cost pricing, but also under Bertrand interaction and RCE.[8/] At the other extreme market share behaviour coincides with pure monopoly, as we expect from the theory, generating only half the socially optimal output at more than twice the competitive price, and the expected monopoly welfare loss of 25 per cent. Cournot interaction cuts the monopoly loss to only 11.1 per cent and Stackelberg behaviour to 6.2 per cent.

Note the perverse relationship between 'market structure' and welfare loss. Thus the Herfindahl index fails to distinguish the social optimum, Bertrand and RCE, on the one hand, and the market share equilibrium on the other, whereas these lie at extreme ends of the range of variation in welfare! Furthermore the intermediate Cournot and Stackelberg cases are ranked perversely, the latter generating little over half the welfare loss of the former, despite a more concentrated market structure. Similarly non-discriminating or perverse results occurred throughout our analysis. We conclude that evidently, and contrary to a strong tradition in industrial organisation, conduct matters.

Product Differentiation

Table 3 confirms the convergence of the Cournot, Bertrand, RCE and Stackelberg equilibria on the market share/collusion outcome. Notice that the convergence proceeds quite rapidly as the degree of product differentiation increases and γ falls from unity. Thus, despite their differing starting levels, the Cournot, Bertrand, RCE and Stackelberg welfare losses all lie between 18 and 20 per cent of the social optimum when $\gamma = 0.25$. At this point the average increase in welfare loss for these solutions compared with the homogenous product case is 15.5 per cent. We conclude that the gradient of the competitiveness - welfare relationship in this plane is quite steep. However, the welfare ranking of the alternative equilibria is preserved. Meanwhile the dominant-firm welfare loss also increases as γ falls, to 12.5 per cent - one half that of other solutions. This simply registers the fact that half the total output produced is subject to pure monopoly pricing and half is priced competitively. However this result is little more than a curiosum, in the absence of the cost asymmetry needed to render the dominant-firm solution concept plausible.

Cost Asymmetry

As expected, where rivalry is reduced due to one firm having lower costs (firm 2 in our examples), relative welfare losses increase with the degree of cost advantage (table 4). At high levels of product differentiation (low γ) the effect is barely perceptible (table 4(b)). It remains small even where products are relatively homogenous; where $\gamma = 0.75$ (table 4(a)) the average percentage welfare loss for five meaningful cases (i.e. omitting the social optimum, M S1 and D1) is 10.6 per cent with a 50 per cent cost differential, compared with 7.7 per cent where there is none. Over this range the welfare ranking is substantially unaffected, only Bertrand and D2 interchanging places, these being very close in the original, symmetric cost case. In practice we would expect differential costs and diverse products to go together; if both firms have access to the same technology and are cost minimisers, inter-firm cost differences are most likely to be product-related. Hence, where cost asymmetries are most likely to be found, their impact on welfare, though adverse, is very slight.

Demand Asymmetry

A similar conclusion applies in the case of demand asymmetry.

Thus, where products are relatively homogenous there is a sharp increase in relative welfare loss in all cases (except, of course, market share) as firm 2's demand advantage is increased (table 5(a)). But this is an unlikely state of affairs. More plausible is that a marked demand advantage will be associated with highly differential products. In this case the impact of demand asymmetry on the indices of welfare loss for different types of equilibrium is, with one exception, minimal (table 5(b)). The exception is dominant firm equilibrium, where relative welfare loss almost doubles from 9.9 per cent where there is no asymmetry to 17.4 per cent where the dominant firm has a 50 per cent absolute demand advantage. Thus the welfare-enhancing effect of a competitive fringe, it appears, is much reduced where it supplies an inferior product.

Joint Variation

Table 6 shows what happens when the degree of product differentiation varies in the presence of simultaneous, offsetting asymmetries in both cost and demand. We focus only on plausible combinations: e.g. 'mild' product heterogeneity accompanied by 'modest' additional costs and demand advantage, etc. The results in general confirm previous conclusions. Thus, scanning any column, we see that the type of interactive behaviour in force makes a substantial difference to welfare. Average percentage losses over the nine reported cases are Cournot 16.8; Bertrand 11.5; Market Share 25.0; RCE 13.7; Stackelberg 15.4; and Dominant-Firm 6.4. Similarly, welfare losses are much affected by the degree of product differentiation. Average percentage losses across all types of equilibria in 6(a) 6(b) and 6(c) are 10.0, 15.8, and 17.7 respectively. However cost and demand asymmetries, in this case across a range of variation appropriate to the degree of product heterogeneity, make very little difference, again with the exception of the dominant firm case.

4. Conclusions

Four principal conclusions emerge from our analysis, subject of course to the assumptions underlying our approach: static duopoly equilibria with no entry and a specific utility function which rules out income effects.

(i) Under duopolistic rivalry the particular form of oligopolistic interaction exerts a major influence on the level of welfare

Conduct matters. In general Dominant Firm equilibria involve least welfare loss, usually around one third of the maximum, Market Share/ Collusion loss level. The intermediate cases are consistently ranked Bertrand, RCE, Stackelberg and Cournot, in ascending order of welfare loss, in the range one half to somewhat over two thirds of the maximum. As we have seen, kinked demand curve equilibria will lie between the Cournot and market share values. It follows that the design and execution of antitrust policies should not focus wholly or primarily on structural conditions. Two cases merit special attention.

First, we have seen that market-share behaviour coincides with joint-profit-maximisation and produces the largest welfare loss: 25 per cent in the case of linear demand. Under competition law in most countries where such policy exists, overt collusion is proscribed. However non-competitive, adaptive behaviour generally does not infringe the law unless an agreement can be inferred. Our analysis shows that, where non-cooperative interaction takes the form of mutual market-share maximisation, precisely the same outcome will be reached. It thus calls into question the existence of a distinction in law between the two cases. In countries like the UK and West Germany, where competition policy provides for the application of a test of the public interest on a case-by-case basis, our analysis suggests that evidence of market-share interaction should invariably lead to a negative finding, whether or not an implicit agreement can be inferred.

Secondly, our analysis draws attention to the welfare-enhancing effect of competition from a competitive fringe. This almost invariably produces less welfare loss than any other form of rivalry, and in many cases the losses amount to only a few percentage points. However, the constraining influence of competition from the fringe is much weakened where products are heterogeneous. When evaluating dominant-firm cases antitrust agencies should therefore pay close attention to the cross-elasticities of demand between the fringe and dominant firm's products. Needless to say they should also be careful to ensure that the fringe prices at marginal cost and earns zero profit.

(ii) <u>The power of inter-firm rivalry to further social welfare is highly sensitive to the degree of product differentiation in the market</u>

Where products are homogenous three types of interactive behaviour generate welfare levels equal to the social optimum, whereas all but the dominant-firm case lead to maximum, market-share/collusion losses if there is complete differentiation of products. Furthermore, welfare losses increase rapidly as product heterogeneity enters.[9/] Antitrust policy and agencies should therefore pay close attention to the cross-elasticities of demand between rival's products in all cases.

(iii) <u>Over broad ranges, asymmetric cost and demand conditions as between rivals generally have little effect on the size of welfare losses</u>

The one (dominant-firm) exception has already been discussed.

(iv) <u>Measures of market structure are an unreliable guide to the level of welfare in duopolised markets</u>

This is a corollary of (i). Because conduct matters it cannot be assumed that there is a unique or even close relationship between particular structural conditions and performance. In particular, measures of seller concentration such as the Herfindahl index may either fail to distinguish different social outcomes or even rank them perversely.

Footnotes

1/ Whatever the level of costs and slope of the demand curve, monopoly output is half the competitive level and the monopoly profit rectangle is twice as large as (a) the consumers' surplus under monopoly and (b) the monopoly deadweight loss triangle. Under competition net surplus is the sum of these areas.

2/ See also Bramness (1979).

3/ For details see Ulph (1980).

4/ Fringe firms assume $dp_j/dx_i = 0$ with $p_j = p_i$, where j is the dominant firm and $i = 1,2, . . . n$ is a member of an n-firm fringe.

5/ Figure 1 is not drawn for this case where, as was seen, B, RCE, D1 and D2 would converge on SO.

6/ Since $H = \frac{1}{n} + \sigma_n^2$ where n is the number of firms in the industry, the minimum H value in our case is 0.5 (except under Dominant Firm equilibrium), obtained whenever $x_1 = x_2$.

7/ Parameter values underlying figure 2 are $\alpha_1 = 20$, $\alpha_2 = 22$; β_1, $\beta_2 = 1$; $c_1 = 6.0$, $c_2 = 6.6$.

8/ Dominant-firm equilibrium is not reported in table 2 for the reasons given.

9/ Focussing on relative welfare losses we ignore improvements in welfare at the social optimum through increased product differentiation and the resource costs of securing them.

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Table 1 : Alternative Equilibria

Model	Maximand/Conjectural Variations	Equilibrium Conditions ("Reaction Functions")	
Social Optimum (SO)	$\text{Max}\{U - (c_1x_1 + c_2x_2)\}$	$\theta_1 = \beta_1x_1 + \gamma x_2$ $\theta_2 = \beta_2x_2 + \gamma x_1$	(4)
Cournot (C)	$dx_j/dx_i = 0$ $(i \neq j;\ i, j = 1,2)$	$\theta_1 = 2\beta_1x_1 + \gamma x_2$ $\theta_2 = 2\beta_2x_2 + \gamma x_1$	(5)
Bertrand (B)	$dx_j/dx_i = -\gamma/\beta_j$ (i.e. firm i chooses x_i assuming x_j changes such that p_j is constant)	$\theta_1 = (2 - \frac{\gamma^2}{\beta_1\beta_2})\beta_1x_1 + \gamma x_2$ $\theta_2 = (2 - \frac{\gamma^2}{\beta_1\beta_2})\beta_2x_2 + \gamma x_1$	(6)
Market Share (MS)	$dx_j/dx_i = x_j/x_i$ (i.e. firm i chooses x_i assuming x_j changes proportionately)	$\theta_1 = 2\beta_1x_1 + 2\gamma x_2$ $\theta_2 = 2\beta_2x_2 + 2\gamma x_1$	(7)
Collusion	$\text{Max}\{\Pi_1 + \Pi_2\}$		
Rational Conjectures (RCE)	Conjectural derivatives are endogenous.	$dx_2/dx_1 = -\beta_1(1 - \delta)/\gamma$ $dx_1/dx_2 = -\beta_2(1 - \delta)/\gamma$ $\theta_1 = \beta_1(1 + \delta)x + \gamma x_2$ $\theta_2 = \beta_2(1 + \delta)x_2 + \gamma x_1$ with $\delta = \sqrt{1 - \gamma^2/\beta_1\beta_2}$	(8)
Stackelberg[(i)] (S1,S2)	$\text{Max } \Pi_i$ s.t. $dx_j/dx_i = -\gamma/2\beta_j$ (i.e. Cournot reaction)	$\theta_1 = (2-\gamma^2/2\beta_1\beta_2)\beta_1x_1+\gamma x_2$ $\theta_2 = 2\beta_2x_2 + \gamma x_1$	(9)
Dominant Firm[(i)] (D1,D2)	$\text{Max } \Pi_i$ s.t. $dx_j/dx_i = -\gamma/\beta_j$ (i.e. 'fringe' supply priced at marginal cost)	$\theta_1 = (2-\gamma^2/\beta_1\beta_2)\beta_1x_1+\gamma x_2$ $\theta_2 = \beta_2x_2 + \gamma x_1$	(10)
Monopoly[(i)(ii)] (M1,M2)	$\text{Max } \Pi_i$ s.t. $x_j = 0$	$x_i = \theta_i/2\beta_i$	

Notes: (i) Equilibrium condition assumes firm 1 'leads'. Similarly for firm 2.

(ii) Strictly, applies only where products are homogenous $(\alpha_1 = \alpha_2\ ,\ \beta_1 = \beta_2 = \gamma)$.

Table 2 : Price, Output and Welfare: Homogenous Products[(i)]

<table>
<tr><th>Model</th><th>x_1</th><th>x_2</th><th>P_1</th><th>P_2</th><th>η_1</th><th>η_2</th><th>Welfare Index (S=100)</th><th>HERF</th></tr>
<tr><td>Social optimum</td><td colspan="2">7.0</td><td colspan="2">6.0</td><td colspan="2">0.9</td><td>100.0</td><td>0.50</td></tr>
<tr><td>Cournot</td><td colspan="2">4.7</td><td colspan="2">10.7</td><td colspan="2">2.3</td><td>88.9</td><td>0.50</td></tr>
<tr><td>Bertrand</td><td colspan="2">7.0</td><td colspan="2">6.0</td><td colspan="2">0.9</td><td>100.0</td><td>0.50</td></tr>
<tr><td>Market Share</td><td colspan="2">3.5</td><td colspan="2">13.0</td><td colspan="2">3.7</td><td>75.0</td><td>0.50</td></tr>
<tr><td>RCE</td><td colspan="2">7.0</td><td colspan="2">6.0</td><td colspan="2">0.9</td><td>100.0</td><td>0.50</td></tr>
<tr><td>Stackelberg(1)</td><td>7.0</td><td>3.5</td><td colspan="2">9.5</td><td>1.4</td><td>2.7</td><td>93.8</td><td>0.56</td></tr>
<tr><td>Stackelberg(2)</td><td>3.5</td><td>7.0</td><td colspan="2">9.5</td><td>2.7</td><td>1.4</td><td>93.8</td><td>0.56</td></tr>
<tr><td>Monopoly(1)</td><td>7.0</td><td>-</td><td>13.0</td><td>-</td><td>1.9</td><td>-</td><td>75.0</td><td>1.00</td></tr>
<tr><td>Monopoly(2)</td><td>-</td><td>7.0</td><td>-</td><td>13.0</td><td>-</td><td>1.9</td><td>75.0</td><td>1.00</td></tr>
</table>

Note (i) Assumes $\alpha_1, \alpha_2 = 20.0;\ \beta_1, \beta_2 = 1.0;\ c_1, c_2 = 6.0$

Table 3 : Welfare Indices and the Degree of Product Differentiation (γ)

<table>
<tr><th>Model</th><th>$\gamma \to 1$</th><th>$\gamma = 0.75$</th><th>$\gamma = 0.5$</th><th>$\gamma = 0.25$</th><th>$\gamma \to 0$</th></tr>
<tr><td>SO</td><td>100.0</td><td>100.0</td><td>100.0</td><td>100.0</td><td>100.0</td></tr>
<tr><td>C</td><td>88.9</td><td>86.8</td><td>84.0</td><td>80.2</td><td>75.0</td></tr>
<tr><td>B</td><td>100.0</td><td>96.0</td><td>88.9</td><td>81.6</td><td>75.0</td></tr>
<tr><td>M</td><td>75.0</td><td>75.0</td><td>75.0</td><td>75.0</td><td>75.0</td></tr>
<tr><td>RCE</td><td>100.0</td><td>92.5</td><td>86.6</td><td>81.0</td><td>75.0</td></tr>
<tr><td>S1
S2</td><td>93.8</td><td>89.3</td><td>85.2</td><td>80.6</td><td>75.0</td></tr>
<tr><td>D1
D2</td><td>(100.0)</td><td>96.9</td><td>93.7</td><td>90.6</td><td>87.5</td></tr>
<tr><td>M1
M2</td><td>75.0</td><td>(-)</td><td>(-)</td><td>(-)</td><td>(-)</td></tr>
</table>

Table 4 : Welfare Indices under Cost Asymmetry

Model \ $c_1=6.0; c_2=$	6.0	5.0	4.0	3.0
(a) $\gamma = 0.75$				
SO	100.0	100.0	100.0	100.0
C	86.8	86.4	85.2	83.6
B	96.0	95.7	94.9	93.8
M	75.0	75.0	75.0	75.0
RCE	92.5	92.1	91.1	89.7
S2	89.3	89.6	89.1	88.0
D2	96.9	95.2	93.5	91.7
(b) $\gamma = 0.25$				
SO	100.0	100.0	100.0	100.0
C	80.2	80.2	80.2	80.0
B	81.6	81.6	81.5	81.4
M	75.0	75.0	75.0	75.0
RCE	81.0	80.9	80.6	80.8
S2	80.6	80.6	80.6	80.5
D2	90.6	89.5	88.5	87.6

Note: Demand symmetric: $\alpha_1, \alpha_2 = 20$; $\beta_1, \beta_2 = 1$; $c_1 = 6.0$

Table 5 : Welfare Indices under Demand Asymmetry ($\alpha_1 \neq \alpha_2$; $\beta_1 = \beta_2$)

Model \ α_1=20; α_2=	20	22	24	26	28	30
(a) γ = 0.75						
SO	100.0	100.0	100.0	100.0	100.0	100.0
C	86.8	85.3	81.8	77.7	73.7	70.2
B	96.0	94.9	92.4	89.5	86.6	84.1
M	75.0	75.0	75.0	75.0	75.0	75.0
RCE	92.5	91.1	88.0	84.4	80.9	77.7
S2	89.4	89.1	86.6	83.3	79.8	76.6
D2	96.9	93.5	90.1	87.2	84.8	83.0
(b) γ = 0.25						
SO	100.0	100.0	100.0	100.0	100.0	100.0
C	80.3	80.2	79.9	79.6	79.3	78.9
B	81.6	81.5	81.3	81.0	80.7	80.3
M	75.0	75.0	75.0	75.0	75.0	75.0
RCE	81.0	80.9	80.6	80.3	80.0	79.6
S2	80.6	80.6	80.4	80.1	79.8	79.5
D2	90.6	88.5	86.7	85.1	83.7	82.6

Table 6 : Joint Variation

	(a) Mild Differentiation (γ = .75)		(b) Medium Differentiation (γ = .5)		(c) High Differentiation (γ = .25)				
	a(i)	a(ii)	b(i)	b(ii)	c(i)	c(ii)	c(iii)	c(iv)	c(v)
S	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C	86.6	86.0	83.8	83.3	80.2	80.1	79.9	79.7	79.4
B	95.9	95.4	88.7	88.3	81.6	81.5	81.3	81.1	80.9
M	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
RCE	92.3	91.8	86.4	86.0	80.9	80.8	80.6	80.4	80.2
S1	88.7	87.7	84.8	84.1	80.5	80.3	80.1	79.9	79.6
S2	89.6	89.5	85.3	85.1	80.6	80.5	80.4	80.2	80.0
D1	97.9	98.6	95.4	96.8	92.1	93.3	94.4	95.3	96.1
D2	95.7	94.5	91.9	90.1	89.1	87.7	86.5	85.4	84.4
Parameter Values:									
α_1	20	20	20	20	20	20	20	20	20
α_2	21	22	22	24	22	24	26	28	30
β_1	1	1	1	1	1	1	1	1	1
β_2	1	1	1	1	1	1	1	1	1
c_1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
c_2	6.3	6.6	6.6	7.2	6.6	7.2	7.8	8.4	9.0

Figure 1

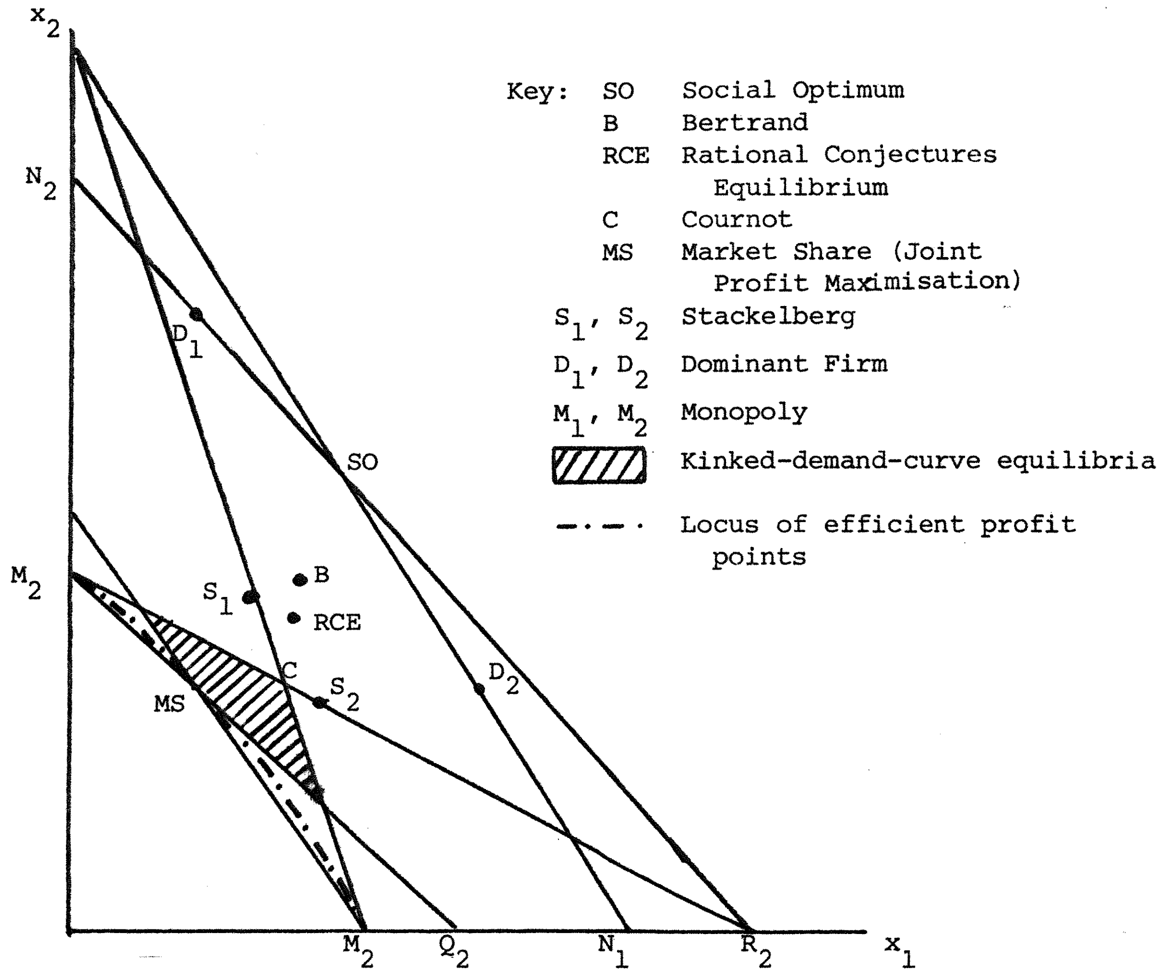

Figure 2