

QUALITY CHANGE AND COMPETITION
IN THE UNITED KINGDOM CAR INDUSTRY

1956-68

by

John Stephen Cubbin
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APPROVAL

Name: John Stephen Cubbin

Degree: Doctor of Philosophy

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Kingdom Car Industry, 1956-68.

Examining Committee:

Chairman: Zane Spindler

R.A. Holmes
Senior Supervisor

C. Lloyd

R. Schwindt

R. Uhler
External Examiner
Associate Professor
University of British Columbia

Date approved: OCT 17 1975

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in the United Kingdom Car Industry

Author:

(signature)

JOHN S. CURBIN

(name)

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(date)

ABSTRACT

The main concern of this dissertation is the role of quality change in the context of oligopolistic rivalry. What is it about the car industry that makes it susceptible to quality change ? Is it a means of increasing profit margins through a process of product differentiation, or alternatively a means of increasing sales, possibly at the cost of reduced profit margins ? The relationship of quality competition to price competition and advertising is thus a central theme.

The theoretical framework used is of a type usually referred to as "structure, conduct, and performance". However a major concern is to go beyond simply, the size distribution of firms and barriers to entry as the determinants of behaviour, to much more detailed consideration of the factors, such as information flows and retaliation lags, which are recognised as affecting oligopolistic outcomes.

The main orientation is, however, empirical. The measurement of changes in quality, using an approach called the hedonic technique, is the major statistical tool. Its advantage is that it allows quality changes to be expressed in money terms. In addition the price-cost margin, a central concept in oligopoly, is estimated

on an annual basis by a regression approach instead of resorting to the more usual profits/sales ratio.

The main conclusion of the theoretical part is that the most persuasive reason for the existence of quality change as a continual feature is the existence of gestation, or retaliation, lags in developing new or modifying old models. From the empirical work it is concluded that price-cost margins were eroded over the period and quality improvement played a significant part in the mechanism by which this occurred - although it does not by itself explain why this happened. Possible reasons for the phenomenon are offered.

A measure of "apparent collusion" is defined and calculated. A value of 1 would imply joint monopoly behaviour and 0 complete non-recognition of oligopolistic interdependence. For the price cost margin the calculated value was 0.453. This shows the net effect of price behaviour and decisions on quality, which typically alter costs. For advertising the measure was 0.9 implying a great deal of tacit collusion in this industry. The use of quality competition as a competitive weapon does not indicate that it was used in response to short-term changes in the situation - for example, a decline in market share. Short-term responses were found to differ considerably between firms.

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CHAPTER 1

Introduction

This thesis is about the use of quality variation as a competitive weapon. The industry chosen, private car manufacturing, has long associated with this kind of competition; it is probably the most common example chosen by textbook writers for illustrating nonprice competition in oligopoly. There has been little systematic quantitative study of quality competition, however. No doubt this has been partly due to the difficulty of expressing quality changes in terms of a common standard of measurement. The hedonic technique used here, which was introduced by Court in 1939, goes a long way towards producing such a standard of measurement for the sort of quality changes that are important for motor cars. Fisher, Griliches and Kaysen {1962} used it in their analysis of the costs of automobile changes - one of the few quantitative studies in this area.

The lack of quantitative analysis must have contributed to the lack of agreement over the welfare and policy significance of quality competition. For example, one author, drawing some conclusions in the final chapter of his (mainly theoretical) book on quality competition says:-

"Analysis of pure quality competition revealed that the results of a rigid price situation may be quite different from those which conventional price analysis would lead us to predict. In fact, quality competition performs, in the absence of price competition, much the same functions that price competition performs.

It was shown too that quality competition performs other functions which cannot be satisfied by price competition. It enables buyers to satisfy their wants with greater precision. It provides a range of choice broad enough to satisfy buyers who differ widely in their circumstances and tastes. It promotes novelty, variety and progress. "(Abbott, {1955} p. 208.)

A rather different view is expressed by a mainstream economics textbook writer :-

"Vast amounts of resources are devoted to advertising and to creating quality and design differentials. The allocation of some resources for these purposes is doubtless justifiable. For example, to the extent that advertising merely reports price and seller location, it helps keep buyers better informed. Similarly, certain quality and design differentials may be socially desirable. Nonetheless, there is a strong presumption (based on purely empirical grounds) that oligopolists push all forms of nonprice competition beyond the socially desirable limits. In absence of evidence to the contrary, it is reasonable to conclude that buyers in oligopoly markets would be better off if there were more active price competition and less nonprice competition." Ferguson, {1972} p. 366.

Part of the argument at least is over empirical matters and not value judgements. Whilst it is not claimed that this work will give any definitive answers to the welfare and policy implications of quality competition, it is hoped that it will shed a little light on some of the underlying empirical questions by finding out how quality competition operated for the car industry in the U.K. in the late 1950's and most of the 1960's.

In the process certain theoretical questions will have to be dealt with. Chapter 2, on oligopoly behaviour, puts quality change into perspective as just one type of rivalistic behaviour which may be observed to differing degrees in different industries. The view is adopted that oligopolists show a range of behaviour "as if" there were varying degrees of collusion between them. The determinants of this "degree of collusion" are considered. They turn out to be many and varied. In the Appendix to Chapter 2 a measure of "apparent collusion" is developed for application later on (Chapter 7.).

In Chapter 3, the many and various determinants of the extent of apparent collusion are considered for the U.K. car industry and the reasons to expect quality competition gradually emerge.

(Although these reasons might appear obvious to some it was considered useful to go through the exercise and derive it from first principles, as it were, in an attempt to avoid ad hoc theorising. The consequence is that much more emphasis than in my earlier work is put on retaliation lags and much less on the "mist of uncertainty" (Abbott, {1955}, p. 210) as the main cause of quality competition.)

Chapter 4 is concerned with the theory of the measurement of quality change. Although the hedonic method of quality measurement is becoming more accepted, the theory underlying is still rather vague. This vagueness is due mainly, I feel, to the vagueness of the underlying price model implicit in the approach. No final solution is offered here, but an attempt is made to clarify some of the associated problems. First to be discussed is the connection with Lancaster's approach to consumer demand - it turns out to be less close than has been thought by some writers, e.g., Muellbauer {1972 } . Second, is the price-quality relation a price function or a cost function? (Answer: a price function.) Third, does the use of weighted regression in the hedonic technique lead to bias in the derived quality-adjusted prices ? (Answer: the argument for a consistent bias is not found convincing.)

Chapter 5 gives an account of the estimation of the price-quality relationship involved in the hedonic technique. The data have been used before (Cowling and Cubbin, 1971, 1972)but a rather more elaborate approach is adopted for the requirements of this study.

Chapter 6 makes use of the previous work on price indexes and cost indexes to estimate the average price-cost margin in car manufacture for each year of the study. This is used as a starting point for the discussion and analysis of Chapter 7, which is mainly concerned with the relation between quality competition and the price-cost margin, but also compares the use of quality competition with advertising as a means of oligopolistic rivalry. These are often lumped together (see the quotation from Ferguson above, p.2), but this study is concerned to draw a clear distinction.

Finally, Chapter 8 summarizes the conclusions of the earlier chapters, mentions some of the limitations of the study and qualifications that must be borne in mind, and then goes on to speculate about the possible implications of the results for both academic and policy questions.

CHAPTER 2A short selective survey of oligopoly theory

Few areas of Economics can have spawned so many apparently competing theories as oligopoly. There are Cournot models, Bertrand-Edgeworth models, entry-limiting price models and conjectural variations models, not to mention "full-cost pricing" and "kinked demand curve" theories. Each one of these theories can be falsified as the theory of oligopoly on the basis of either its assumptions, internal contradictions or predictions, sometimes all three, for some given oligopoly situation. The assumptions have often been rather arbitrary and must have left many with the feeling that "yer pays yer money and take's yer choice" of assumptions. Without a theory of which assumptions to make, this seems to imply that the oligopoly situation is completely indeterminate in the sense that one cannot predict any outcome of a particular situation and explain only on the basis of ex post facto rationalisation rather than a priori generalisations. However, there are other possibilities. One of these is that there is a theory of oligopoly (waiting to be invented) that can explain a priori and predict any oligopoly situation with certainty. More likely is the possibility of isolating those factors which influence the probability that one outcome will be the result of a particular oligopoly situation. These factors are the sort of entity usually regarded as elements of market structure, in that it is market structure which under the current convention is held to determine market conduct and performance, which are the objects of interest in oligopoly theory. Scherer (1970) has managed to isolate many of these factors. In this chapter these factors are put into a framework suggested by the work of Stigler (1964) and Nicholson (1972).

This chapter first discusses some of the traditional oligopoly situations with their shortcomings. The collusive solution is then introduced and the barriers and limitations to collusion are then discussed. The conflict that this implies brings us to the question of Game Theory and experiments in oligopolistic games. These are found to shed light on the variables that are important in deciding how a particular oligopoly situation will be resolved.

The Cournot Solution is the first widely-known attempt to model oligopoly behaviour. The essential elements are that each firm adjusts its output on the assumption that other firms keep their outputs fixed and that price adjusts to clear the market. It can easily be shown that the result of such behaviour is a convergence to a determinate price-quantity equilibrium, with an aggregate output of $\frac{N}{N+1}$ where N is the number of firms. of the purely competitive output level / This model can be criticised in two ways for unrealism. First, there is the empirical observation that firms with market power generally make a decision on price rather than on output. The second criticism is of the element of what Fouraker and Siegel (1963) term "simple maximising" behaviour. Fellner (1949) in particular has been at pains to point out the paradox in this sort of behaviour. Equilibrium can only be reached if each firm is continually proved wrong in his assumption, since the other firms must change their output in response to output change of any one firm except at equilibrium. The question then arises as to whether the firms in question would not then modify their behaviour in the light of their discovery that the basis of their action has proved false.

The other problem, that of quantity, rather than price, being

the dependent variable, was attacked by Bertrand (1883) and a model formulated by Edgeworth (1897). A clear exposition of this and the Cournot duopoly is to be found in Lloyd (1967). The "solution" is that if each firm assumes that the other will stick to its present price and will not sell more than the profit-maximising quantity, this output being less than the quantity demanded (i.e., each firm's capacity less than the full extent of the market) then continual fluctuations in price are likely to occur. Prices will fall as the firms undercut each other infinitesimally, thus temporarily gaining all the demand they can supply. When price reaches a certain level, however, it pays one firm (A) to let the other (B) sell all it can at its quoted price. Under Edgeworth's assumption there will be a residual market (which cannot be satisfied by B's capacity) left for the first firm to exploit monopolistically by raising its price. It then pays B to raise its price to a level infinitesimally less than A's, and the price starts to descend once more as A undercuts B.

Two things need to be said about this model- the first being that it has the same naïve maximising element of the Cournot model. More important is the point that there is an implicit assumption of absolute product homogeneity in the way demand switches violently between the two firms concerned. However, the empirical observation of firms with market power on which the criticism of Cournot was made was almost certainly based on products which were differentiated in some way even if only on the basis of information or transport costs. Allowing for product differentiation vitiates the oscillations of the Bertrand-Edgeworth model. Product differentiation of the most general sort means that a non-infinitesimal price reduction is required to capture a sub-

stantial proportion of the rival's market share. This implies, as Fellner points out, that "if the product is differentiated {price} reaction functions may be defined, and the problem acquires characteristics similar to the Cournot problem ", (p.88).

However, "it may not be taken for granted that the reaction functions intersect for positive prices and, if they do intersect, it may not be taken for granted that an intersection point is stable in the sense in which Cournot intersection point is stable", (p.89).

This question of existence and stability is a matter of the form and parameters of the reaction functions. The reaction function of each firm is a locus of profit-maximising prices given the other firm's price. This will depend on the revenue and cost functions, the former depending on the market demand function and the degree of product differentiation in so far as it affects the partial demand function facing each firm.

These facts are of interest only in so far as the Cournot-type behaviour can be justified as a particular oligopoly form, and the circumstances under which it will be found, identified. So far the case in favour of it looks decidedly weak; since it assumes a mode of behaviour which is inherently self-falsifying; and furthermore behaviour which is apparently arbitrary. Unless we can find good reasons for this apparently arbitrary behaviour we shall have to cross it off our list as a partial oligopoly form.

This criticism of arbitrariness can also be levelled at the

Bowley-von Stackelberg type of analysis, which have reaction functions of various specifications and behaviour which may not be self-falsifying in the sense that Cournot behaviour is, but which need justifying in terms of a wider framework for oligopoly theory. For instance, in the Stackelberg leader-follower case (where firm A chooses the point on B's reaction function which is optimal for himself) we need a framework which will tell us what characteristics of an industry are important in determining whether this will be the mode observed in any one situation, and, even more specifically, under what circumstances this behaviour will occur.

The so-called "collusive solution" is a convenient place to start discussion of the wider framework. The limitations to this mode of behaviour have been widely explored and these limitations yield us a list of some of the characteristics relevant in determining the mode of oligopoly behaviour.

The possibility of collusion stems from the recognition of mutual dependence :-

"Let each seller, then, in seeking to maximise his profit, reflect well, and look to the total consequences of his move. He must consider not merely what his competitor is doing now, but also what he will be forced to do in the light of the change which he himself is contemplating." (Chamberlin {1933}, 8th Edition, 1962, p.47.)

With the possibility of immediate retaliation to price cuts, the stable duopoly price-output combination is, according to Chamberlin, the monopoly one with total output shared equally between the two firms.

Nor is there any gradual change to a competitive level, as with the Cournot solution. In this analysis, as numbers increase it is impossible to say at what point recognition of mutual dependence ceases to be a factor.

The first limitation on collusive behaviour, then, is that of numbers. For Chamberlin, the main question was at what point the effect of an individual firm's price policy on others' market shares was negligible. At this point each firm could make the assumption of zero mutual dependence, assuming there was a threshold level of market share change below which competitors do not react.

This has been embodied in a formal model by Stigler {1964} Changes in a firm's market share of more than one standard deviation are taken to be indicative of secret price cutting by a rival. Probability of detection falls rapidly with an increase in numbers, although this rate of decline can be slowed down if firms pool information on market shares. As probability of detection falls the incentive to cut one's own price obviously increases, and faith in the adherence to the collusive solution by one's rivals obviously diminishes. Therefore numbers are rightly regarded as one of the crucial limitations to collusion as a mode of oligopoly behaviour. Bain {1951} in his famous pioneering investigation found that where more than 70 per cent of a market was held by the biggest eight firms, profits significantly in excess of the competitive level were found.

The question of detection of secret price cutting is then a crucial one for oligopoly. Ease of detection depends not only on the

number of competitors but also, of course, on the quality of information available. Complete information concerning all firms' policies combined with knowledge that one's own policies are subject to scrutiny by rivals is obviously conducive to cooperation. In circumstances where such information sharing may be taken as evidence of illegal activities or where the transmission of information is difficult for other reasons (e.g., complexity in the case of highly differentiated products), a more limited amount of information may be sufficient to achieve some collusive benefits. Information and communication, then, are further possible limiters of the extent to which collusion can prevail.

Inability to agree on a collusive price is a further possible barrier. Since the optimal collusive price is equal to marginal cost plus a mark-up depending on the industry elasticity of demand failure to agree must arise as a result of a difference across firms of marginal costs or estimate of the industry demand elasticity.

Situations involving such conflicts of interest are the sort analysed by game theory. Von Neumann and Morgenstern (1947) obtained a solution which included all those outcomes which are Pareto optimal (to the participants) in the sense that each participant gets at least as large a profit as he could guarantee himself if he did not collude with the others. As it stands this is not a very strong hypothesis, since it includes so many different possible outcomes, including, for example, outcomes involving an equal split of profits or a maximisation of the sum of profits, as two plausible but not necessarily identical alternatives. Where the alternative to agreement is a fixed outcome (as it might be in a wage bargaining process), Nash (1953) has derived

a solution which involves the maximisation of the product of the pay-offs (profits) when measured as deviations from the threat point. The variable threat two-firm case has also been solved by Nash - it consists of two stages, the first of which is a straightforward zero-sum game to determine the threat, which is followed by a "fixed-threat" game. These solutions are offered as rational policies for the firms concerned rather than as predictions of actual behaviour. They are derived from axioms concerning the nature of an optimal solution, so the optimality of the solution depends on the "optimality" of the axioms. There is room for disagreement on this issue as the fact that Luce and Raiffa (1957) obtain a different solution testifies. In addition, these models are limited to the case of full information concerning the pay-off matrices of all participants. Solution of the n-firm ($n > 2$) case is more difficult owing to the possibility of forming coalitions. (Bishop, (1963), gives a useful survey of these game theory models.)

The limitations of analysis have led some researchers to adopt an experimental approach, (Fouraker and Siegel, (1963), Murphy, (1966), Friedman, (1967) and Dolbear et al, (1968)). In these experiments the participants were made to play oligopolistic games, each game consisting of a series of moves in which a decision variable, either price or output, was chosen. Between moves each participant was given information about the previous outcome, such as whether the other oligopolists' prices were higher or lower, the amount of profit gained, or the exact price chosen by competitors. The amount of information differed from experiment to experiment, as did the number in each market, the number of moves per game, and the exact details of the pay-off matrices involved. Fouraker and Siegel, using Reserve Officers Training Corps members as participants,

found a marked tendency for non-cooperative price-output combinations to emerge especially with more than two participants in each market. An increase in information tended to increase the dispersion of equilibrium prices in duopoly due to a greater tendency to approach cooperative levels. Using a different profit function, Dolbear et al. found again that small numbers decrease competition and found that "information is likely to increase the variability among markets, but should reduce the variability within one market over time."

Murphy also tried changing Fouraker and Siegel's profit table. This was to allow the possibility of one firm inflicting losses on another firm to "punish" it for departing from a co-operative price level. He also allowed more transactions before finishing each play in order to ensure that equilibrium was reached, and found that co-operation did indeed increase after the 14th move (when the other studies just mentioned terminated play). There was for several pairs a breaking away from the middle price range to a co-operative extreme which "suggests a learning process being induced simply through the communication of price bids". It should be emphasised, however, that not all of Murphy's duopolists did reach the co-operative solution.

Friedman's experiments were different from those just mentioned in that he allowed communication before each move. As is to be expected, he found a substantial proportion of the moves involved points which were Pareto optimal for the participants. However, these games were not symmetrical between participants with regard to the pay-off matrices, so that the point of joint profit maximisation did not yield an equal profits split. Friedman was interested in observing the particular type of Pareto

optimal (or collusive) agreement reached. In a frequency distribution of outcomes the main mode occurred near the points of joint maximisation, and the Nash solutions (which were fairly close) and a much smaller mode occurred at the point of equal split. Almost 85 per cent of Pareto optimal non-symmetric games were near the Nash solution.

Over all these experiments a great deal of variation was found between "markets". Co-operation can develop especially with few numbers and ability to communicate either directly or through a long series of bids. This co-operation is not necessarily stable, however. In one of Murphy's experiments a mistake was made in a play which had commenced with price at the co-operative level. This mistake resulted in one of the participants (wrongly) thinking that the other had abandoned the co-operative strategy. He retaliated and the play turned from a co-operative to a competitive sequence.

Other attempts have been made to introduce other strategies, such as advertising, into a game theoretic approach to oligopoly, (Reichardt, {1962}, Nicholson, {1972}). The important consideration here is the different lags involved in putting different strategies into effect. Nicholson concludes that the more flexible the type of strategy, the less likely are the stable points (and hence the solutions) to be fully competitive. Thus, "the most flexible of all strategies in economic situations is typically the price strategy. Prices can normally be changed at very short notice. This makes price strategies the most suitable for many forms of collusive activity." The downward stickiness of oligopolistic prices is then explained in these terms. The corollary of these remarks is that in oligopolies advertising and product change should be subject

to more fierce rivalry than is price, and casual observation would seem to support this. Brems, (1958) has emphasised the importance of response lags in explaining quality competition in the car market.

Nicholson's work focusses on the dynamic aspects of oligopolistic behaviour which are more or less ignored in the experimental work on oligopoly as a game. We may generalise Nicholson's results to emphasise the importance of dynamic considerations in oligopoly. Of these, the ability or otherwise to innovate the product is of central importance, since it provides a method of competing with a long lead time, and hence a long retaliation lag. Technological change in methods of production can also have important implications for pricing behaviour. If cost functions are changing rapidly it is unlikely that they will change the same for each firm. This is likely to produce conflict over the collusive price. Therefore, rapid technical change is conducive to competitive behaviour on the part of the oligopolists as long as it lasts.

Another dynamic consideration is, in economic terms, the "lumpiness and infrequency of orders", or in game-theoretic terms, "the number of times the game is played", the "game" referring to the pricing, etc., decision. If the game is played just once the participants are in a "prisoners' dilemma" type situation, where their dominant strategy is one of acting competitively. If the game is to be repeated many times however, the sequence of games may be regarded as a "supergame" in which a strategy is a sequence of moves, each move conditional on the other participants' previous behaviour. This is the sort of situation acted out in the experimental oligopoly games referred to. In such a situation a policy of

encouraging collusive prices and punishing competitive prices is shown to produce more profits than competitive behaviour and, especially where direct communication between the transactors was possible, was shown to be the chosen strategy of a large number of the participants. Furthermore, the extent of collusiveness tended to increase with the number of moves but broke down when the players were informed that the game was to end in three moves. This information transformed the situation back into a "prisoners' dilemma". The counterpart of these two different types of situation in real world oligopolies are summarized by Scherer--

tacit collusion is most likely when orders are small, frequent and regular. It is least likely when requests for price quotations on large orders are received infrequently and at irregular intervals", (1970), p. 206). The reason for this is that the larger and more infrequent are orders the more resemblance the situation has to a one-shot affair, and the smaller is the possibility of punishing non-collusive behaviour.

One static consideration which has only been touched on so far is the actual pay-off matrix, which has two elements. The first element is the actual table of profits resulting from different combinations of strategies by the participants and the second is the utilities attached to these figures and possibly to the strategies themselves. In real life oligopolies, the first is a matter of costs and revenue functions of the industry and the firms in it; the second is a matter of the personalities of the managers of the firms or the characteristics of the internal structures of the firms concerned. (In the experimental games, for instance, different participants were found to have varying degrees of rivalistic individualistic or co-operative attitudes. A purely rivalistic person would gain utility from the difference between his profits and other persons', a co-operative person

would gain utility from the (possibly weighted) sum of his and other peoples' profits.) The question of the individual elements in the profit matrix is obviously complicated due to the large number of possible combinations, but one characteristic has been identified as being of potential importance. That is the ratio of fixed to variable costs. If fixed costs are very high then an industry price that will enable firms to break even will have a high ratio of price to average variable costs. The collusive price will tend also to be much higher than marginal cost. This means that the gains from chiseling and hence gaining extra sales will be very high, since unit marginal profit is very high. A low degree of product differentiation will, by making it easier to gain rivals' market shares, enhance the attractiveness of undercutting. This should increase the instability of collusive or quasi-collusive price agreements.

In such cases, especially combined with other instability-promoting characteristics, the breakdown of a collusive price system, whether of an exploitive or merely genuine "fair-trading" nature could lead to chronic losses being suffered by the industry. These losses could result in feedback effects, such as changes in market structure through merger or withdrawal, or in changes in what Scherer has termed the "industry social structure". This involves such objective characteristics as the existence or otherwise of industry organisations such as Trade Associations and such subjective factors as homogeneity of goals. The existence of common educational backgrounds and of direct or indirect social contacts are obviously factors of potential importance here. Inter-firm migration of management is another. Such considerations might well account for the difference in the competitive atmosphere of the U.S. and

the U.K. which cannot be explained in terms of the other more easily quantifiable factors such as concentration ratios. Because they are not easily quantifiable, however, Scherer refers to this class of influences as a residual factor - "consequently the economist is forced, without denying their importance, to view variations in industry conduct and performance due to differences in social structure as an unexplained residual or 'noise' ". This seems a rather pessimistic view to take.

Enough has been said so far to falsify the proposition that oligopoly is a completely indeterminate market structure. On the other hand, the theory of games and the evidence from experimental oligopoly games suggests that in any "objective" situation, a variety of outcomes is possible. We can, however, identify certain influences on the probability distribution of outcomes. We conclude that a partially, but not fully, determinate theory of oligopoly is possible. Game theory, both pure and experimental, seems a fruitful framework to use, since other oligopoly "models" such as the Cournot model and the kinked demand curve model can be analysed in terms of strategy choices.

For example, the Cournot equilibrium point has been shown (Nicholson, (1972)), to be an equilibrium point without involving any irrational judgement procedure. To be sure, whether or not it represents a solution point will depend on dynamical considerations. However it is a unique equilibrium point in that it is the one with the largest output and lowest price. At any output greater than the Cournot output a firm can always do better by selling its Cournot output (or, for differentiated products, at its Cournot price). Therefore the Cournot price is the lower limit to oligopoly equilibrium price. Similarly, the joint monopoly

price represents the highest oligopoly equilibrium point. The factors discussed above and the initial price will determine where in this range the actual solution equilibrium, if one exists, will lie.

The kinked demand curve construction describes a conflict situation in which the equilibrium in force at the start of the period is stable. Unfortunately, it is incomplete since it does not analyse the conditions under which the pessimistic assumptions of the oligopolists concerned would be justified.

Our conclusion so far is that oligopoly price will lie between a point that is Pareto optimal for the firms concerned (e.g., the joint profit maximising, Nash equilibrium or equal split points) and the Cournot equilibrium point. The latter depends on the number of firms in the industry and the degree of product differentiation. Where in this continuum prices will actually lie depends upon :-

1. The number of firms in the industry.
2. The degree of product differentiation, as expressed by the cross elasticities of demand.
3. The cost structure of the industry which, together with the demand elasticities determines the pay-off matrices involved.
4. The homogeneity of firms with respect to both size and costs.
5. The completeness of information about the plans, options and pay-offs for competitors.
6. The extent of direct or indirect communication of firms.
7. The length of gestation lags, with respect to various strategies.
8. The dynamics of rivalry, whether continuous or discrete.
9. The rate of technological change.

10. The psychological stance of participants.
11. Industry social structure.
12. The conditions of entry.
13. The legal framework.
14. The initial conditions.

Some of these obviously overlap (such as 6 and 7). The condition of entry has not been dealt with so far. Suffice it to say that the possibility of a collusive solution may be vitiated by the possibility of entry into the industry in the absence of very high barriers to such entry.

Since there may be more than one equilibrium state, the initial conditions are important in determining which one will be reached, in addition to the path taken in reaching it. The number of firms limits the extent of possible collusion by increasing the probability of disagreement, and increasing the costs of communication, information and enforcement of the agreed solution. The degree of product differentiation reduces the difference between the joint monopoly and Cournot equilibrium points and also reduces the short-run gains from undercutting rivals. The greater it is the more stable is collusion, although it may make it more difficult to agree on what 'the' collusive price should be. A high ratio of fixed to variable costs (especially in the absence of differentiation) increases the gains from chiselling. Once a low level equilibrium is reached (where losses are being made) the same condition increases the gains from collusion however. We may expect this condition to increase the instability of such markets, therefore.

Homogeneity of costs will tend to promote agreement as to a Pareto optimal price, as will homogeneity of size. On the other hand,

great inequalities in size are likely to lead to price leadership or 'umbrella' pricing.

As we have seen in the oligopoly experiments, completeness of information tends to promote collusion and stability within any one market but may increase the level of uncertainty as to where in the collusive-competitive continuum the actual outcome will lie. We also saw that communication between participants greatly enhanced the probability of collusion.

Nicholson, {1972}, concluded that firms would collude over policies in which gestation lags are very short (such as price) but compete over policies (such as product characteristics ?) where these lags are great, taking into account the short- and long-run pay-offs from these different policies. Lumpiness and infrequency, other aspects of the dynamics of oligopoly, are obviously closely related to this question. The rate of technological change may also be considered a dynamical question but its main influence is rather different, in that it affects the homogeneity of costs and the possibility of carrying out such policies as product improvement.

The psychological stance of the participants affects how they translate the profit pay-off matrices into matrices of utilities. In cases that would otherwise be indeterminate the assessment of one's competitors' psychological stance and hence their optimal equilibrium or most likely strategy could well affect the choice of one's own strategy. The social structure of the industry is therefore likely to be of great importance in these cases. For example, if one's competitors went to the same school

or type of school where one absorbed values such as 'team spirit', 'not rocking the boat' and 'gentlemanly behaviour' a collusive type of equilibrium seems much more likely than in an industry whose owners and managers came from a background where freedom to compete was held in the highest esteem. Industry social structure can also affect the ease of communication between firms.

The presence of entry barriers are obviously very important, affecting an industry's ability to raise price above long-run average cost at all. The presence of legal constraints on collusion or information sharing will also affect the ability of firms in oligopolistic industries to raise price above what it would be if they acted independently.

The considerations presented here indicate that oligopoly is a good deal more complex than perfect competition and therefore in the present author's view much more interesting. Some kind of systematisation appears possible without having to invoke all sorts of assumptions of arbitrary and sometimes self-falsifying behaviour. This systematisation is a first step necessary before more sophisticated tests than hitherto are performed on industry structure, conduct and performance.

APPENDIX TO CHAPTER 2A measure of apparent collusion in oligopoly⁽¹⁾

The notion of joint monopoly and "zero interdependence recognized" (as in the Cournot or Chamberlin "large numbers" case) as the extremes of possible oligopoly equilibrium behaviour can be used to derive a measure of apparent collusion. The mathematics below is based on an idea in papers by Cable and Cowling, {1972}, which can be traced back to Lambin {1970 }.

Consider a differentiated oligopoly with the property that in equilibrium all firms charge the same price. By definition

$$Q = q_i/s_i \quad (1)$$

in equilibrium, where

s_i = market share of firm i

q_i = demand facing firm i

and Q = total industry demand.

Let η^I = industry elasticity of demand, which measures the response of demand when all firms change their prices by the same amount.

η_i^f = firm elasticity of demand which measures the response of demand facing firm i when all other firms keep their prices constant.

We can find η^I by the following :-

$$\eta^I \equiv \frac{dQ}{dp_i} \cdot \frac{p_i}{Q} \quad \text{when} \quad \frac{dp_j}{dp_i} = 1 \quad \text{for all firms } j \quad (2)$$

(1) I am grateful to D. Leech and P. Stoneman for their helpful comments.

$$= \frac{dq_i}{s_i dp_i} \cdot \frac{s_i p_i}{q_i} ; \quad \frac{dp_j}{dp_i} = 1 \quad (3)$$

$$= \frac{p_i}{q_i} \left(\frac{\partial q_i}{\partial p_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \cdot \frac{dp_j}{dp_i} \right) ; \quad \frac{dp_j}{dp_i} = 1 \quad (4)$$

$$= \frac{p_i}{q_i} \left(\frac{\partial q_i}{\partial p_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \right) \quad (5)$$

$$= \eta_i^f + \frac{p_i}{q_i} \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \quad (6)$$

$$\therefore \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \equiv \frac{q_i}{p_i} \left(\eta_i^I - \eta_i^f \right) \quad (7)$$

Now consider the typical firm's profit-maximising decision on price. By definition,

$$\Pi_i \equiv p_i q_i - C(q_i) \quad (8)$$

C is the firm's cost function. (9)

To maximise profits $\frac{d\Pi_i}{dp_i}$ is set equal to zero :-

$$\frac{d\Pi_i}{dp_i} = q_i + \frac{p_i dq_i}{dp_i} - \frac{dC_i}{dq_i} \cdot \frac{dq_i}{dp_i} = 0 \quad (10)$$

$$\text{Now } \frac{dq_i}{dp_i} = \frac{\partial q_i}{\partial p_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \cdot \frac{dp_j}{dp_i} \quad (11)$$

In this case $\frac{dp_j}{dp_i}$ is i 's conjecture about j 's behaviour.

Substituting (11) in (10) yields

$$q_i + \left(p_i - \frac{dC_i}{dq_i} \right) \left(\frac{\partial q_i}{\partial p_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \cdot \frac{dp_j}{dp_i} \right) = 0 \quad (12)$$

If $\frac{dp_j}{dp_i} = 1$ we have the Chamberlin small numbers case and the

joint monopoly solution prevails. The other extreme is where $\frac{dp_j}{dp_i} = 0$

(mutual interdependence not recognized) and the Chamberlin "large numbers" result prevails. The general case however, is where

$$0 \leq \frac{dp_j}{dp_i} \leq 1.$$

Let $\frac{dp_j}{dp_i} = \alpha_{ij}$. What does α represent? It probably does

not represent the exact true value of j 's response to i 's projected price change, except at that price level at which all firms are simultaneously in equilibrium. This is analogous to the Cournot and Chamberlin "large numbers" model in which the assumption of no reaction (on which each individual firm's behaviour is supposedly based) is only true when the industry is in equilibrium. α_{ij} is a parameter describing the behaviour of i rather than of j . In other words, this model analyses what would happen if firm i acted as if firm j would respond to a price change at the rate α_{ij} .

Putting α_{ij} in (12) yields

$$q_i + \left(p_i - \frac{dC_i}{dq_i} \right) \left(\frac{\partial q_i}{\partial p_i} + \sum_{j \neq i} \alpha_{ij} \frac{\partial q_i}{\partial p_j} \right) = 0 \quad (13)$$

$$\text{Let } \alpha = \frac{\bar{\alpha}_{ij} \sum_{j \neq i} \alpha_{ij} \frac{\partial q_i}{\partial p_j}}{\sum_{j \neq i} \frac{\partial q_i}{\partial p_j}} .$$

This represents a value for α averaged over all other producers.

(13) now becomes

$$q_i + \left(p_i - \frac{dC_i}{dq_i} \right) \left(\frac{\partial q_i}{\partial p_i} + \alpha \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \right) \quad (14)$$

Substitute the identity $\frac{\partial q_i}{\partial p_i} \equiv \eta_i^f \cdot \frac{q_i}{p_i}$ and equation (7) in (14) :-

$$\therefore q_i + \left(p_i - \frac{dC_i}{dq_i} \right) \left(\eta_i^f \cdot \frac{q_i}{p_i} + \alpha \frac{q_i}{p_i} \left(\eta^I - \eta_i^f \right) \right) \quad (15)$$

Since $q_i \neq 0$ we can divide (15) by q_i and rearranging gives us

$$\frac{p_i - \frac{dC_i}{dq_i}}{p_i} = - \frac{1}{\alpha \eta^I + (1-\alpha) \eta_i^f} \quad (16)$$

This is the required result. When $\alpha = 1$ the price-cost margin is

$-\frac{1}{\eta^I}$, which is the familiar monopoly result. When $\alpha = 0$

$$\frac{p_i - \frac{dC_i}{dq_i}}{p_i} = \frac{-1}{\eta_i}, \text{ which is the Chamberlin large numbers case}$$

result.

In the context of this model α is the extent to which the individual firm takes into account the effect of his pricing decision on that of other firms. When $\alpha = 1$ the result is the same as if the firms are colluding perfectly. When $\alpha = 0$ the result is the same as if the firms are acting as though there were no mutual interdependence, and failing to create any effective collusion.

For any price-cost margin a value of α can be calculated if the firm and industry price elasticities are known. Rearranging (16) gives

$$\alpha = \frac{\eta_i^f + p_i / (p_i - dC_i/dq_i)}{\eta_i^f - \eta^I} \quad (17)$$

Any particular price-cost margin may be generated by some mechanism other than the model outlined here; but by whatever mechanism a price-cost margin is generated a value of α can be calculated if the elasticities are known. The most general model of oligopoly is probably one based on Stigler's {1964} work. Stated briefly, in this view of oligopoly the aim of the firms in the industry would be to achieve the joint monopoly - or "perfectly collusive" - price. For a variety of reasons, including the difficulty of detecting and punishing price-cutting, collusion is almost never perfect. The more perfect is collusion, the higher

would be the calculated value of α , which would therefore be a suitable index of the degree of apparent collusion.

α is said to be a measure of apparent collusion because the price-cost margin underlying it may not be generated by any explicit act of collusion on the part of the firms involved. For example, the price might be a historical accident kept constant by the existence of a kinked demand curve in the minds of the oligopolists. Indeed, the price might even be generated by the firms acting according to the model of conjectural variations in the context of which α was conveniently introduced. But because the way of looking at oligopoly in terms of the success of attempts at reaching the joint profit-maximising price is felt to be the most general, α is considered to be an index of apparent collusion. This "collusion" might not involve any explicit act of communication by the firms involved, but may be the sort found in the literature on empirical games, e.g. Lave, {1962}.

Another way of looking at α might be as an index of the effective tightness of the oligopoly. It is clearly related to the Lerner, {1943} index of monopoly power, but is a different concept since it separates out the effects of variations in the industry and firm elasticities of demand, which might be unrelated to the factors affecting an oligopoly's success at maintaining a high price.

A similar coefficient can be derived and calculated for advertising behaviour. Again assume a differentiated oligopoly.

Let μ^I be the elasticity of an industry demand with respect

to total industry advertising. This will be equal to the elasticity of industry demand with respect to an individual firm's advertising when all other firms change their advertising expenditures equally, i.e.,

$$\mu^I \equiv \frac{dQ}{dA_i} \cdot \frac{A_i}{Q} \quad \text{when} \quad \frac{dA_j}{dA_i} = 1 \quad \text{for all } j. \quad (18)$$

where Q = industry demand.

A_i = firm i 's advertising expenditure.

In equilibrium, by symmetry

$$Q = q_i/s_i \quad \text{where} \quad q_i = \text{firm } i\text{'s demand and} \\ s_i = \text{firm } i\text{'s market share.}$$

(18) becomes

$$\mu^I \equiv \frac{dq_i}{s_i dA_i} \cdot \frac{s_i A_i}{q_i} ; \quad \frac{dA_j}{dA_i} = 1 \quad (19)$$

The s_i 's cancel out and

$$\frac{dq_i}{dA_i} \equiv \frac{\partial q_i}{\partial A_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial A_j} \cdot \frac{dA_j}{dA_i} \quad (20)$$

Substitute (20) into (19)

$$\mu^I \equiv \frac{A_i}{q_i} \left(\frac{\partial q_i}{\partial A_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial A_j} \cdot \frac{dA_j}{dA_i} \right) ; \quad \frac{dA_j}{dA_i} = 1 \quad (21)$$

This gives us

$$\mu^I \equiv \mu_i^f + \frac{A_i}{q_i} \sum_{j \neq i} \frac{\partial q_i}{\partial A_j}, \quad \text{where} \quad \mu_i^f = \frac{A_i}{q_i} \frac{\partial q_i}{\partial A_i} \quad (22)$$

$$\therefore \sum_{j \neq i} \frac{\partial q_i}{\partial A_j} = \frac{q_i}{A_i} (\mu^I - \mu_i^f) \quad (23)$$

This identity will be used later on. Now consider the firm's optimal advertising budget. The firm's profits,

$$\Pi_i = p_i q_i - C_i(q_i) - A_i \quad (24)$$

The separation of production costs from advertising costs is more convenient, but not essential. To find the optimal advertising expenditure, set the derivative with respect to this variable to zero :-

$$\frac{d\Pi_i}{dA_i} = p_i \frac{dq_i}{dA_i} - \frac{dC_i}{dq_i} \cdot \frac{dq_i}{dA_i} - 1 \quad (25)$$

$$\text{Now} \quad \frac{dq_i}{dA_i} = \frac{\partial q_i}{\partial A_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial A_j} \cdot \frac{dA_j}{dA_i} \quad (26)$$

$$\therefore \left(p_i - \frac{dC_i}{dq_i} \right) \left(\frac{\partial q_i}{\partial A_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial A_j} \cdot \frac{dA_j}{dA_i} \right) = 1 \quad (27)$$

Let $\frac{dA_j}{dA_i} = \beta_{ij}$. We can either take the weighted mean value of β_{ij} ,

$$\bar{\beta}_{ij} = \frac{\sum_{j \neq i} \beta_{ij} \frac{\partial q_i}{\partial A_j}}{\sum_{j \neq i} \frac{\partial q_i}{\partial A_j}}$$

as we did after equation (13) with α_{ij} or assume that β_{ij} is constant and equal to β . In either case this leads to

$$\left(p_i - \frac{dC_i}{dq_i} \right) \left(\frac{\partial q_i}{\partial A_i} + \beta \sum_{j \neq i} \frac{\partial q_i}{\partial A_j} \right) = 1 \quad (28)$$

Substitute for $\sum_{j \neq i} \frac{\partial q_i}{\partial A_j}$ from (23) :-

$$\left(p_i - \frac{dC_i}{dq_i} \right) \left(\frac{\partial q_i}{\partial A_i} + \beta \frac{q_i}{A_i} \left(\mu^I - \mu_i^f \right) \right) \quad (29)$$

Multiply through by $\frac{A_i}{q_i}$ and substitute $\frac{\partial q_i}{\partial A_i} \frac{A_i}{q_i} \equiv \mu_i^f$:-

$$\left(p_i - \frac{dC_i}{dq_i} \right) \left((1 - \beta) \mu_i^f + \beta \mu^I \right) = \frac{A_i}{q_i} \quad (30) \quad (2)$$

$\left(p_i - \frac{dC_i}{dq_i} \right)$ is found from the rule for pricing behaviour,

equation (16) :-

$$p_i - \frac{dC_i}{dq_i} = - \frac{p_i}{\alpha \eta^I + (1-\alpha) \eta_i^f} \quad (16')$$

(2) From this we can obtain an expression

$$\beta = \frac{\mu_i^f - (A_i / p_i q_i) (p_i / p_i - dC_i / dq_i)}{f - I}$$

Substituting this in (30) and rearranging yields

$$\frac{A_i}{P_i q_i} = - \frac{\beta \mu_i^I + (1-\beta) \mu_i^f}{\alpha \eta_i^I + (1-\alpha) \eta_i^f} \quad (31)$$

This is a generalisation of Cowling's {1972} version of the Dorfman-Steiner {1954} condition for the optimal advertising outlay. With perfect collusion in both advertising and pricing behaviour it becomes the Dorfman-Steiner condition for monopoly. If no mutual interdependence is recognized $\alpha = \beta = 0$ and only the firm elasticities count. This is an intuitively obvious result since in these conditions the oligopolists are behaving as if they were monopolists facing a demand function of elasticities η_i^f and μ_i^f .

Further results can be obtained for the case where firms manage to "collude" over one variable but "compete" over the other, and with varying degrees of success at "conscious parallelism" over price and advertising strategies. What are essentially the determinants of α and β are described at length in Scherer's book {1970} in the chapters on oligopoly pricing. (For example, Chapter 7 is entitled, "Conditions Facilitating Oligopolistic Co-Ordination".)

All this analysis is strongly hinted at in both Cowling's paper and Cable's in the same volume, (e.g., see page 103) but is nowhere made explicit in terms of all four demand elasticities used here. It is hoped that this appendix will simplify the discussion of the wide variation of advertising/sales revenue ratios observed, as well as the link between advertising and profits.

CHAPTER 3The Structure of the U.K. Car Industry, 1956-68.

The study of oligopoly theory and behaviour suggests that firms acting as oligopolists will fall somewhere between two extremes of behaviour. One extreme is completely successful collusion where the industry acts as if it were a monopolist. This is sometimes referred to as joint monopoly. The other extreme is where firms fail to recognise the fact of their mutual dependence. This leads, in the case of differentiated products, to the solution proposed by Chamberlin, {1933} for the so-called "large numbers" case in short-term equilibrium. Although restricted by Chamberlin to the short-term equilibrium and to the case of large numbers we can consider it as a limiting case of long-term equilibrium if there are sufficiently high barriers to new entry into the industry. In the case of non-differentiated products the Cournot equilibrium point has been shown by Nicholson, {1972} to represent the lower bound on equilibrium price. Thus the Chamberlin and Cournot points have in common the property that they are the equilibria which we would expect to observe if oligopolists ignored their mutual interdependence.

Where, between these two extremes of behaviour actual behaviour lies depends on a whole series of considerations, discussed in the previous chapter. These are the elements of structure it is important to identify for an industry in order to gain an understanding of the way the firms in it behave. This chapter examines these factors for the U.K. car manufacturing industry, especially for the period 1956-68.

1. Numbers

The post-war period saw a substantial reduction in the number of independent car producers. In 1947 the six largest firms produced 90% of industry output, (Rhys, {1972}) whereas by 1970, 99.5% of all British made cars were produced by only four firms, (N.E.D.O. {1971}). Not only was the industry concentrated, but the level of concentration increased over the period.

This increased concentration was achieved mainly by mergers. Although some firms (such as Lea-Francis and Jowett) were forced out of the industry by bankruptcy, there was some entry at a small scale for specialist cars (such as Lotus). In 1952 the Nuffield organisation with about 21% market share merged with Austin (19% market share) to form B.M.C. Singer were purchased by Rootes in 1955, Jaguar by B.M.C. in 1966 and Rover by Leyland in 1967. In January 1968, Leyland bought out the bigger B.M.C. to form British Leyland. Leyland, originally a bus and commercial vehicle manufacturer had bought its way into the car assembly business by its purchase of Standard-Triumph in 1961.

In addition to these mergers, control also changed hands in the case of Rootes, in which the Chrysler corporation purchased a shareholding in 1964, which was increased to a majority shareholding in 1967. This meant that by 1968 there were three American-owned firms (Ford, Chrysler and Vauxhall, a subsidiary of General Motors Corporation) and one British-owned firm accounting for most of the home market production. In 1968 imports accounted for only 8.3% of new registrations (N.E.D.O. {1971}) ,

although this proportion had been growing. In addition, Rhys, (pp. 55,56) lists nine independent sports cars producers and five producers of high performance and quality cars for 1968. Altogether these accounted for a little less than 0.5% of total production in 1968.

The market clearly qualifies as an oligopoly. After the number of sellers the next most important characteristic of an industry's structure is the number and size of purchasers. The final purchasers are many and on the whole small, the exceptions being organisations such as the Post Office which buy fleets of vehicles. It is unlikely that these have a substantial impact on the overall behaviour of the industry. In between the final purchasers and the producers are the dealers.

Despite some amalgamations in the 1960's leading to a number of dealer chains such as Henlys and Bristol Street Motors, by 1970 there were still 12,500 retail outlets in the U.K., 7,000 of them franchised to B.L.M.C., 2,200 to Rootes, 2,000 to Ford and 1,000 of them to Vauxhall. None of these was large enough to pose the threat of counter-vailing power. Rootes owned much of its distribution network, having vertically integrated backwards from car retailing before 1939. Thus although dealers might compete among themselves for sellers, they were unable to influence the announced list prices set by the manufacturers to any great extent. Decisions to cut prices, give excessive trade-in values for used cars, or any other competitive devices, would cut into their profits rather than the manufacturers'. The allowed margins for dealers were more or less fixed at 17½ - 20%. This was not an area in which the manufacturers competed in the post-war period.

2. Product Differentiation

The notion of product differentiation was introduced by Chamberlin :

"A general class of product is differentiated if any significant basis exists for distinguishing the goods (or services) of one seller from those of another. Such a basis may be real or fancied, so long as it is of any importance whatever to buyers, and leads to a preference to one variety of the product over another. Where such differentiation exists, even though it be slight, buyers will be paired with sellers, not by chance and at random (as under pure competition), but according to their preferences." ({1933} p. 56).

On this basis it is clear that motor cars are differentiated products. Since people are in different situations they will find different combinations of characteristics (and of price) best suited to their needs. In addition there may be genuine differences in tastes among people. The implication is that firms can charge different prices for their products and any small change in price by a firm will not result in a switch of all the industry demand from all other firms to the firms which cuts its price. In other words the price elasticity of demand facing the firm is not infinite.

Cowling and Cubbin, {1971 b} found that the price elasticity of demand facing firms in the car industry was between -1.95 in the short-run and -7.06 in the long run. This suggests that the products are not sufficiently differentiated to be regarded as belonging completely to separate markets, as an extremely low value might have indicated.

In addition to these fairly objective measures of product

differentiation, each firm has a slightly different image and a reputation for different things. B.M.C. was known for producing cars with interesting engineering, often innovative (a reputation based mainly on the Mini). Fords have a reputation for cheapness and simplicity and, in the past at any rate, being difficult to start. Standard-Triumph have tended to produce cars with a bit extra within each size class, this extra being in terms of performance or merely the comfort of the interior surroundings. They are not alone in having had "teething troubles" with early versions on new models which has damaged their reputation. Vauxhall, the subsidiary of General Motors, seems to have been strongly influenced by American designs. Most of their models had an American look about them. (The obvious exception to this is the Viva, the first car they produced in the range of small cars.) Rootes relied for many years mainly on the Hillman-Minx and the Humber Hawk, and variants, until they brought out the Imp. It is difficult to see what these three have in common, except that they are somewhat out of the ordinary without being very exciting.

"A survey completed in 1967 revealed that the company had a stodgy image and that, although people over fifty were loyal to it largely on the grounds of reliability and comfort, many potential younger customers felt that the performance of its models and their styling left a good deal to be desired." (Turner, {1969}, p. 430.)

By 1968 these differences had started to diminish. Ford's Capri, the imitation Mustang, stood out as an attempt at product differentiation. The thing that helped its success was that beneath the sporty exterior it was a conventional family car, only a bit cramped in the rear passenger seat. Apart from this there seemed to be a convergence towards a common

accepted range of vehicles - a process which, however is not yet by any means complete.

3. The Cost Structure of the Industry.

A very high level of fixed costs increases the temptation to cut prices in periods of slack demand. Because the process of car manufacturing in Britain is essentially assembly fixed costs are only a small proportion of the total costs, which are dominated by bought-out components and materials. Rhys, (p. 269) has figures for a typical car's cost structure in 1968. Bought-out components and materials account for 62%, direct labour 8% and other variable costs 14%. Development and tooling and other fixed expenses are reckoned to account for the other 16% of total costs in the short run. This means that much of the brunt of slack demand is borne by the suppliers of components and materials, (and, at times, by the suppliers of labour). We conclude that the car assembly industry is not one where the presence of high fixed costs is an important factor increasing the probability of price wars.

4. The Homogeneity of Firms

If firms are very homogeneous it is likely that if they manage to create a collusive price there will be little disagreement over it. At the other extreme if one firm has significantly lower costs than the others it will be able to engage in price leadership.

The processes of merger, takeover, and bankruptcies have ironed out the major discrepancies of costs. Comparisons of cost levels are more difficult for such differentiated goods as automobiles, since the quality of the product must be taken into consideration. The best way of measuring this is probably to compare profit figures, although these will incorporate the costs of strategical mistakes made by management in, for example, their marketing and product design decisions, and their labour relations, as well as the profits and losses from commercial vehicle divisions.

If a consistent picture emerges from this it is that Ford is the lowest cost producer. Certainly they have a reputation for toughness over costs in both their cost control techniques and in their attempts to ensure a very high level of production per man and per machine. However, Vauxhall and Standard-Triumph have also shown healthy profits over most of the period. B.M.C. have been rather erratic. Rootes has consistently showed mediocre results making total pre-tax profits of only £2.26m. over the years 1957-67 as compared with £168m., £123m., £249m. and £137m. for B.M.C., Leyland, Ford and Vauxhall respectively for the same period. The main distinction to be made is between Rootes and the other firms together. This is reflected in the fact that Rootes often pursued a pricing policy that was more independent than those of the other firms.

The other important aspect of homogeneity (besides costs) is size. B.M.C. was the biggest firm with market share varying between 40% and 30%. Ford was the next largest with about 28% of the market : in 1954 Standard and Rootes had market shares of 11% with Vauxhall being the smallest of the "Big Five" at 9%, (Rhys, pp.20,24). This understates Vauxhall's

impact in its sector of the market because it only produced large and medium sized cars until the introduction of the Viva in 1964.

There was some variation in market share over the period with B.M.C. losing out slightly to the other producers but by 1968 the general position had not changed much. Ford and B.M.C. were easily the biggest firms and might be expected to take the role of price-leaders - if such a role were taken at all - B.M.C. because of its size, and Ford because of its slightly greater efficiency.

However, the other three major firms were too large to be dominated by the two biggest firms so that if there were price leadership it would occur by consent rather than by coercion.

It appears that both costs and market shares are fairly homogeneous - for the mass markets at least. Consequently we should not expect to observe domination of the industry by the two largest firms. Furthermore, any collusion over price which might occur would be unlikely to be upset by bickering over what is the "correct" collusive price. The only exception to this might be Rootes, who because of their lower efficiency would probably prefer a higher industry price than the others.

5. Completeness of Information

The literature on empirical games suggests that the more complete is information about the strategies of and payoffs to rivals, the easier it is for oligopolists to achieve a price nearer the industry

profit maximising price. Tacit collusion becomes easier and departures from it simpler to detect and react to. This makes attempts to cut price below that tacitly agreed upon less attractive.

Information about list prices is well-known in the trade. No attempts at cutting list prices could be secret to rivals without being secret to customers. We should not expect in general to observe price cuts as a competitive weapon in this industry except when (if ever) price is above the joint monopoly price or else in an attempt to forestall entry by new competitors such as importers. Both types of price cut would probably meet the approval of all the rivals - with the possible exception of Rootes/Chrysler.

A second type of information which helps to detect unexpected competition is total sales. With knowledge of total sales a firm can very quickly work out its market share. Any sharp changes in market share would in the absence of other obvious causes such as strikes suggest to the firm that one or more of its competitors were engaging in some new form of competition. Stigler, {1964}, has based a whole theory of oligopoly on the use of market share movements to detect secret price cuts. The easier such cuts are to detect the less likely they are to occur

The Society of Motor Manufacturers and Traders has since the last World War produced a Monthly Statistical Review which gives a great deal of information on production not only of cars but also of commercial vehicles and related things like trailers and caravans. This clearly helps producers detect significant deviations in their market shares. Perhaps this explains why strategies such as secret discounts to dealers

which would then be passed on to customers via higher trade-in allowances do not appear to have been used.

(In addition the publication of Glass's Guide to Used Car Values reduced price competition among dealers and the losses suffered by them on used car sales according to Rhys (p. 334). However, competition among dealers is not the concern here since it did not affect the prices paid to the producer.)

Information on press and television advertising is published monthly. In any case an increase in advertising competition by one firm is immediately obvious to the other firms. There is no evidence however that firms give advance notice of changes in their advertising policy.

Similarly, in the case of quality competition, once the new model or model change is put on the market, rivals can (and do) examine the model in great detail. They cannot know the exact impact the car will have on consumers but they can estimate the likely price-cost margin.⁽¹⁾ However, before a new model or model change is launched

(1) It is said that when B.M.C. brought out the Mini, Ford engineers and accountants analysed and re-analysed it for they could not see how B.M.C. were making any profit out of it at all at the price they were charging. Some people go so far as to say that the Ford people were right and no money was being made on it. Whether this story is true or merely apocryphal, it illustrates the widely-held belief that at B.M.C. they produced soundly-engineered cars but were haphazard at cost control and the business aspects of car production, whereas Ford produced cheaply with stringent financial controls and charged the right price but did not produce anything that could be regarded as a major technical advance.

there is a great deal of secrecy surrounding it. This situation can be contrasted with price increases which are often announced in advance both to rivals and to the world at large.

6. Communication between firms

Attempts to raise prices are much easier if the firms involved can communicate with each other and discuss what the new set of prices should be. Naturally no record of any such communications is publicly available. Organisations such as the Society of Motor Manufacturers and Traders and London "gentlemen's clubs" provide meeting places and channels of communication. In addition the extent of inter-firm mobility among management increased. No evidence is available to suggest that great use was made of these channels of communication before 1968, and any evidence there is for 1968 and after is purely circumstantial.

7. Gestation lags

The greater are gestation lags the greater are the temporary gains from breaking away from an agreement, tacit or otherwise, not to compete on a certain basis whether price, quality or advertising. Conversely, the greater are these lags the greater are the potential losses from not competing on this basis when one's rivals do. Response lags are an important factor in the relations between price, advertising and quality competition.

Responses to price changes can be more or less immediate - of the order of a week or two. Calculations have to be made about the likely

effects on profits, a decision must be made, a chairman's statement written explaining the reasons for the price change, new price lists printed and the dealers informed. All this does not take very long and it is very unlikely that a price-cutting firm could gain sufficiently large increases in sales in the intervening period to make up the subsequent lower profitability when rivals match the price reduction. Price response can be taken to be more or less instantaneous.

With advertising, the situation is a little more complicated. Advertising expenditure of a sort can probably be undertaken in great haste; but in general it is probably true that effective advertising campaigns take some time to prepare. Space in newspapers, on television and on hoardings needs to be booked in advance, possibly to coincide with each other, and a great deal of thought probably goes into wording and layout. Responding to a well-thought-out campaign by a hasty one is not likely, one imagines, to have the desired effect on sales.

I regard the response lag for advertising for the car industry to be of the order of a few months, but certainly nowhere near a year. The problem is complicated by the fact that car sales have fluctuated seasonally, (with a big peak in spring and a small one in summer) so a retaliatory advertising campaign may be better left until the next wave of demand or until the introduction of a new model. The important point is that the lag for advertising is greater than for price but less than that for quality change.

The lag for quality change depends on the sort of change considered. For a completely new model three or four years was the usual

gestation period, although Fiat have managed it in as little as 2½ years and Rolls-Royce may take over nine years (Rhys, pp. 164,300). Less drastic measures take less time. Changing the size of the engine may require other changes, especially to the transmission and suspension. The exception to this is where a model range is produced, designed for different sized engines to be fitted into the same body. This was not very common before 1968 and in any case required planning well ahead. Minor changes such as including the heater in the list price of the vehicle or superficial alterations to the body take far less time. Even such a small thing as including a heater in the price requires planning ahead, though, to ensure that enough heaters are available to fit into every car made. Engine modifications which make minor improvements to power or fuel economy may require the preparation of fresh castings. It is difficult to imagine the gestation periods for even small changes in quality being less than six months to a year. To gain the full benefit from improving quality one can expect to have to advertise the improvement.

Where this is the case the length of the advertising lag sets a lower bound on the length of the quality change lag.

On the basis of the length of lags alone, the theory of our previous chapter would suggest that price competition would be rare, advertising competition would be more usual and quality competition the common rule. Response lags are of course only part of the theory. Furthermore, the three types of competition cannot be regarded as independent of each other.

8. The Dynamics of Rivalry

By this we mean whether rivalry is continuous or discrete. One example of "discrete" rivalry is where individual orders are very large and involve production over considerable period of time - for example defence or research contracts where the job is tendered for. If there is no communication of bids between rival firms, the situation then approximates the "prisoner's dilemma" situation as the size and infrequency of the order increases. Conversely, the smaller are individual orders and the more frequently they are tendered for, the easier it will be for a less competitive price to emerge.

In the case of cars, the individual order is small and insignificant to the firm. This appears to be conducive to the formation of a collusive price. However, we have seen that response lags for quality change are such as to make it a fairly infrequent event. Another consideration is that during the period under study, most changes in specifications, and many of the price changes, came into effect at about the time of the annual Motor Show. The idea was to introduce the new models at a time when demand was usually slack and so stimulate demand. This was abandoned towards the end of the period, but it added an institutional rigidity to the dynamics of rivalry, making quality competition just a little bit more likely.

9. Technological Change

Two types of technological change are usually distinguished - process innovation and product innovation. The former means changes in production

technique which lower the costs of producing a particular specification of a product. Pure product innovation is where the production technique is unchanged but the nature of the product is changed so as to be more efficient at satisfying the requirements of the purchaser. (This assumes that the technological innovation is an improvement, of course.) The two cannot always be separated. A change in production technique might require that the nature of the product be altered in some way. New products will often require new techniques of production. If the good in question is intermediate, one firm's product innovation (a new machine) becomes another firm's process innovation.

Despite this the distinction can be useful. Process innovations, partly as a consequence of their sometimes being other firms' product innovations, are less dependent on the nature of oligopolistic rivalry than are product innovations. A profit-maximising firm will seek to minimise its production costs for a given output regardless of whether price, advertising, or the nature of the product itself is the basis of competition. The extent to which the product is changed, on the other hand, will to a certain extent be endogenous to the structure of the industry and the mode of competition. An agreement to fix the price of the industry product may induce the firms to indulge in product improvement as a competitive mode. In this case we would say that the apparent high rate of product innovation is endogenous to the nature of rivalry rather than being the determinant of the nature of the rivalry - the real cause being the high price. Nevertheless there must be something in the nature of the product to allow it to be improved.

Process innovations, whilst cutting costs, generally do so with

differing speeds for different firms. Firms with bigger market shares may well have a faster turnover of machinery. If a certain machine does a job 100,000 times exactly before falling to bits, the firm that sells enough to use it 50,000 times a year will replace it anyway after two years. The firm that uses it only 2,000 times a year will only need to replace it after 50 years. However, in the meantime technical change is likely to have made that machine obsolete. The small firm either uses obsolete equipment or buys the new machine without having made as full use of the old machine as the big firm has. Which decision is taken in practice will depend on the relative costs and revenues of the two decisions. In general we can expect the larger of two profit maximising firms to adopt innovations faster, other things being equal.

There may be other differences between firms in characteristics which lead to different rates of adoption of new processes. The process innovations might suit one firm's product more than another's. The attitude of management or workers towards the innovation may vary between firms.

All this means that the impact of process innovations will often be to increase the cost differentials between firms. When this happens it may add instability to the oligopoly situation. When costs are very different, it becomes less obvious what the best industry price is. As a consequence there may be misunderstandings, conflicts of interest, and price competition may appear - possibly even to the extent of driving out the high-cost firms.

Most of the crucial types of process innovation were available

before 1939 - in particular the use of assembly-line techniques, quick-drying paints and unitary construction in which the chassis and body were combined. Much of the innovation since then involved an increase in the value of capital per man in the move from "mechanised" to "automated" production techniques. For example, one development has been the use of machines for automatically transferring the part to be processed from one processing point to the next. Another is the greater use of special purpose machines which are less flexible but more efficient at their own job than the general-purpose machines.

None of this seems to have had much impact on cost differentials. Possibly this accounts for the much slower rate of exit from the industry since 1945. It has been more or less equally easy for the surviving firms to make use of these "improved" techniques. Even the smallest of the "Big Five" was a large firm by any standards, which allowed them to take advantage quickly of technical improvements. The postwar expansion of the market must have been an important factor, too, in that it permitted the latest techniques to be used in any additional capacity laid down. In short, I have found no evidence to suggest that process innovations have had any upsetting effect on the U.K. car industry's competitive/collusive balance in the last 30 years.

Product innovations have been more immediately obvious insofar as the external appearance has changed substantially. To a large measure however, the changes in car design have been fairly superficial. Improvements have been made in most departments - engine, steering, suspension, braking system and tyres. Perhaps the suspension has been subject to most improvement. Despite some modifications, engines have not really changed very much. Disc-brakes represent an improvement over drums, but were still the exception by

1968. Greater understanding of body construction permitted the use of thinner gauge steel to achieve the same strength - though this should perhaps be classified as a process innovation.

This leads one to suspect that most of the product change has been endogenous rather than exogenous. To put it another way, much of the change in the appearance of cars was due to the nature of the oligopolistic rivalry in the industry rather than implicit in the nature of automobiles. This is not to deny that as a result of these product changes some modern cars may be better than their predecessors of thirty years ago; but we have to look beyond mere technological possibilities to realise why this should be so.

10. The Psychological Stance of the Rivals

This includes both the utility functions of managers with respect to profits, sales, growth, employment, etc., and their attitude towards rivalry or co-operation. It is a very difficult variable to quantify or to obtain much information on at all. Perhaps the easiest way to approach this problem is to examine each firm in turn for evidence of either sleepiness or dynamism.

Standard-Triumph was for many years preoccupied with production of agricultural tractors, which gave a steady return in a stable market. These tractor interests were bought out by Massey-Harris which eventually split off to form an entirely separate company, Massey-Ferguson. This left Standard-Triumph vulnerable since it now relied on car production. It did not sell enough to achieve the minimum efficient scale of production, and felt itself

heavily dependent on outside suppliers so it launched a new model in haste and bought up a foundry, engineering works and a car body builder. This proved too much for the company which was bought out in 1961 by Leyland Motors, a commercial vehicle producer. After losing over £7m. in 1960-61 the entire board was fired but for one man; and three hundred senior staff also left the company.

Standard-Triumph was the company where Donald Stokes (later Lord Stokes and Chairman of British Leyland) rose to pre-eminence. From 1963 onwards, with the success of the Triumph 2000 the company became very profitable. This suggests that, as far as the car trade is concerned, Standard-Triumph changed from a rather sleepy firm to a dynamic one round about 1961, when it was taken over by Leyland.

Ford has always been considered a profit-maximising firm, where other objectives, including sometimes that of good labour relations, are sacrificed to that of profits. The company's product planning committee has been the major instrument of its success. Turner (1969) gives the Cortina, a medium sized car launched in 1962 just when that segment of the market was starting to grow rapidly, as "a classic example of near-perfect planning".

The cost of every part was rigorously controlled from the time the specification was drawn up. "The Cortina's steering wheel was redesigned four times because it was exceeding its target by one penny." (Turner, (1969)).

This attitude on the part of Ford managers must have had its effect on the other firms in the industry, although this is not obvious from what Turner has written about the state of the industry. Although Vauxhall was

already using advanced management techniques in the 1930's, the atmosphere in the company is described as having "always given the impression of being a cosy, provincial outfit", (p. 427). "It has tended to concentrate on the large car market and commercial vehicles in which market it was the second largest producer in 1954." (Rhys, p. 81).

At the time when Chrysler bought a minority shareholding in 1964, Rootes is described by Turner as "still very much a family business, and a family business with a philosophy consistent with that of a company which had started by selling cars and then moved into manufacture".

B.M.C., prior to the formation of British Leyland in 1968, could not be called a very "rivalistic" firm. The first managing director of B.M.C. Leonard Lord (later Lord Lambury), had made the joke that the initials stood for "Blast My Competitors". Sir George Harriman (the chairman and managing director of B.M.C. at the time of the merger) said of the 1800 that they were so confident of the car's potential that they had not bothered to compare its performance and cost with its competitors. One consequence of these attitudes was that the market share had fallen to 27.7 per cent - only just ahead of Ford - from a market share of over 40 per cent. (There is a discrepancy between the figures just quoted from Turner, (1969), p. 416) and those given by Rhys (1972), p.24, who shows a much smaller decline than Turner from 38 per cent to 35 per cent. My own figures, which were supplied by the manufacturers, are closer to Turner's than Rhys's).

From this brief and second-hand survey, it can be concluded that the car manufacturing industry contains a wide range of attitudes on the part of managements - from Ford, almost a parody of the profit-maximising

firm to the other extreme where some of the characters might be taken from Gilbert and Sullivan. Taking this factor in isolation it is difficult to see what theoretical implications follow:

11. Industry Social Structure

This only really becomes relevant when some sort of "old boy" network exists. Many of the managers in the Motor Industry came from different backgrounds, not usually via "good" schools or university. Some worked their way up from relative obscurity. Leonard Lord and George Harriman (of B.M.C.) started as apprentices: Sir Patrick Hennessey, the dominant force in Fords from 1948 to 1963 had been a buyer and was not in any sense a hereditary manager. Four out of five of Vauxhall's managing directors have been Americans. Rootes, until the Chrysler takeover, was the only real family firm, where traditional British notions of the ungentlemanliness of competition might have been perpetuated; but it would have required a few more firms like it in the industry to make completely collusive behaviour "the done thing".

Of course, managers in the industry must meet at times. In addition, "shakeouts" of managers as in Standard-Triumph in 1961, and B.M.C. in 1968 help to increase the mobility of middle managers and improve their acquaintance with each other. In the long-run this may lead to an increase in the amount of collusive activity - mainly through an increase in information and communication however, and not through change in the social ethos.

12. Barriers to Entry

This brings us back to an area where academic economists feel more at home, and which is more easily quantifiable than the previous sections. Under barriers to entry I shall consider

- (i) Economies of scale.
- (ii) Absolute size requirements.
- (iii) Cost disadvantages to potential entrants.

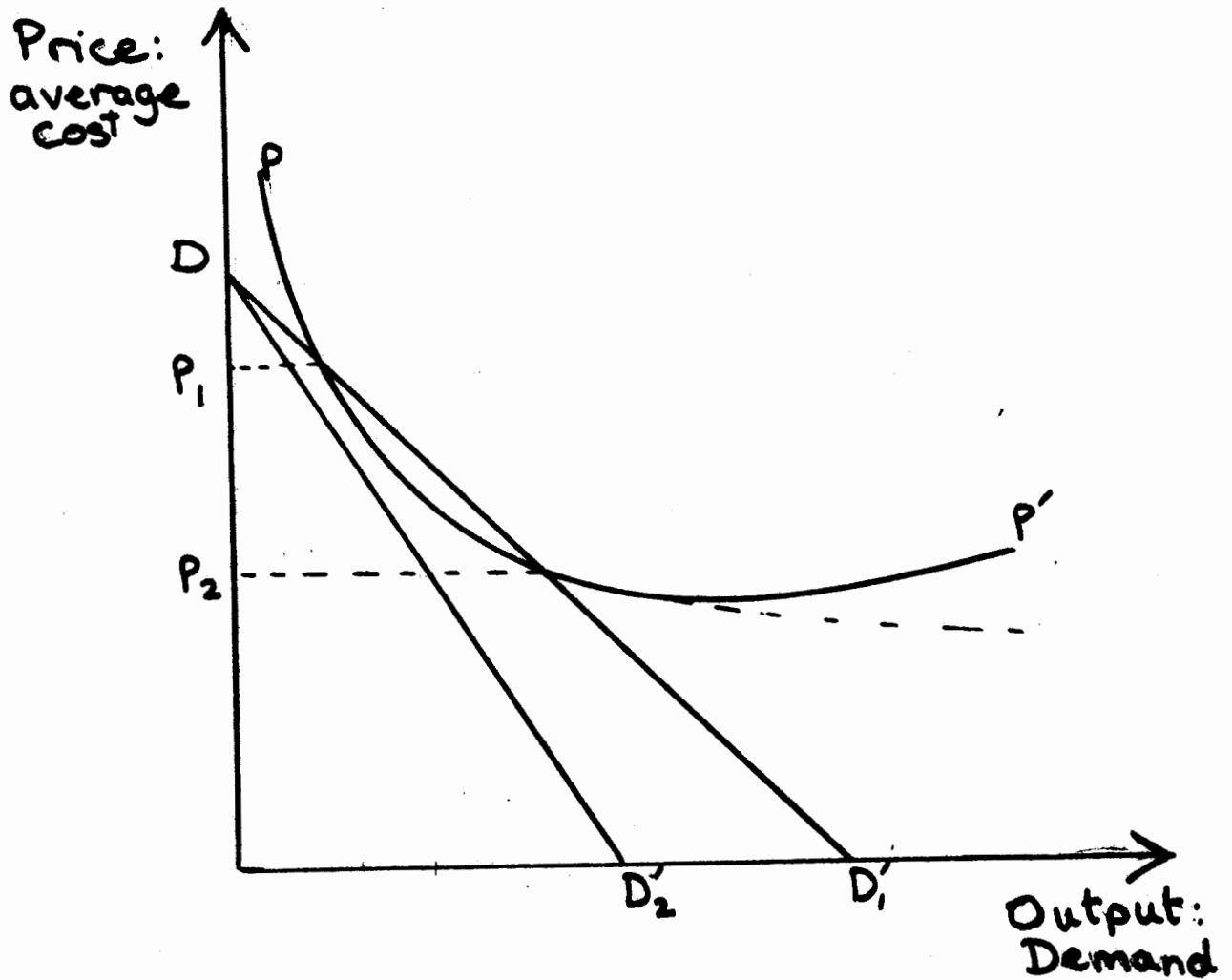
In addition, the so-called product-differentiation barrier will be discussed as well as the growth in demand and the extent of vertical integration. These are not classed as separate entry barriers, however, since their influence is mainly felt through their effect on the three main categories of barriers mentioned.

(i) Economies of Scale.

Stigler ([1968], p. 6) would not call this a barrier to entry, which he defines rather narrowly as "a cost of producing (at some or every rate of output) which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry". If we accept a wider definition though, it is clear that economies of scale as such can discourage entry.

Consider Figure 1. PP' is the scale curve showing average total cost at different levels of output. DD'_1 shows the level of demand faced by each (assumed identical) firm at different industry prices (assumed equal for each firm) before entry occurs. DD'_2 shows the demand curve facing a firm after it has entered, assuming that it manages to capture an equal share

Fig 1. Returns to scale as an entry barrier.



of the market as the indigenous firms. From the figure it can be seen that i) before entry any price between P_1 and P_2 would allow each firm in the industry to make profits greater than normal and ii) after entry occurs there is no industry price which covers average cost at any feasible level of demand.

If we further allow for the probable fact that due to what Bain could call the product differentiation barrier, a new firm is unlikely to gain a large market share very quickly, we can see how the existence of large scale economies would discourage new entrants.

One aspect of economies of scale is the optimum or minimum optimal, scale of production. Rhys estimates that :

"The overall optimum of the integrated car firms appears to be around 2 million units a year. The assembly-optimum is around 200,000 units a year and in all probability the foundry-optimum is not much greater than this. The machinery-optimum is around 1 million units a year and the overall-optimum is governed by the pressing-optimum of around 2 million units a year. As regards the optimum production level of bought-out components it is likely to be high for electrical components and some forgings." ({1972} p. 289.).

Pratten (1971) gives more detail. Taking the cost index to be 100 for 100,000 units a year, this declines to 89 for 250,000, 84 for 500,000 and 81 for 1 million units. Thus the initial steep drop in costs slackens off considerably after 200,000 units. This range is more relevant, since it is here that the established firms are producing. This still represents a market share of 5-10% for a single-model firm, which could be quite difficult for a new entrant to achieve in less than four or five years. This figure could be somewhat reduced by using unconventional production techniques.

Using bought-in components, fibre-glass or wooden bodies, using the large firms' distribution system, small firms can enter and survive producing for odd corners of the market (such as the utilitarian three-wheeler section or the high-performance luxury class). Such firms are heavily dependent on the big producers for the supply of parts and do not pose any real threat to them.

A much bigger threat is from imports. Cars produced abroad can take full advantage of scale economies in production despite achieving only a small penetration into the British market. One way of looking at imports is to see the actual extent of import penetration. By 1967 this had increased to 8.1% (N.E.D.O. {1970} p.12 and Table 1 below) after a slowly rising trend throughout the 1960's. This was low compared with other countries (12.4% for U.S.A., 23.9% Germany, 15% France and 12.1% Italy, (N.E.D.O., {1970} p. 12)). The likely impact of imports on the behaviour of firms will depend upon the level of tariffs, which will be discussed under the appropriate heading of absolute cost barriers.

(ii) Absolute size barriers

This type of entry barrier depends upon the minimum optimal scale being so large as to imply unusually large capital requirements which a "new entrant" may not be able to raise. If the capital can be raised but only at a higher interest rate this would appear as an absolute cost barrier. In any case a limit is set on the numbers of potential entrants.

As we have seen, a new firm wishing to set up a complete integrated mass-producing car firm in the U.K. would probably face enough economies of scale barriers that the worries about the absolute capital requirements would be superfluous. By 1964 the four largest firms

and their subsidiaries employed £986 million assets. It is difficult to see how a new mass-producing entrant could get away with assets less than around £50 million, (N.E.D.O., [1971] p. 35). A small producer of specialist cars who did not threaten the Big Six/Five/Four would probably find the capital requirements not unusually large. Such a firm would have to use mainly components bought from the rest of the industry, with the possible exception of the body which might be made of moulded fibre-glass. Whether such a firm, having gained a toehold in the industry, could expand to become a mass-producer is an open question.

(iii) Absolute cost barriers

These are the only type of barrier to entry that Stigler would classify as such. Even here we use a definition broader than Stigler's and include not only production costs but also the other costs of bringing the goods to market and selling them.

Absolute cost advantages in production may arise through the control (through patents or secrecy) of superior production processes or techniques of organising production or through superior access to raw materials and other inputs. Motor car production is not a highly secret process. It requires a good deal of engineering skill, but this is not rare in the U.K. Much of the knowledge required for production probably resides in the machine tool industry, which builds most of the specialised machinery required for automated mass production.

Neither can the design of motor vehicles be held to be such a specialised process that a new entrant would find it difficult to find the necessary skills. If necessary these could be bought by hiring employees

from the firms already in the industry. Insofar as higher salaries might have to be paid to lure people away this would create an absolute cost differential. Whether that extra payment would be necessary is another matter since there may well be a good deal of engineering design talent in the industry waiting to be given its chance.

The supply of components- electrical equipment, tyres, brakes and transmission parts - is oligopolistic in nature. It is difficult to judge how these suppliers would react to a potential new entrant. Presumably they would, on the whole, welcome it as reducing the monopsonistic power of the indigenous firms. They might even be willing to supply it at lower prices initially. Only if the new firm were going to be a disruptive influence, reducing profitability all round, would it be rational for the components industry to act in a hostile manner.

On the distribution and marketing side, the problems that a potential entrant might face are even more difficult to judge. Much would depend on the reputation of the firm which entered. Penetration of the market would probably be faster for a firm with a good reputation in a related market. Distribution would probably not have been a great problem. Even by 1970 B.M.G. had 400 distributors and 4,500 dealers in the U.K. (Rhys, p. 339). This was too many for efficiency. Many of them would probably have been willing to change over to a new entrant if they thought the volume of sales would justify it. The recent experience with the growth of imports has demonstrated this - dealers seem to be quite prepared to change the brand they deal in.

So it appears that absolute cost barriers are not the major

obstacle to a potential domestic entrant. The most important barrier for a home producer is likely to be that created by scale economies. For importers however, it is the absolute cost barriers which are most significant. Of these, the two most important are likely to be transport costs and import duty.

The size of transport costs is not known in detail. But Pratten suggests a figure of £28 for Canada-U.K. traffic at large volumes - far less than the import duty. The size of the tariff over the years and the magnitude of imports is shown in Table I.

It is evident that before 1968 substantial protection from imports existed and appeared to be effective in most years.

Product Differentiation Barriers

Bain (1956) considers the dealer network to be the major source of differentiation barriers for the U.S. industry. This is far less crucial in the U.K. with its greater population density. On page 58 it is argued that there was no shortage of dealers for potential entrants.

A more direct measure of this barrier would be the rate of adjustment by consumers to price changes. Slower adjustment implies that new entrants would incur a greater financial penalty while establishing themselves. The rate of adjustment implied in Cowling and Cubbin (1971b, equations 2 and 5a) is in the range 28-34% per annum. A new entrant could therefore expect to attain 30% of his equilibrium market share after one year without suffering from any financial penalty in the form of lower price or higher advertising costs. I would judge this to be a moderate entry barrier and a secondary, rather than a primary, source of discouragement to potential entrants.

TABLE I Import Duty on Cars and Percentage of Imports in Sales

<u>Period</u>	<u>Full Rate</u>	<u>Period</u>	$\frac{\text{No. of New Cars Imported}}{\text{No. of New Registrations}} \times 100$
1915-56*	33.3	1931-35	3.3
		51-55	1.5
56-62	30	56-60	3.8
1961	30		3.0
62	30-25.2		3.6
63	25.2		4.7
64	25.2		5.4
65	25.2		4.8
66	25.2		6.1
67	25.2		8.1
68	25.2-17.5		8.9
69	17.5		10.1
70	15		14.0
71	13		21.1
72	11		27.1

Source : Rhys, (1972)pp. 377-378)
SMMT, The Motor Industry of Great Britain, various years.

There was a small discrepancy between SMMT and Rhys for the 1960's.
 The figure given is that supplied by SMMT.

* Except for a period in 1924-5.

The extent of vertical integration may affect the ease of purchasing raw materials and other inputs. If existing firms make most of their own inputs this also increases the capital requirement for an entering firm. There has been some backward integration over the period studied. In 1965 B.M.C. bought Pressed Steel, a car body manufacturer which led Rootes to buy one of Pressed Steel's plants for its own use. This meant that all the major producers were self-sufficient in body production. However, the extent of vertical integration is quite small and apart from machinery the engine and gearbox and body-building the main activity of the manufacturers is assembly. Rhys (p. 268) shows that by 1968 bought-out components and materials still accounted for 62% of total costs. Electrical equipment, castings and drop forgings, tyres, wheels, front suspensions and brakes are all major items which are bought out from independent suppliers. One of the component firms is AC.Delco a joint subsidiary of General Motors Corporation with Vauxhall supplies other companies besides Vauxhall (and Bedford) with equipment. The extent of vertical integration, then, does not appear to add anything to the barriers to entry.

The post-war growth in demand has been if anything an encouragement to new entry. An expanding market is easier to enter than a contracting one, since there are usually new customers who have not developed any brand loyalty. This mitigates the effect of any product differentiation-induced barriers. Table II documents the post-war growth in demand. Production has almost quadrupled in the 22 years between 1950 and 1972, but the home market has increased more than tenfold. On the face of it this rate of increase in demand would have proved attractive to a potential entrant. If we accept Rhys' figure of 200,000 units per annum as the minimal

TABLE II Growth in the U.K. Car Market 1935-72.Source: SMMT The Motor Industry of Great Britain.

<u>Year</u>	<u>U.K. New Registrations 000's</u>	<u>U.K. Total Production 000's</u>	<u>Rate of Purchase Tax % from April unless otherwise indicated</u>
1935	281	325	0
1950	134	522	$33\frac{1}{3}$
51	138	476	$66\frac{2}{3}$
52	191	448	"
53	301	595	50
54	394	769	"
55	511	897	60 (October)
56	407	708	"
57	433	861	"
58	566	1,052	"
59	657	1,190	50
60	820	1,353	"
61	756	1,004	55 (July)
62	800	1,249	45
63	1,031	1,608	25 (November)
64	1,216	1,868	"
65	1,149	1,722	"
66	1,091	1,606	$27\frac{1}{2}$ (July)
67	1,143	1,553	"
68	1,144	1,816	$33\frac{1}{3}$ (March) $36\frac{2}{3}$ (Nov.)
69	1,013	1,717	"
70	1,127	1,641	"
71	1,335	1,742	30 (July)
72	1,663	1,921	25 (March)

efficient scale of assembly, we can see that it might have taken a few years for demand to catch up with the capacity installed by a potential entrant. In periods of rapid expansion such as 1962-4 and 1970-72 this might be made up in a single year.

The feature of demand which would be a disincentive to entry was its instability. This arose as a consequence of the use by the government of the motor industry as a tool of stabilisation policy, coupled with an alleged tendency of the government to react to changes in the balance of payments situation. Table II shows how the rate of Purchase Tax on cars was changed over the years. These tax changes were generally accompanied by changes in the regulations governing deposits and repayment periods for hire purchase contracts which had a tendency to reinforce the fiscal actions.

Faced with this uncertainty a potential entrant might have been easily persuaded to enter another industry where the level of demand, whilst growing, was rather more predictable.

In addition to the above considerations, there is also the fact that no potential large scale entrant seemed to be lurking in the shadows. To qualify they would have had to raise at least £50 million and be capable of eventually selling at least, say, 100,000 units (half the optimal scale). The only likely contenders would be foreign producers trying to dodge the barrier of import duty.

In the absence of such an entrant producing domestically, the only threat of competition comes from importers. Over all the period 1956-68

they had to contend with very high import duties. Assuming foreign competitors to have the same costs, this implies an entry-forestalling mark-up of price over long-run marginal cost of up to 25%. (This also assumes that the minimum price an importer requires is the long-run marginal cost and that in practice he will set his price sufficiently above this.) This being the case, I feel justified in claiming that the barrier to new entry into car manufacturing in the U.K. before 1968 was significant.

13. The Legal Framework

The car manufacturers themselves have been little affected by either the Monopolies Commission or the Restrictive Practices Court. The main object of attack by these bodies has been one form of resale price maintenance or another and price discrimination by components manufacturers. The main impact has been felt by the components suppliers and retailers.

The countervailing power of the manufacturers meant that they could ensure that components manufacturers did not charge them an unduly high price. The Monopolies Commission, investigating the tyre industry in 1955, found that when supplied as original equipment the price of tyres was not excessive, but that price discrimination existed between the original equipment and retail market. In 1963 the Commission reported on the supply of component electrical equipment to the motor industry and found the price discrimination between the two markets against the public interest.

In 1956 the Restrictive Practices Act was passed which made the collective enforcement of retail price maintenance illegal. This meant that a dealer could no longer be excluded from the industry for selling below list price or giving excessive trade-ins on used cars. This was replaced in 1959 by a scheme of enforcement of retail prices by individual manufacturers, but the Restrictive Practices Court ruled it unacceptable in 1960. The effect of this was to make the retailers' profit margin subject to his own control to some extent. Possibly it eventually led to the conclusion by some firms that the number of dealers was excessive. But it did not affect the extent of competition, so far as I can tell, between the manufacturers themselves. For example, in 1960 when Vauxhall dealers cut their prices, the manufacturer refused to be forced into cutting his list price. The Resale Prices Act of 1964 abolished Resale Price Maintenance almost completely.

14. The Initial Conditions

In 1956 the industry was in a highly favourable position. There was still a shortage of cars as a result of the almost complete shut-down during the war and the difficulty of building up capacity in the post-war period. (In 1943, only 1,649 cars were produced, (S.M.M.T.)). Since the prices of new cars were not raised by enough to clear the market, the prices of secondhand cars were for many years above the prices of new vehicles. By 1954 the situation had started to change but it was not until the end of the 1950's that the boom in second-hand cars came to an end. For the three years 1955-57 Ford made an average rate of return on sales of 10%. In the same period B.M.C. earned 6.3% despite 1956 and 1957 being poor to mediocre years for sales (as a result of the Suez crisis). The industry

was certainly in 1956 in a position to decide what prices it would like to see in the long-run. It was long-term considerations which they claim prevented them from raising new car prices to market-clearing levels. Such considerations would be the effect on customer loyalty of raising prices so far above costs of production, the possibility of inducing entry, and the long-term industry elasticity of demand which might lead customers to develop other forms of transport. It is possible that the car producers feared that when prices were eventually reduced, as they would have to be when capacity built up, this might make people come to expect price competition as a normal phenomenon in the industry.

15. The Consequences of Market Structure for Expected Conduct

The above pages have outline those elements of market structure which our survey of oligopoly theory led us to believe might be relevant in determining market conduct. Some turned out to be of little relevance for this particular industry, (for example, the social structure of the industry). Others, in particular the number of buyers and sellers, the nature and extents of barriers to entry, and the gestation lags for different types of strategy, turned out to be of great potential importance. The other, less crucial, aspects of the car industry are probably more important in determining the details of how particular types of behaviour worked out in practice (for example the annual Motor Show and model changes).

In the period studied we can regard the British family car manufacturing industry as a closed oligopoly with a differentiated product and fairly homogeneous firms; over most of the period five firms dominated the mass market. Information on prices and numbers sold was good, buyers

were many and small as were individual sales. The retaliation lags for price reductions was small. All these factors lead one to expect the absence of price competition. On the other hand no evidence of open collusion has been found.

The major limit on the producers' ability to raise prices above marginal cost was the level of import duty which fell from $33\frac{1}{3}\%$ to 17.5% over the period.

The absence of price competition does not imply the absence of all rivalry. Advertising was subject to slightly longer lags than price changes and might be expected to play some small part in oligopolistic rivalry.

Quality competition emerges as likely to be the most important form of rivalry. The lags involved are much greater than for price or advertising competition and the level of secrecy during the gestation period is very high. In addition the product is differentiated and complicated and highly amenable to quality change. There were also a number of technical improvements to the product which provided the main justification for the introduction of new and changed models.

The observation of quality competition in the motor industry is far from novel. Maxcy and Silberston {1959} comment on it at length and claim it is the dominant form of rivalry in the U.K. Motor Industry. In the U.S.A., J. K. Galbraith has dwelt on what he considers the implications, {1958 }. Whilst these writers have pointed out that quality competition is an alternative to price competition, it was Brems, {1958} who drew attention to the role of response lags in making it the most common form.

CHAPTER 4The Measurement of Quality Change

By the quality of a good we mean the set of characteristics that it possesses. "Characteristics" as used here, is a very general concept, and in principle encompasses both objective, physical attributes such as size, and more subjective, psychological ones. Psychological attributes include such mundane things as one's beliefs about the intrinsic, physical attributes to much more elusive properties such as glamour, and the capacity of the good to capture one's imagination.

As Triplett and Cowling {1971} point out, economists seem in the past to have emphasized the latter type of quality variation and product differentiation at the expense of the former. Product differentiation has been regarded principally as a market imperfection, rather than as a source of utility. This tradition goes back to Joan Robinsons' The Economics of Imperfect Competition , (the word "imperfect" demonstrates the point) and is continued in those studies such as Bain, {1956}, which regarded product differentiation as a source of entry barriers. Yet consumers may have different tastes or endowments and may therefore legitimately have preferences over goods with different objective characteristics. Insofar as utility is a psychological notion one might claim that preferences over subjective attributes are also legitimate, particularly those which are not based on ignorance.

Chamberlin, in The Theory of Monopolistic Competition recognised that a real basis for product differentiation may exist, (Chapter IV). His

notion of "the product as a variable" combined with his distinction between selling costs and production costs depend upon this possibility. This difference in emphasis from Joan Robinson is captured in the title of his book which implies a certain uniqueness in the product of each firm.

Lancaster, ((1966)a,b), has set out a theory of consumer behaviour which takes account of differing product characteristics. He recognises three sorts of entity: goods, characteristics and activities. In the more elaborate Journal of Political Economy version, goods are consumed insofar as they contribute to activities. The activities have characteristics, which are the ultimate source of utility. The relationship between goods consumed and the level of activity, and between characteristics and activities is assumed strictly linear and implicitly fully divisible. In the American Economic Review version which is aimed at a more general audience and is much less complicated, characteristics are regarded as a function of the goods themselves rather than of the activities they permit. An assumption of linear homogeneity is made between goods and characteristics, such that one unit of a good containing a certain level of characteristics is deemed equivalent to two units containing half as many. The presence of indivisibilities is recognised in this article in acknowledging the impossibility of combining half a Cadillac with half a Volkswagen to produce a vehicle with a level of characteristics and of price half-way between the two, although an entirely separate car might be produced having those properties.

The approach adopted here is to regard the characteristics as functions of the goods themselves rather than of the activities to which they contribute. But the assumption of linearity between characteristics

and goods will not be made. This is because of the difficulty of defining characteristics operationally which have this property, except perhaps for goods such as staple foods where the quantity of carbohydrate, amino acids etc., which are the ultimate sources of utility are presumably proportional to the quantity of food. The implicit assumption of independence is also avoided. In Lancaster's A.E.R. version where characteristics are a property of the goods one should be indifferent between wearing a grey hat sitting in a red car and wearing a red hat sitting in a grey car. That this is not necessarily the case should be clear. Therefore "characteristics" as the term is used here cannot be considered separately from the good in which they are embodied. To take another example, a given horsepower is very much a different matter embodied in a motor car and a motor mower. In the J.P.E. article, characteristics are assumed as a facet of activities rather than of goods. This is rather less restrictive and makes Lancaster's theory of consumer behaviour more acceptable as a general description of the real world, but this is achieved at the expense of vagueness and the necessity of using concepts which compared with product characteristics such as size or horsepower, are much more difficult to define operationally.

For our purposes then, characteristics are defined as properties of goods and there is no assumption of linearity or additivity of characteristics. We restrict ourselves to characteristics with an operational definition and which are directly or indirectly a source of utility to the consumer. This means that certain attributes that have been defined as aspects of quality must be left out of our analysis because measuring them is very difficult. This applies particularly to the psychological aspects of quality, such as glamour, but also some rather more objective

attributes such as comfort, for which there is no accepted standard of measurement.

This problem, of being able to take into account a proportion of all quality attributes, will vary from good to good. For producers goods such as power transformers and electrical generators objective measurable factors are probably of overwhelming importance, since performance in use is the sole criterion. This also applies to an extent to goods which are intermediate in consumption, such as lawnmowers. The closer one gets to final consumption the less likely this is to be the case. Even in final consumption, objective factors may be the primary consideration for such basic goods as food, clothing, housing and transport, at least until a measure of affluence is achieved. It is mainly in goods usually designated as luxuries where subjective factors become fundamental, as in questions of entertainment or ornamentation. (This distinction cannot be made always. For example, high technology in producer goods has a glamour of its own for some people, and this may have influenced decisions to go ahead with such projects as Concorde.)

Glamour may often be the decisive factor when choosing between two goods with equivalent objective characteristics and equal prices; but at the same time it may be relatively unimportant in the context of the whole decision by a purchaser. The fact that the Ford Edsel was a failure despite millions of dollars being spent on motivational research and promotional expenditure illustrates this distinction. A motor car which keeps breaking down soon loses any glamour it may have had; and "dream cars" which have sold in large quantities such as the Ford Mustang (in America) or Capri (in Europe) provided at least a minimum level of

family transportation.

However, it must be admitted that all aspects of quality cannot be measured and taken into account, and the more expensive and luxurious and less "utilitarian" the good in question becomes, the more important do immeasurable factors become.

Assuming that we can measure a sufficient number of attributes to make the exercise worthwhile, the next question that arises is how we can compare changes in one characteristic with changes in another for the purpose of either analysing quality competition or deriving a price index adjusted for changes in quality. In other words, how can we compare an increase in horsepower, a decrease in fuel consumption and an increase or decrease in price? The economist's usual answer is to transform these into variables with a common unit of measurement, usually money. The method commonly used by official bodies in constructing price series is to work on the basis of the cost to the producer of any change he makes in his product. Under conditions of perfectly competitive equilibrium this would be equal to the extra price paid by the consumer and, incidentally, the marginal valuation he places on the improvement if he is indifferent between the two varieties. But when the producer has market power this is no longer true. For example, the price differential of a four-door version of a two-door car may be much greater than the marginal cost of putting four doors on instead of two, since the producer is in an essentially monopolistic position in this respect. The market's valuation on "four-dooriness" will then be in excess of the cost of that quality difference. Secondly, some real quality improvements may be costless to the producer and yet be of value to consumers. Producers

may charge a premium for latest models embodying that improvement. Finally, some product changes which are costly may even be disliked by consumers, although this should not happen if producers are rational and informed.

The reason why we wish to know the value of a particular quality change is because of the impact of that change on consumers' and producers' behaviour. For example, in correcting a price index for quality change we will be interested in deriving the price of a "bundle with constant utility". In looking at the competitive behaviour of firms one of the main subjects of interest is the impact of the change in quality on the quantity demanded of the firm's product. These imply that the "value" we wish to assign to a quality variation is the price the consumer in equilibrium pays for that variation. As long as the consumers are free to choose between two varieties and some choose one and some the other there is likely to be one or more consumers who would be induced to change from one variety to the other by a very small change in the relative prices of the two varieties. For such consumers the marginal utility of the quality variation will be equal to the price difference (if we assign an arbitrary value of unity to the marginal utility of money).

Multiple regression is a technique which allows us to estimate the market prices of the characteristics of goods. If we observe the prices and n characteristics of T different versions of a good we can estimate the equation

$$P = a_0 + a_1 X_1 + a_2 X_2 \dots + a_n X_n + U \quad (1)$$

so long as $T > n$.

a_i then represents the extra price paid on average for an extra unit of characteristic i when the levels of other characteristics are constant. This can be termed the shadow price of that characteristic. The earliest suggestion for this method came from Court, {1939}, who suggested applying it to automobiles. Stone {1956} applied it to alcoholic drinks but it was not until Griliches' {1961} article that the method (called the hedonic technique by Court), started to gain widespread use. It had been applied to automobiles (Griliches {1961}, Triplett {1966}), tractors (Fettig {1963}, Cowling and Rayner {1970},) refrigerators (Burstein {1961}, Triplett {1966} housing (Kain and Quigley, {1970}, Cubbin {1974}) and by Kravis and Lipsey, {1971} for a variety of producer goods including aircraft engines, diesel engines and power transformers.

Although for classical regression, equation (1) must be linear in the parameters a , this does not imply linearity in actual physical attributes. X_i can be, for example, $\log Z_i$, Z_i^2 , $Z_i Z_j$ or $\frac{1}{Z_i}$, where Z_i is some physical attribute such as length or weight or power or whatever, depending on the product in question. These functional forms allow the shadow price of the physical characteristic Z_i to vary according to both the level of Z_i and, in the case of $Z_i Z_j$ and other forms involving interaction terms, the level of other physical attributes.

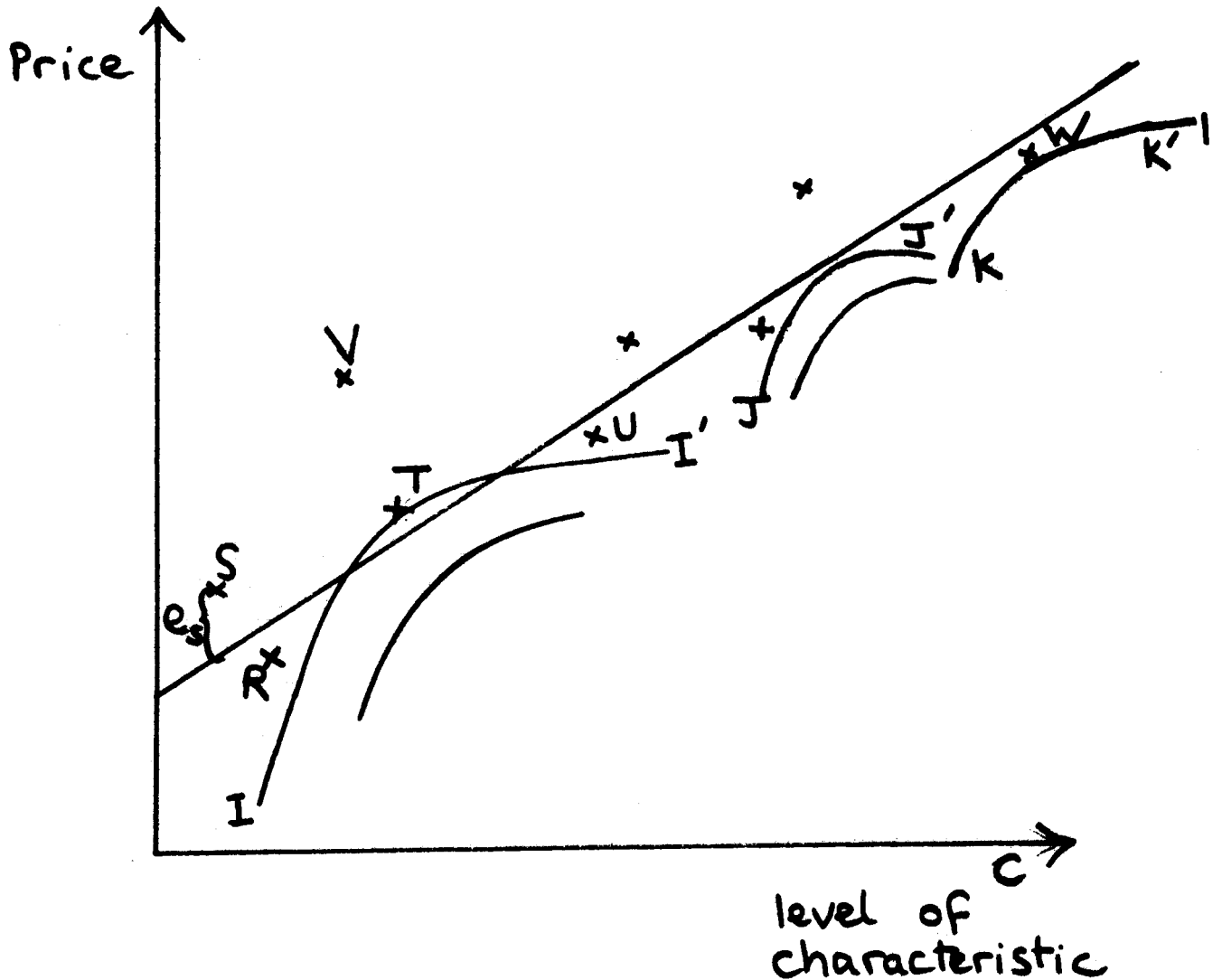
Least-squares regression gives the average price paid for the increase in a given characteristic. To ensure that this average represents a synthesis of market opportunities and consumer preferences some sort of

weighting system is desirable. If some brand of a commodity has a very low market share compared with its competitors it should be treated as less relevant in determining the shadow price of a characteristic. For weights Dhrymes, {1967} used numbers sold in his analysis of car manufacturers' pricing functions.

It has been suggested (Dhrymes, {1967}) that such a procedure may involve problems of simultaneous equation bias, particularly if the price-quality relations derived are used to examine the behaviour of market share. Griliches does not analyse this possibility and states his opinion that he does not "... believe that it is relevant for the derivation of characteristics prices to be used in the construction of a 'purer' price index".

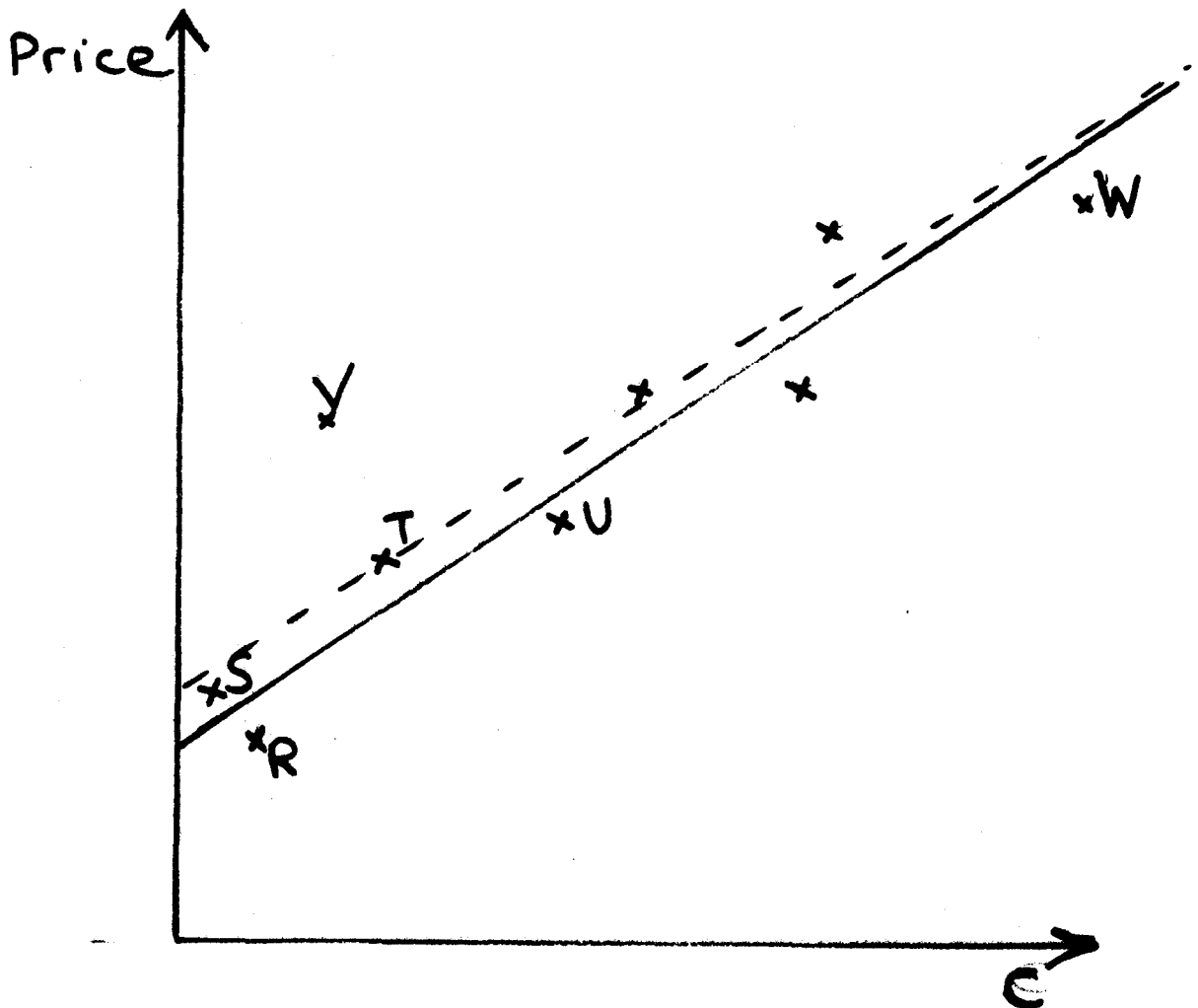
Let us examine this argument. In the process we can put forward some concepts to be used later on. For simplicity, assume the good has one characteristic only, which we shall call C . For each brand we can denote its price and level of ' C ' by a point on a diagram, with price and quality as axes. By doing this for each brand we can represent the whole market which yields a scatter of points, (Figure 2.) through which a regression line may be drawn. Points lying above the fitted line can then be said to have a higher price than expected for that level of C (or a lower level of C for that price). As a result we should expect such a point, for example T in the Figure, to attract fewer sales than either U or R . (Strictly this depends on the distribution of consumers' preferences: it might happen that for many people, C_T was, just the right level of C .)

Fig. 2 Choice of different brands by different consumers



In fact if (i) C really was the only relevant characteristic and (ii) all consumers had perfect knowledge of the values of C and P for each brand and (iii) consumer preferences give rise to indifference curves like $I I'$ in Figure 3 (i.e., more C always preferred to less), then brands like S and V would not be purchased at all. Since R is lower in price and higher in C it dominates S . Similarly T and U both dominate V . U does not dominate T , however, because although higher in C it is also higher in price and it is possible that some

Fig 3. The effect of weighted regression.



consumer represented by II' would prefer not to pay the extra price in order to get the extra C.

However, if (i) there are some secondary characteristics, not so important as C, but having some influence, or (ii) knowledge is imperfect, or (iii) preferences are not monotonic, it is possible that S and V would find some buyers, and people would then perhaps find it worthwhile to produce them. None of these conditions is necessary for further argument as all

statements will be applicable to non-dominated points like R, T, and U. Discussion of points like S and V, however, make the illustration of arguments more vivid.

So the situation under discussion is one where, because of their good value for money, brands such as R and U have high market shares : on the other hand, brands T, S and V have smaller market shares, V probably the least. What will be the effect of using a weighted regression? This means, in effect, minimizing the weighted sum of squares of the residuals, e_i . If the weights are sales or market shares and points like U and R have high market shares this will have the effect of pulling the regression line downwards, reducing the absolute size of the negative residuals like e_r and increasing the positive residuals like e_g .

The main effect of this will be to make the unweighted sum of residuals positive, rather than zero. The slope of the fitted line will be more nearly equal to that of an imaginary "envelope of efficient points". Brands such as V with possibly a secondary characteristic of interest to only a very few people, or bought only by extremely ignorant consumers, would sell in very small numbers. Weighting the regression by some measure of sales is the only way of taking into account V's relative unimportance in the market.

The use of market shares as weights may not be the most efficient procedure, however. The purpose of using market shares as weights is to give brands with unrealistically high prices (and hence low sales) their due importance and no more. The use of market shares will, however, tend to reduce the influence of those brands with specifications that are on the extremes of the range considered and have low market shares because there are few consumers with those particular tastes rather than because they are bad value for money. Now the variance of a regression estimate is, in the two-variable case, inversely proportional to the variance of the explanatory variable. An analogous, but a little more involved, situation holds in the multivariate case (where the independent variation of each explanatory variable is important). Brands with extreme characteristics are a rich source of variation in explanatory variables in price-quality regressions, and so there is a case for not giving them weights commensurate with their low market share. One way to deal with this is to split the market into a number of segments and use the brand's share of that market segment as the weight in the regression. This ensures a wide variation in the characteristics whilst giving due emphasis to those brands which are most efficient at satisfying consumers' wants.

The choice of appropriate segments of the market is obviously a matter of judgement. They should be as nearly equal in size as possible, so that it does not matter if a borderline brand is assigned to one segment of the market or the next. There is for many goods one primary characteristic which can be used for segmentation. In houses it would be floor

area, in cars horsepower, and in refrigerators and freezers cubic capacity. This primary characteristic can be used as the basis for market segmentation. The need for judgement occurs throughout the estimation of price-quality relationships. Physical characteristics must be chosen with care and the choice of the best functional form may be very important. Indeed the initial problem of defining the boundaries of a market is also a matter of weighing conflicting considerations. The need for a wide variation in characteristics must be weighed against the requirements that the brands must be close substitutes of each other. On the other hand it is not necessary that each brand be a close substitute of every single other brand. There should, though, be a fair amount of continuity of characteristics between brands. These terms, substitute, continuity, are vague. As more experience of price-quality relationships is gained it should be possible to make these requirements more explicit, and to develop the theory of the hedonic technique on a more rigorous basis.

CHAPTER 5Estimation of a price-quality relationship for British family cars 1956-68.The sample

The sample consisted of 295 observations on approximately 45 distinct models of family saloon cars over the years 1956-68. It was restricted to mass-produced cars assembled by the five (later four) largest car producers in the country - the British Motor Corporation, (later, with Standard-Triumph, Rover and Jaguar, part of British Leyland), Ford, Vauxhall, Rootes, (later Chrysler United Kingdom Limited). Sports cars were excluded, as were Jaguars and Rovers since it was thought that these really constituted separable markets where different characteristics assumed greater importance. A more complicated specification would then be required, and failure to take account of this would lead to specification bias. Information on sales was obtained directly from the companies themselves. The characteristics, including prices of the vehicles were discovered from the magazines Motor and Autocar, based on their own measurements. This is the most tedious part of estimating price-quality relationships. For the particular application involved here an extra check on the data was necessary to eliminate variations in the reported model characteristics due to printing and clerical errors, as any such spurious quality changes would have distorted the results.

One of the problems is to decide which of the characteristics which are available are important. This is likely to vary over time. Presumably "self-starter" would have been a relevant characteristic at one time, for example. Acceleration would have been a useful piece of

information to collect. However, for some models the data available were in the form of time taken to reach 60 m.p.h. from rest: for others time taken to reach 50 m.p.h. while for other no data at all on acceleration was available. Similarly, a measure of durability would have been useful, but like "roadholding" is difficult to quantify and no precise measures are available. With the benefit of hindsight it would have been reasonable and possible to include as a "dummy", i.e., "zero-one" variable the characteristic of independent suspension, especially in the rear.

The thing that all these omitted variables have in common is that, directly or indirectly, they are a source of utility to the purchaser. For the choice of variables there must be a stable relationship between the quality variables and the services which, in combination, they provide. It is not sufficient that a variable can explain a significant amount of price variation between cars. For example, brake horsepower has a fairly constant relation to requirements like speed and comfort, whereas weight has not.

Unfortunately, early applications of the hedonic technique to motor cars used weight as a quality variable. Triplett has pointed to the dangers in such a procedure, {1969}. The argument for including weight in the price-quality relation is that in any one year there is a fairly strong relationship between many attributes of quality and weight. (The weight variable in fact seems to provide most of the explanatory power in the regressions with $\ln(\text{price})$ as the dependent variable, for American cars at least. In Triplett's table 1, weight and the dummy variable "power steering or brakes included in the price" are the only variables with consistently significant coefficients.) However, for most purposes we are interested in observing changes in quality from year-to-year and

weight will only provide a good measure of this if the relationship between weight and quality is fairly fixed. We cannot assume this to be the case. Indeed, weight in itself is an undesirable quality (except in collisions). We would expect that technical progress would enable a given level of quality to be attained using less steel and hence with less weight. More recent car body designs have managed to attain the same strength and rigidity as older ones but using thinner steel. So we expect the relationship between weight and quality to change over time. In consequence, changes in weight over time will be bad indicators of changes in quality.

A further problem is that weight summarizes many disparate components of quality including body and engine size, thickness of carpets, electric motors for automatic window winding and so on, each of which will have a different ratio of value to unit weight. If the relative quantity of these components changes so will the average relationship between weight and value. Furthermore, since the relative quantities of these components varies from model to model in any year, weight will be but an imperfect indicator of quality exaggerating the quality level of those vehicles containing a lot of low value steel and under estimates the quality level of cars with a lot of high-value weight such as expensive upholstery and trim, a radio, cigar lighters or rev. counters. So if weight is used as the major explanatory variable the price-quality relation will not yield very accurate quality-adjusted prices for comparing different makes of car. Another problem, fairly minor by comparison, is that the coefficient on weight will be biased towards zero because the estimating equation is an "errors in explanatory variables" model.

From this it follows that we should attempt to use variables that allow all the different attributes to vary independently; and the variables should be as close to the ultimate means of achieving utility as possible. The latter should ensure stability in the relationship between "true" quality and quality as we measure it.

The variables used

In British cars the difference between cheap and dear models is mainly due to differences in engine power, size, comfort of interior and of "ride" and quality of finish. Cars vary also with respect to ease of starting, handling, fuel consumption, reliability and durability. The three most important factors are, however, size, power and comfort. The relationship between these factors and utility is fairly obvious. For example, the greater the horsepower the faster is acceleration and cruising speed. Consequently journey times are shorter and possibly less tiring. With increased power manufacturers generally have to improve the suspension, steering and brakes for the sake of safety; so the cost of increased power includes the cost of improving these attributes. "Brake horsepower" was the variable chosen to represent this characteristic.

For size, both internal and external dimensions were used. Over the period in question length, as well as costing more, was considered a stylistic advantage. It also produced more potential room for passengers and luggage. Inside, the main considerations seem to be leg room, especially in the rear, and internal width. Length of course will be fairly highly correlated with internal width, ($r = 0.83$) but has in fact a fairly low correlation ($r = 0.27$) with rear leg room.

Comfort depends on a number of factors including power and size, but also on how well-insulated the passenger compartment is from engine and road noise, and the suspension. Different people have different reactions to various types of suspension. The most important single improvement in the last 30 years in this respect was probably independent front suspension and only one car in the sample did not possess it, (the Ford 93A). As there is no single index of quality of suspension and little prospect of synthesising one, it was decided not to attempt to take account of this variable. The standard of interior trim such as thick carpets and comfortable seats can have a considerable effect on comfort. For this variable a subjective assessment was used and each model was assigned a value of 1 or 0 for this variable according to whether or not the interior met a certain standard.

The question of safety was not very comprehensively covered. In the sample period 1956-68 people were apparently not very concerned about car safety. There appeared to be little difference in safety either across models in any one year or between one period and another. The only brand that made any claims to safety, Rover, was not included in the sample as belonging to a separate sample. The variable which comes closest to indicating safety, ceteris paribus, was the variable disc and/or power brakes.

This variable had the property that if either disc brakes or power assisted drum brakes were fitted the model was given a score of 2. If servo- or power-assisted disc brakes were fitted the model was given a score of 3 for this variable. For cars with "muscle-operated" drum brakes the value for this variable was zero. This imposes a particular functional

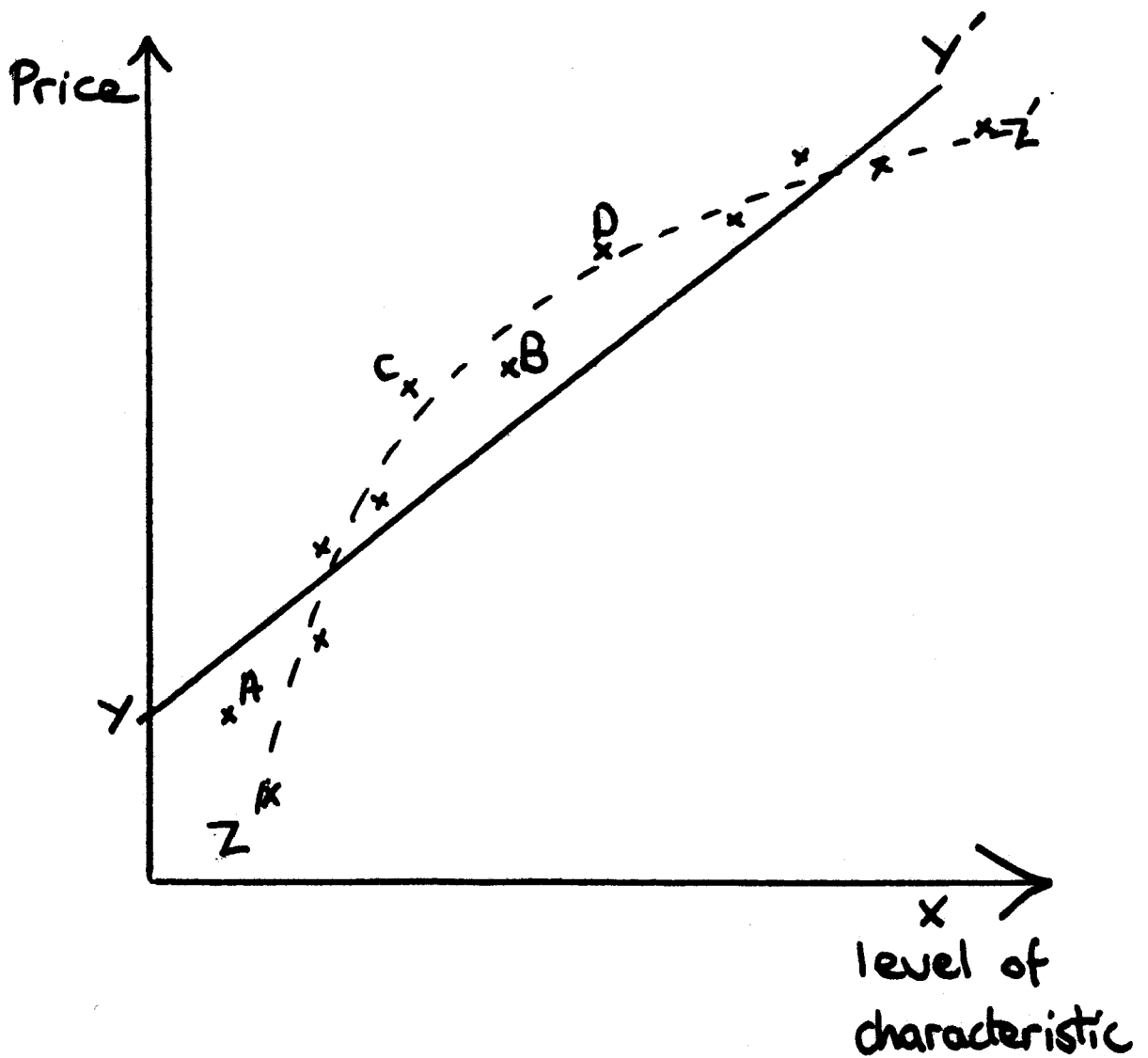
form on the relation between price and quality of brakes. This was necessary because few models, especially in the early years, had "non-standard" brakes leading to too few effective degrees of freedom for estimation purposes and there was a good deal of collinearity between disc brakes and power brakes. A general principle of diminishing returns was used to justify the use of the 0,2,3 scale.

The number of forward gears is relevant in that it increases the flexibility of the engine, especially for engines with low power. Three forward gear ratios were standard on the earlier Fords in the sample, but were also on some Rootes and Vauxhall cars. A car with three forward gear ratios plus overdrive was treated as equivalent to one with four forward gears.

The functional form

The choice of functional form was based on a number of considerations. It was thought desirable to use the best functional form so that the estimated quality-adjusted prices for cars with dissimilar specifications would be comparable. For example, in Figure 4, fitting straight line YY' would probably give an apparent good fit (apart from a low Durbin-Watson statistic if the observations are ranked according to the size of X). A will appear to be relatively good value for money and have a negative residual, which we term "quality-adjusted price". Conversely, B will have a positive residual and hence will appear to be poor value for money. Relative to its close competitors such as C and D, B, is in fact, good value for money. This can only emerge if we fit the better regression line ZZ' . B will then have a negative residual indicating that it is relatively

Fig.4. The importance of using the best functional form.



good value for money. The sign of the residual for A will also be correct, i.e., positive.

The prices for product characteristics which emerge from price-quality regressions are those set by the producers and represent a sort of average of producer behaviour. The price which producers decide to charge will depend on the marginal cost of production of the characteristic and on his view of the price-elasticity facing him of a model containing an increment of that characteristic. This will depend on, amongst other things, how unique an increment of that characteristic makes the model. To put it more concretely; the effective price elasticity for a car in the middle of the range is not greatly reduced by adding a few horsepower. Therefore the producer is unlikely to be able to obtain a higher percentage price-cost margin than average on the additional few horsepower. We should expect the price of horsepower, particularly in the middle range, to be more or less proportional to the cost of producing horsepower.

In contrast, suppose the producer also adds disc brakes, a sunshine roof, two extra doors, leather-upholstered seat and thick carpeting. The car becomes more differentiated than the average run-of-the-mill car. Consequently at any one price the price elasticity of demand may be expected to be lower, enabling the producer to obtain a higher percentage mark-up on such cars than on the average. (As a competitive tactic this was heavily used by B.M.C. in the fifties. Many different variants of the same basic model were produced with different grades of carpet and different brand names that the firm had inherited from the past, such as Riley and Wolseley. This came to be known as "badge engineering". The problem with it was that it raised

overheads more than it raised price-marginal cost margins.)

This would imply that non-basic or unique features would have a price determined by "what the market will bear". This requires some consideration of the inherent usefulness or satisfaction-promoting ability of the characteristic in question. In general it is necessary to consider both cost and utility aspects when deciding on a sensible functional form.

For example, over most of the range of horsepowers in the sample, it is fairly safe to assume that the marginal cost of an extra horsepower is diminishing. However it is reasonable to suppose that there is some level at which the marginal cost of increased horsepower is increasing - possibly this occurs at the upper end of the scale of what is currently being produced. Increasing power at this end might bring new technical problems.

On the utility side it is also fairly reasonable to assume diminishing marginal utility, expressed in money terms, of increased horsepower. However, at the top end of the horsepower scale it is quite possible that extra power can be sold with a higher mark-up because of its greater rarity value. There are people who prize having a slightly faster car than most of the others on the road, and who are willing to pay substantially for the privilege.

These two considerations, of cost and utility, suggest that a cubic function might fit the data very well. This would enable us to have a diminishing price of power increments at low levels and an

increasing price at high levels. It has the further advantage that if our speculations about costs and utility are wrong, the estimated coefficients will reflect that. For example, if a linear relationship between price and horsepower is correct, the coefficient on HP^2 and HP^3 will be non-significant, and the graph of the expected price against horsepower will not be very bendy.

According to Taylor's theorem any function provided it has continuous derivatives up to $(n + 1)$ th order at least can be approximated by a polynomial of the n th degree. Therefore where the theoretical restrictions on the functional form are not clear it seems reasonable to use a polynomial of a fairly high degree. Of course, if a high enough degree is chosen, the function will go through every single point, no degrees of freedom will be left, and no information will have been gained. Theory should be adequate, however, to give the maximum number of possible turning points in the function or its derivatives and this will dictate the highest degree of polynomial necessary. In most cases where regression analysis is applied in economics, such complications are not usually possible because the range of independent variation of the explanatory variables is usually limited, especially in time series analysis. In such circumstances high standard errors on the estimated coefficients are to be expected. In the present case we have ensured that this problem does not arise by using cross-sections of cars with widely differing combinations of characteristics.

The expected relationship between price and length is one where a priori considerations are conflicting. Very long cars were believed to look more stylish than shorter models. Moreover the longer a car is

the easier it is to provide ample luggage and passenger space and to make the engine accessible for maintenance and repair. Insofar as these factors are not taken into account in our other variables, we should expect length to have a significant positive coefficient.

On the other hand, long cars are not usually so easy to manoeuvre or park and at smaller lengths increasing ingenuity is required to fit the engine and the passengers in. This should imply that length has a negative price.

The actual relation between price and length is the resultant of these two opposing considerations. Each may be dominant over different ranges. This being the case, it seemed that a polynomial function would provide the best way of approximating the true functional form. It was considered that one of the third degree would give sufficient flexibility for our purposes allowing for up to two switches between one influence and the other.

For fuel consumption gallons per mile was taken as the explanatory variable in preference to the more usual, and more immediately appealing miles per gallon. The cost of running a vehicle for so many miles includes fuel costs which are directly proportional to the number of gallons required per mile, assuming fixed fuel prices. In valuing a car the discounted sum of these fuel costs should be subtracted from the benefits. This discounted cost will be proportional to gallons per mile, not miles per gallon.

For passenger room theory is more specific than for length. We

should expect that the marginal costs of increasing width or leg-room would be fairly constant but that for very small cars the marginal utility of extra room would be extremely high, diminishing as roominess increases. Hence we should expect the price of roominess to be positive but diminishing. This can be captured by a logarithmic function of distance. However simply taking the logarithmic of the distance in question, (e.g. leg-room) would not be sufficient since it would not impose a much higher value on an increase in roominess which turns a cramped car into a tolerable one than on the same absolute increase which transformed a roomy vehicle into a spacious one. Subtracting a constant from leg-room before taking logarithms - i.e., $\log(\text{legroom}-33)$ - implies an initially extremely high value for increases in leg-room, declining to moderate levels as the car becomes a more reasonable size. (It is necessary to ensure that the constant which is subtracted is less than every observed value for that variable to avoid the anomaly of the logarithm of a negative number. If this happens, the constant subtracted is too high anyway.) This was applied both to the leg-room and elbow-room variables.

In addition to these cubic and logarithmic functions and dummy variables already described, some "interaction" terms were included. An interaction term involves the product of two variables already included in the equation. For example in the equation $Y = \alpha X + \beta XZ + \gamma Z$ the term βXZ is the interaction term. It allows for the possibility that the derivative of Y with respect to X is a function of Z . In this case $\frac{\partial Y}{\partial X} = \alpha + \beta Z$. It also implies that the derivative with respect to Z is a function of X .

The most important interaction term in the estimated equation

is probably that involving power and fuel economy, the variable "brake horsepower \times gallons per mile". We would expect the costs of improving fuel economy to be larger, the greater is the power of the car. Since an improvement in economy requires a decrease in gallons per mile (GPM) a negative coefficient is to be expected in this interaction term. This would also imply that the more wasteful of fuel the model is, the cheaper are the increments to horsepower. Both of these arguments are on the cost rather than demand side. From demand considerations there are no clear influences on the sign of this variable.

"Luxury" is involved in two interaction terms, with power and length. The cost of luxury should increase somewhat as the size of car increases. On the other hand we should expect a luxurious interior to be less rare on large cars than on small. The expected sign of coefficients on these variables is not clear.

The other twelve variables are dummy, or zero-one, variables representing the years 1957-68. For example, if an observation relates to price and attributes in 1959 it is given the value of one for the variable 1959, zero for all other variables in this set. Observations on 1956, of course, had zeros for all of these variables. Because of the inclusion of a constant term in the regression the use of a thirteenth dummy variable for 1956 would have created a singular $[\bar{X}'X]$ matrix rendering estimation impossible. The coefficients on these twelve variables can be regarded as deviations in weighted average quality-adjusted price from the 1956 level. (Because of the weighting procedure adopted however, these coefficients should not be used in constructing a quality-adjusted price index. Equal weights overall are given to three segments of the market, small, medium

and large for the purpose of efficient estimation of the parameters. In fact the proportions of sales to these segments were not exactly equal at any time, and tended to fluctuate rather a lot.)

The possibility of bias arising from the pooling of cross-sections from many years must now be discussed. To see how this might arise, first consider the simpler case where no annual dummy variables are included. Let the true marginal price of horsepower be constant both cross-sectionally and over time, but let the true constant term increase over time. If average specifications stay much the same from year to year no bias will result, but the estimated constant term will have a large standard error. If, however, average horsepower increases over time, the effect of the rise in the constant term will be attributed to some extent to the rise in horsepower. This will impart an upward bias to the coefficient on horsepower. Inclusion of annual dummy variables will remove this source of bias since these variables allow the estimated constant term to shift from year to year, thus dealing with what is essentially an omitted variables problem. In my view this was the main source of possible bias and that is why the annual dummy variables have been included.

However, this does not eliminate all the possible bias. The true marginal price of horsepower may change. If this is simply a result of an increase in power or a change in fuel consumption, our complicated functional form will take it into account. But insofar as it is due to a change in the underlying relationship due either to technical progress or changing input costs, then our functional form will not have taken it into account. To prevent this bias we should add interaction terms between

horsepower and our annual dummies. This would allow the marginal price of horsepower to change from year to year. A second best alternative would be to include a single interaction term between a time trend and horsepower. This would allow for the possibility that the marginal price of horsepower had changed uniformly over time.

The objection to these procedures is computational complexity. One of the principal aims of the estimation procedure was to obtain quality-adjusted prices for individual models that are comparable from one year to the next. As it was, a correction had to be made to the residuals to allow for the fact that the annual dummies had been used. If interaction terms between horsepower and the dummies had been used, the meaning of the residuals from the regression would have become obscure and "corrected" residuals even more obscure.

Previous work had suggested that no great distortion would be introduced by assuming that the relationship had not altered over time. In Cowling and Cubbin, {1972} two different quality-adjusted price indexes were calculated. One used characteristics prices which were estimated separately for each year. The other assumed constant marginal characteristics prices and used the median of the estimated coefficients in deriving the index. The two gave very similar results.

Thus it was decided to accept the bias and be consoled by the probable efficiency of the estimates. The residuals were after all the important things, since it was from them that we could derive quality-adjusted prices. Much had been done by way of using a complicated functional form to make sure that the residuals were comparable across different models

and over time. Furthermore, before being analysed the quality-adjusted prices were to be tested to see if there was a significant negative correlation with market share. This is a fair but quite powerful test of the relevance of derived quality-adjusted prices- one which not many have passed, particularly at this level of disaggregation.

The results

The specification of the equation described above was not based purely on a priori considerations. A certain amount of experimentation went on before the final functional form was settled on. For example, quadratic forms were tested but it was eventually decided that they did not give enough flexibility. Estimates were calculated for each segment of small, medium, and large cars separately. This gave a feeling for the sort of relationship to be expected when the segments were pooled, but standard errors tended to be higher than for the pooled data. Finally a few different specifications were tried and this one chosen as corresponding most closely to prior expectations. This stage was completed and the choice made before any further work was done using the derived residuals.

As a consequence of this procedure, the "t-statistics" cannot be employed to test the coefficients for significance in the usual sense. Such a test would be biased towards significance. This does not matter very much since the derivation of the price-quality relation was an intermediate stage. I was not testing, for example, the theory that price is a function of horsepower, but rather assuming it, and using that assumption

to test for the existence of theoretically more important relationships determining the behaviour of quality adjusted prices.

Furthermore, once the price-quality relation was chosen there was to be no turning back to re-estimate it if subsequent results were not as expected (as to some extent they were not). It may be that the use of a different price-quality equation would lead to different conclusions about the nature of quality competition. But I started the second stage of my statistical analysis with what I believed was the most accurate price-quality relation it was possible to estimate.

Weighted least squares was used as the estimation technique. Each model was assigned to a segment of the market (large, medium or small models) and each observation was weighted according to the model's share of its segment in that year. No sales data were available for 1956 so segment shares were based on sales in 1957 for this year.

The results are shown in Table III. The first equation, which omits the annual dummy variables is shown for comparison.

Most of the individual coefficients have "significant" t-values. Only the elbow-room variable is unambiguously of the wrong sign. When the interaction variable $BHP \times GPM$ is ignored gallons per mile appears to have the wrong sign. More detailed examination is required before pronouncing judgement on the cubic and quadratic terms in the equation. This can be done by the use of graphs, as in Figures 4 - 7.

TABLE III Price-Quality Relationship for U.K. Motor Cars, 1956-68

Price Dependent Variable				
Variable	Coefficient	t-value	Coefficient	t-value
Constant	-5.4026	-2.40	-4.291	-1.91
BHP	22.26	5.48	20.0	5.04
Length (L)	111.9	2.50	89.8	2.01
Gallons per mile (GPM)	3,905	1.40	5,025	1.79
4 forward gears (inc. O/D)	28.78	3.51	35.2	4.19
Luxurious trim	963.5	3.59	912	3.44
Log (front elbow room - 40)"	-64.51	-1.78	-73.9	-2.07
Log (rear leg room - 30)"	2.29	0.09	9.79	3.71
Disc and/or power brakes, 0, 2 or 3	12.30	3.18	13.3	3.04
BHP ²	-0.168	-2.90	-0.153	-2.66
BHP ³	0.00058	2.28	0.00053	2.08
L ²	-0.795	-2.66	-0.651	-2.18
L ³	0.0019	2.87	0.0016	2.39
BHP × LUX	4.694	3.37	4.47	3.24
BHP × GPM	-109.1	-3.00	-106.8	-2.96
L × LUX	-7.271	-4.31	-6.86	-4.11
1957			27.89	1.91
1958			29.01	1.98
1959			23.96	1.62
1960			16.39	1.11
1961			8.06	0.54
1962			-4.82	-0.31
1963			-7.31	-0.46
1964			-0.38	-0.02
1965			4.15	0.25
1965			3.61	0.22
1966			30.88	1.86
1967			36.84	2.21-
1968				
$\frac{R^2}{R^2}$	0.896		0.905	
$\frac{F}{F}$	0.891		0.895	
freedom	159.4		93.3	
Designation of residual	(15,276)		(27,264)	

Figure 5 Effect of horsepower on price
(non-luxurious cars.)

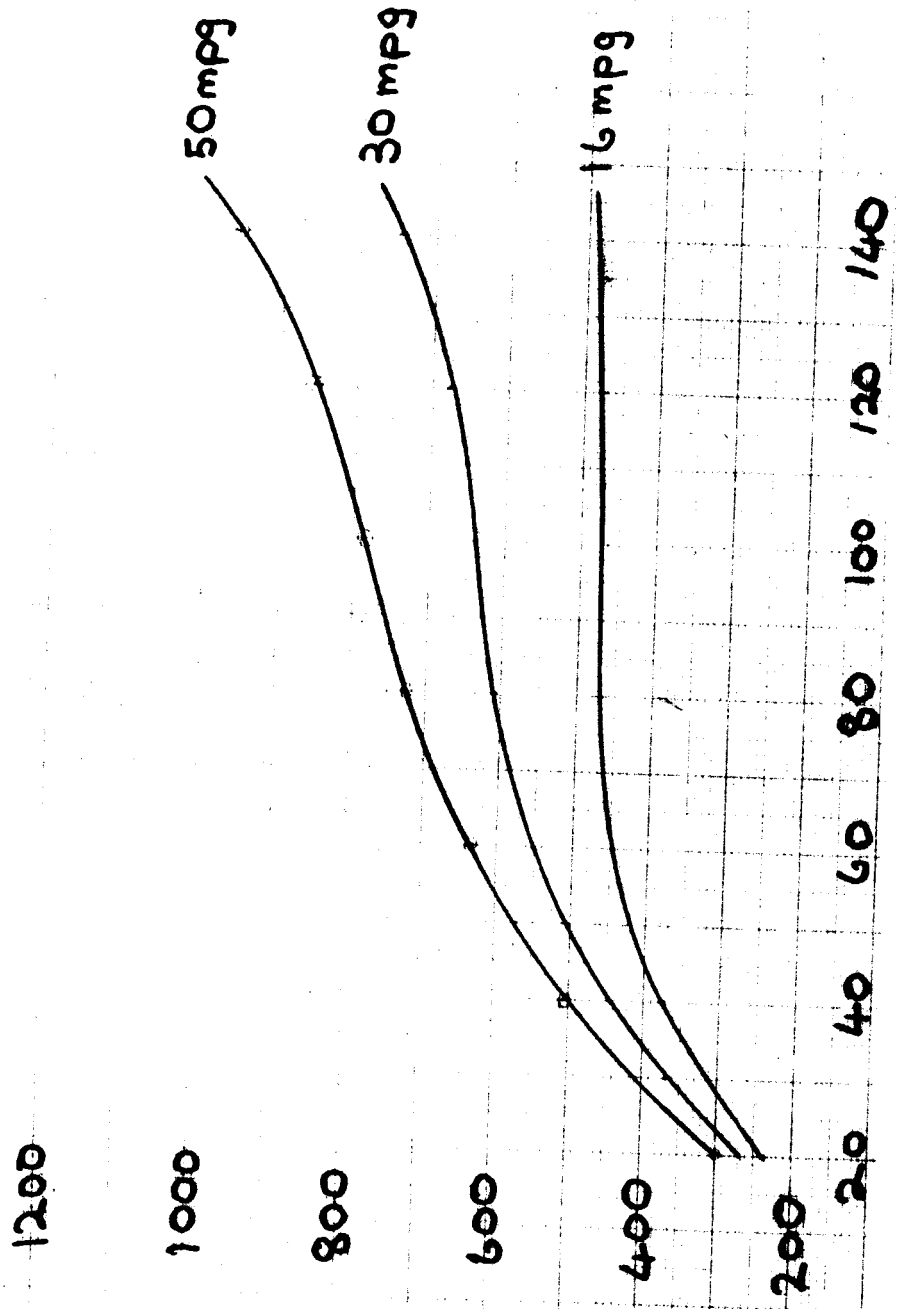
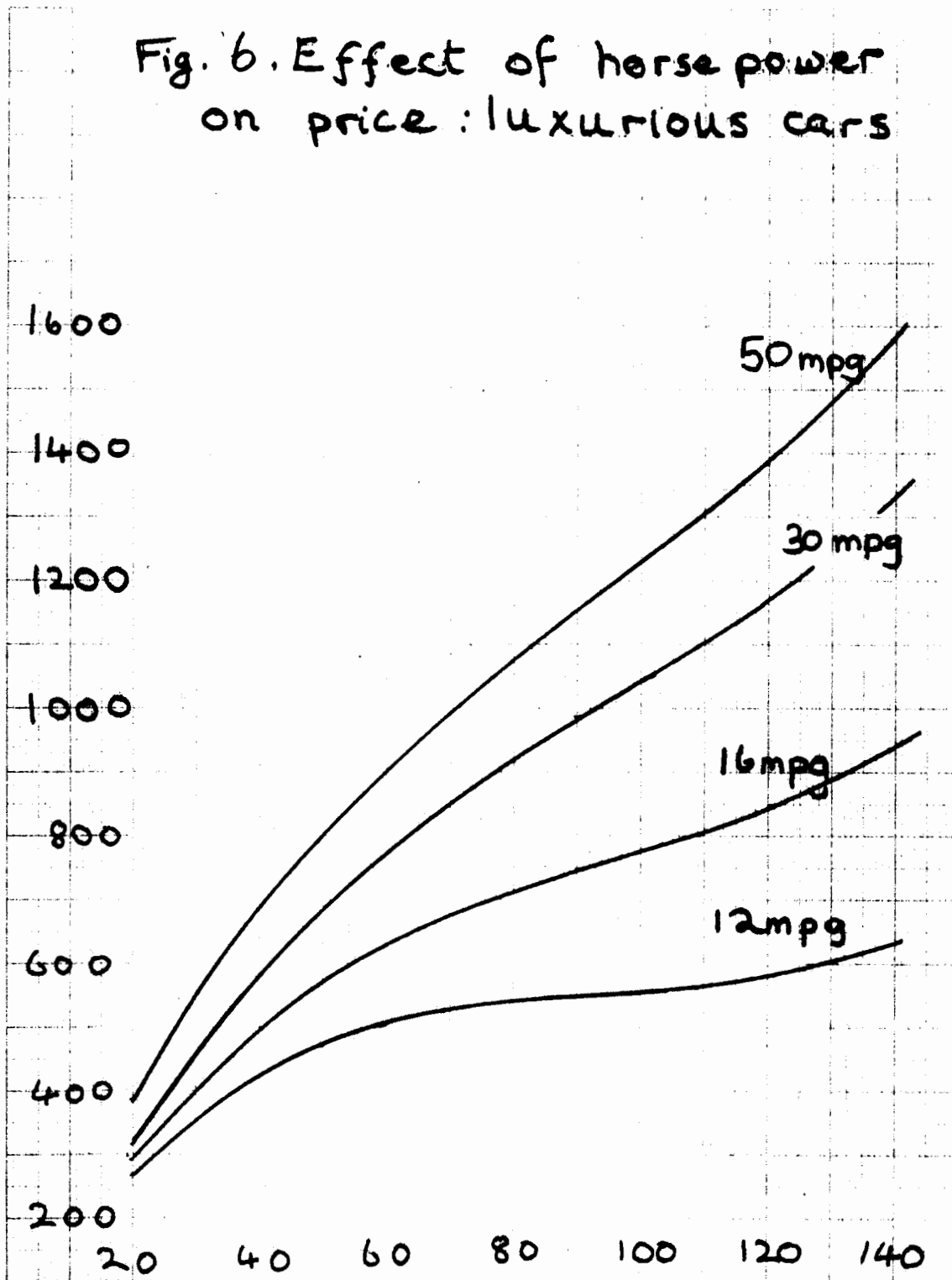


Fig. 6. Effect of horse power on price: luxurious cars



For example, Figure 5 shows the partial relation between price and horsepower for non-luxurious cars having different fuel consumption ratings. It can be seen that the marginal value of power declines up to the point where fairly high values are reached. (The turning point is approximately 96 b.h.p. but the change is not really discernible on the graph until 120 b.h.p.)

It appears that as fuel consumption increases the marginal price of power falls - this possibly reflects the ease with which power can be increased when fuel economy is not a consideration. In addition, very high levels of fuel consumption are likely to be observed only on the most powerful cars - where power itself is a less important consideration.

The partial relation between price and power will be different again for cars in the luxurious category. This is shown in Figure 6. The curve for any level of fuel consumption is steeper in 6 than in 5. This reflects the fact that if we take the derivative of price with respect to power the term $4.47 \text{ BHP} \times \text{LUX}$ in the price-quality relation will ensure that it will always be greater by 4.47 for models for which our value for "luxury" is 1.

In contrast to its effect on the price of horsepower, luxury has a negative effect on the price of length. Possibly this reflects demand considerations; luxury and power might be complements, but luxury and length substitutes. This sort of speculation is not likely to be fruitful though. Both cost and demand forces are at work, often pulling in different directions, and it is probably just as easy to justify the opposite signs

of some of the coefficients in the interaction terms.

For instance, it would have been no surprise to observe a negative sign for the coefficient on GPM coupled with a positive sign for the coefficient on BHP \times GPM. This would indicate that high fuel consumption had a negative price at zero horsepower which increased as horsepower increased (and which would eventually become positive). This would be based on the (demand) consideration that fuel economy was more likely to be of importance to a man who only bought a low-powered car, this possibly reflecting his low income level. However, we observe a positive coefficient on GPM and a negative one for the interaction term. This means that at very low levels of power, fuel economy has actually a negative price which increases as power increases. Above 47 hp the marginal price of fuel economy is actually positive, (i.e., the price of fuel consumption is negative). This can be claimed to represent cost considerations, in that the more powerful a car is the more expensive it is to improve fuel economy. Table IV shows the price estimated from Table III of an improvement in fuel consumption from 20 to 25 mpg, and from 35 - 40 mpg.

TABLE IV Estimated price of fuel consumption improvements £s.

BHP	(i) 35-40 mpg	(ii) 20-25 mpg.
40	-3.3	-9.3
60	4.3	12.0
80	11.9	33.4
100	19.6	54.8

Figures 7 and 8 show that for non-luxurious cars the price of length is consistently positive in the relevant range; whilst for cars with luxurious interiors length has a negative price for cars up to 170 inches, but positive above this length. 170 inches was a fairly average length for cars in the large size category. So it appears that length had a negative price up to the point where the car became long compared to most other cars on the road. This seems justifiable from the utility point of view, in that length per se is not desirable until it is sufficiently exaggerated to be impressive. I feel that too much should not be read into these curves however. In themselves they are not important.

The annual dummy variables had only two coefficients significant at the 5% level. Because the weights used in the regression are wrong for this purpose, they cannot be used as the basis of a quality-adjusted price index although they follow the same general pattern as previously - calculated indexes, (Cowling and Cubbin, {1972}).

Testing the price-quality relationship

The price-quality relationship shows us the amount that on average we would expect to pay for a car of given specifications in a particular year. The actual price paid for such a car will usually be different from this expected price. The difference between these two prices, which is the residual V_{it} from the regression, is a measure of the value for money of the car in question. A positive residual indicates that the actual price is higher than the expected price and a negative residual that the actual price is less than one would on

Fig. 7. Effect of length on price:
non-luxurious cars.

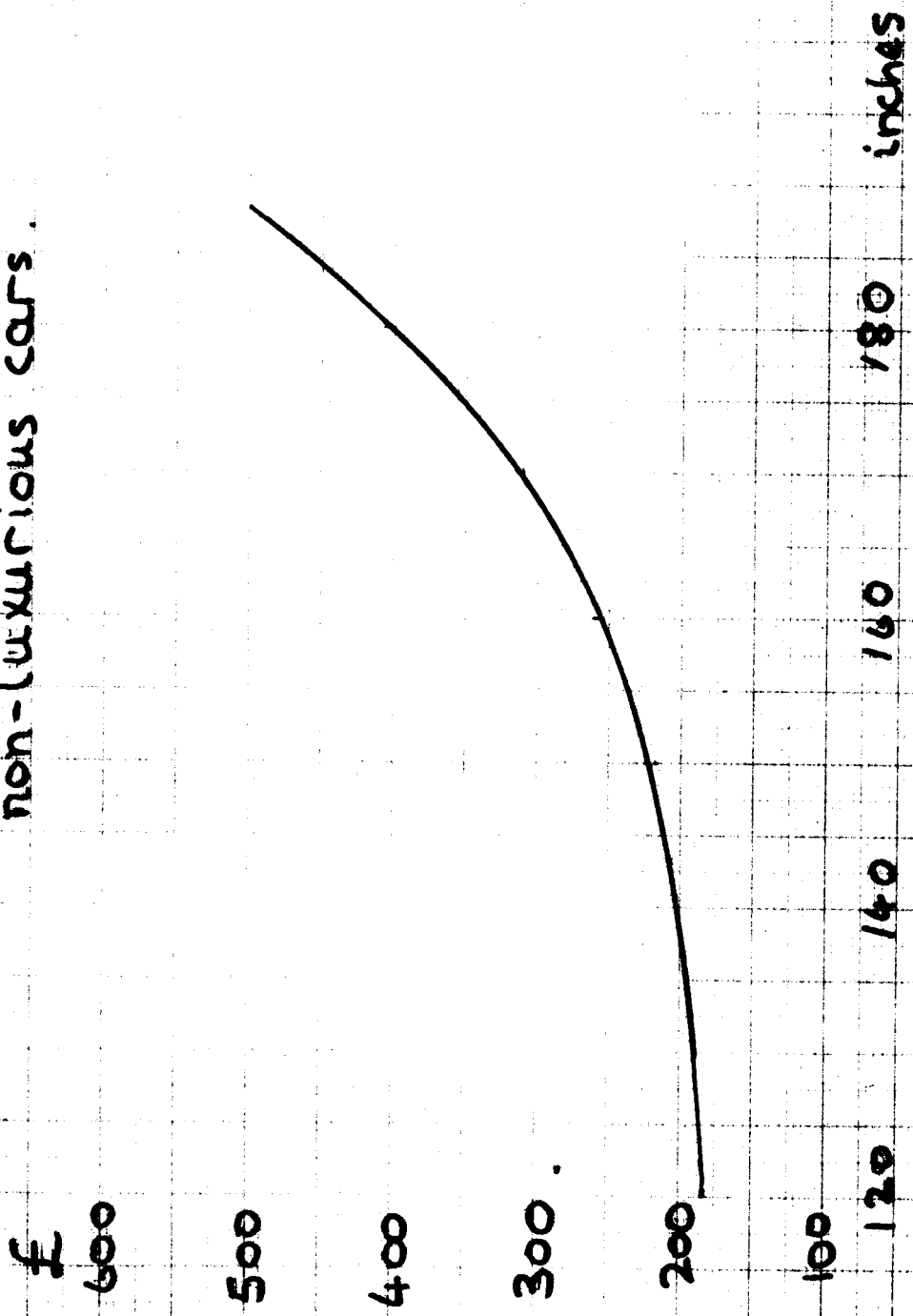
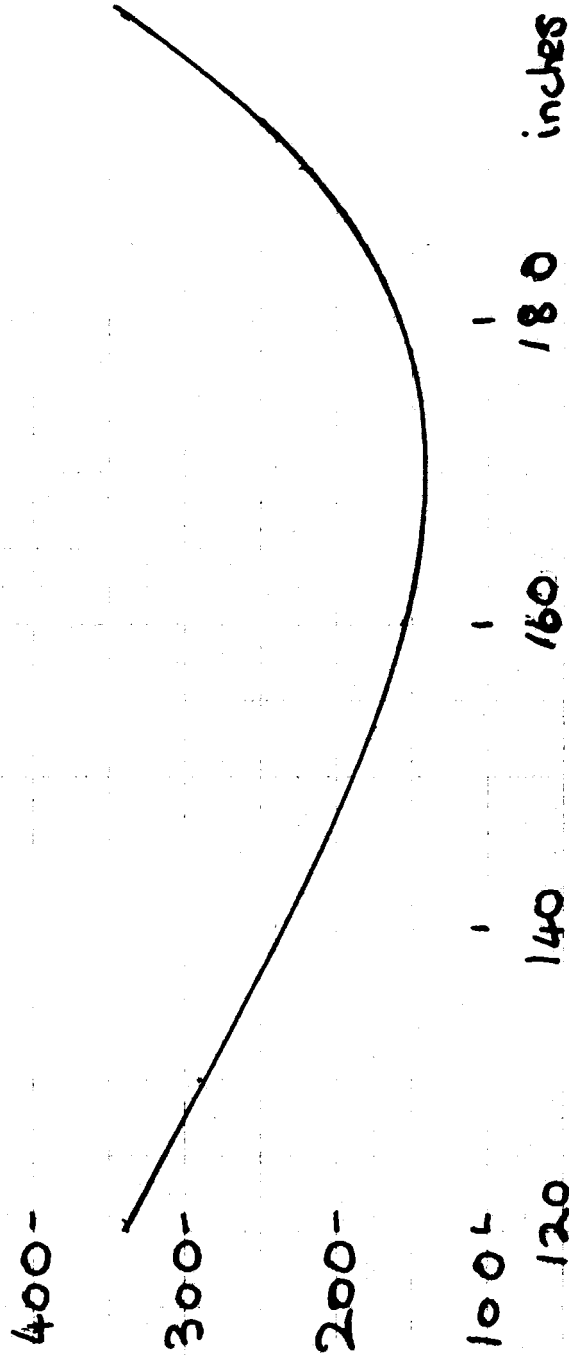


Fig. 8. Effect of length on price:

£ Luxurious cars.



average expect to pay for such a car. For want of a better name, this residual is termed the "quality-adjusted price" for the model in question in that year relative to other models in that year.

The demand for a brand of car is a function of many variables. These variables include characteristics included in the price-quality relation and some, such as a reputation for reliability and number of close competitors, which it was not possible to include. Other things being equal, however, we should expect that our estimated quality-adjusted price, or residual, insofar as it is a measure of value-for-money, should be negatively correlated with model sales. If this were not the case some doubt must be cast on both the price-quality relation itself and the derived quality-adjusted prices.

The coefficient of correlation between V_{it} and model sales is -0.3156 and between V_{it} and \log_e (model sales) is -0.3668 , both of which are significant at the 1% level. Table V shows the regression results obtained when we investigate this relationship. These are based on 246 observations over the period 1957-68 and encompass approximately 40-45 different models. (Some new models were essentially modifications or replacements of existing models but the name was changed, thus making the demarcation between "new model" and "model change" rather arbitrary).

The existence of significant coefficients on V_{it} even in the presence of lagged sales represents a vindication of the process by which this variable has been derived.

Ramsey {1972} indicates that the limiting functional form for a market with consumers behaving according to well-behaved, but not unduly restrictive probability distributions is exponential with an additive disturbance term

$$Q_{it} = Ae^{BV_{it}} + U_{it} \quad (2)$$

Unfortunately to estimate this functional form requires a maximum likelihood program not available at Warwick at the time this research was completed. However, the nearest approximation to this is the semi-log functional form (equations 3 and 4 of Table V.).

The estimates of price elasticities (for a car of mean price) are very similar to the equivalent estimates for aggregate market share elasticities based on OLS presented in Cowling and Cubbin, {1971a} which were -4.6 for the instantaneous adjustment model (equation 3 of Table V) as opposed to -4.7 here and -7.06 for the lagged adjustment model as opposed to -7.07 here. The short-run elasticities were -1.95 against -2.01 here.

These similarities seem remarkable, especially in view of the differences in specification. In the earlier article, market shares across all models were the dependent variable and this was expressed as a function of the average of individual models' quality adjusted prices. These quality-adjusted prices were based on a different price-quality relation. At this level of aggregation advertising data were available and it was possible to include the effect of advertising in the model. It was not possible to do this in the present instance.

TABLE V. The relation between sales of individual models and their estimated quality-adjusted prices

Dependent Variable	Constant	Quality-adjusted price V_t	Lagged Dependent Variable	F	R^2	\bar{R}^2	Implied elasticities at unweighted and weighted means respectively	
							Shortrun	Longrun
Model sales (Jan.-Dec.)	34,704 (16.97)	-187 (-5.20)		27.0	0.010	0.092	4.014 3.411	
Model sales	5631 (3.81)	-41.95 (-2.24)	0.886 (27.15)	422.7	0.776	0.774	0.900 0.765	7.895 6.712
Log_e (Model sales)	9.859 (117.47)	-0.009094 (-6.16)		37.9	0.135	0.127	5.565 4.729	
Log_e (Model Sales)	2.85 (6.78)	-0.003860 (-3.66)	0.716 (16.80)	181.8	0.599	0.594	2.362 2.007	8.318 7.067

Notes:

Number of observations = 246

Approximately 45 distinct models

V_t refers to prices generally set in previous October

Figures in brackets are t-statistics

Table VI shows the effect of including another explanatory variable, the level of quality, the omission of which was mentioned as a possible source of specification bias in Chapter 4. Here quality level is defined as the weighted sum of the characteristics the weights being derived from the equation 2 of Table III, p.98. The negative sign on the coefficient for this variable is expected since the cheaper end of the market, with fewer quality characteristics, is more popular than the upper end of the price range. Comparison of Tables V and VI shows that the estimated price elasticities are not much altered by this change in specification.

Dependent Variable	Constant	V_t	Lagged Dependent Variable	Level of Quality	F	R^2	\bar{R}^2	Implied elasticities at unweighted and weighted means respectively.	
								Short-Run	Long-Run
1) Model Sales	102,727 (13.83)	-181.07 (-5.87)		-114.51 (-9.43)	62.77	0.341	0.332	3.887 3.303	
2) Model Sales	20,473 (3.63)	149.36 (-2.64)	0.834 (22.24)	-22.10 (-2.72)	292	0.783	0.780	1.060 0.900	6.392 5.430
3) Log_e (Model Sales)	27.95 (14.91)	-0.00872 (-6.93)		-2.85 (-9.66)	72.8	0.475	0.367	5.336 4.534	
4) Log_e (Model Sales)	9.96 (4.84)	-0.00443 (-4.25)	0.620 (12.46)	-0.971 (-3.53)	131	0.619	0.613	2.714 2.305	7.146 6.071

CHAPTER 6The Price-Cost Margin

The relation between price and marginal cost is an important aspect of oligopoly behaviour. Especially important is the ratio (price-marginal cost/price). When oligopolists manage to maintain the price at the joint monopoly price

$$\frac{P - MC}{P} = \frac{1}{\eta_p^I} \quad (3)$$

where p = price

MC = marginal cost

and η_p^I = price elasticity of demand facing the industry

The less "tight" the oligopoly the lower will be the price-cost margin until at the point where the oligopolists are acting without taking any advantage of their interdependence, the right-hand side of the above expression becomes $-\frac{1}{\eta_p^f}$ in the case of differentiated products or

$-\frac{H}{\eta_p^I}$ in the case of a homogenous industry product, where η_p^f = price

elasticity of demand as faced by the individual firm and H is the Herfindahl measure of concentration. (See the appendix to Chapter 2 for the differentiated case and Cowling and Waterson, {1974} for the undifferentiated products case.)

By estimating the price-cost margin therefore, we can gain an idea of how "tight" the oligopoly is. Lerner, {1943} has suggested that

the price-cost margin can be used as an index of monopoly power. In the appendix to Chapter 2 I have suggested an index based on the price-cost margin, called the "measure of apparent collusion", which measures where in the continuum between monopoly price and the Cournot price the actual price lies.

The term $\frac{P - MC}{P}$ has in the past been approximated by the ratio of profits to total revenue, (e.g., Collins and Preston, {1969}). This implicitly assumes that marginal cost = average total cost and thus makes no allowance for the possible existence of fixed costs. The approach used here is different. It makes use of the fact that $P - MC$ is the extra profit generated by an exogeneous shift in demand. The basic idea is to regress industry profits on sales expressed in terms of the number of vehicles :-

$$\Pi = a + bN + u \quad (4)$$

where Π = industry profits

N = number of vehicles sold

b is then an estimate of the price-cost margin and $-a$ can be interpreted as the level of fixed costs.

To obtain a good measure of b , however, the other factors which affect Π must be taken into account. First, the price-cost margin may change from year to year as a result of changes in the price and in the costs of production. The latter may change as a result of changes in quality requiring a more inputs of raw materials and labour; or as a result of increases in the prices of inputs.

Furthermore, profits of large car manufacturers derive from other sources, too - principally commercial vehicles. The specification would presumably be improved by taking some account of these.

Accordingly, the following equation was estimated :-

$$\Pi = \alpha + \beta PN + \gamma I_Q CN + \delta V + \epsilon \quad (5)$$

where P is a crude price index showing average price paid, 1956 = 100.

I_Q is various indexes of average quality bought, 1956 = 1.0.

N is the total number of cars and light vans bought in each year.

V is the number of commercial vehicles other than light vans.

C is an index of wages and materials costs, 1956 = 100.

We should expect $\hat{\beta}$ to be positive and $\hat{\gamma}$ to be negative.

The price-cost margin, $\frac{\partial \Pi}{\partial N}$, is then $\beta P + \gamma I_Q C$ which we would normally expect to be positive.

Alternative quality indexes were derived by deflating a crude, or average price index by different quality-adjusted price indexes. (See Cowling and Cubbin, {1972}). A cost index was derived from Census of Production data to obtain weights and input prices supplied by the Board of Trade (as was), see Cowling and Cubbin, {1971b}. N was aggregate sales both home and export markets. Profits data (pre-tax) were obtained from the published accounts of B.M.C., Ford, Rootes (Chrysler U.K.) and Vauxhall. (Standard-Triumph accounts proved difficult to trace. The pieces of evidence available suggest that this firm's profits and losses were one or two per cent of the industry totals.) The financial year from which they were taken

does not necessarily correspond to the year January to December on which the sales and cost data is based.

The results of the regressions are shown in Table VII. It is apparent that the use of hedonic measures to allow for quality change considerably enhances the fit of the regression, the favoured method being the "Champernowne" one of using the median value of the estimated coefficients on characteristics (see Cowling and Cubbin, {1972 }, p. 976). The use of the pseudo-index derived from the equation in Table III to allow for quality change is a great improvement on no allowance at all but does not perform as well as a genuine price index. (The year dummies from Table III do not yield a "real" quality-adjusted price index and hence a quality index because the market segments represented by large, medium and small cars are given equal weights.) Incidentally, the superiority of the Champernowne (constant characteristics coefficients) index over the Chain Laspeyres index form once more justifies our pooling the years 1956-1968 in the price-quality relationships of Table III. As expected $\hat{\beta}$ is positive and $\hat{\gamma}$ negative, and both are significant. The coefficient on sales of commercial vehicles is of the wrong sign, and not significant. This is a puzzle. However, the constant term is negative as expected, but not always significant.

By taking the values of P , I_Q and C for each year the difference between price and marginal cost $\beta P + \gamma I_Q C$ can be estimated and the results of doing such an exercise are shown in Table VIII. Manufacturer's selling price was estimated by discounting the weighted mean list price by 18% (see Rhys, {1972}, p. 339). Marginal cost was then found by subtracting the estimated price-cost margin from the resultant figure.

TABLE VII Estimation of Profit Function Using Different Adjustments for Quality Change

Explanatory Variables	Type of Quality Index Used			
	(1) None	(2) Median Character- istics Prices	(3) Laspeyres Chain Hedonic	(4) Pooled years regress- ions: Equal segment weights
Constant	-3.83×10^7 (-1.03)	-5.67×10^7 (-2.23)	-5.21×10^7 (-1.87)	-5.37×10^7 (-1.76)
PN	1.72 (2.92)	1.87 (5.37)	1.63 (4.69)	1.68 (4.21)
I_Q^{CN}	-1.04×10^{-2} (2.91)	-8.47×10^{-3} (-5.39)	-7.08×10^{-3} (-4.72)	-7.65×10^{-3} (-4.23)
V	57.7 (0.30)	-26.1 (-0.20)	-19.7 (-0.14)	19.5 (0.13)
R^2	0.554	0.801	0.757	0.716
\bar{R}^2	0.330	0.702	0.636	0.574
F (2,8)	3.30	10.76	8.31	6.73
Durbin-Watson Statistic	2.30	2.19	2.33	2.25

N.B. (1) Dependent variable = Pretax profits of B.M.C., Ford, Rootes and Vauxhall (£).

(2) Figures in brackets refer to 't' statistics.

(3) For details of quality indexes used in columns (2) and (3) see Cowling and Cubbin, {1972}.

TABLE VIII Estimates of price-cost margins for "average car" 1956-68

Year (Oct-Oct)	Estimated Values of		
	(1) Price-cost margin %	(2) $\frac{P-MC}{P}$ %	(3) Implied elasticity $\hat{\eta}$
1956-57	102.3	27.7	3.6
1957-58	114.0	28.7	3.5
1958-59	124.4	28.0	3.6
1959-60	116.4	27.0	3.7
1960-61	99.8	23.7	4.3
1961-62	110.0	25.8	3.9
1962-63	100.7	23.4	4.3
1963-64	97.9	22.1	4.5
1964-65	89.1	20.5	4.9
1965-66	94.0	20.3	4.9
1966-67	92.7	19.7	5.1
1967-68	102.3	21.0	4.8
1968-69	100.9	19.0	5.3

It is apparent that over the period percentage mark-up over marginal cost declined from around 28% to approximately 20%, the break starting round about 1960. The "implied elasticity" in column (3) which is the reciprocal of column (2) shows the implied elasticity of demand facing the firm if we could regard the firm as behaving like a profit-maximising monopolist. At one extreme, this implied elasticity would be equal to the industry elasticity of demand. This would imply fully collusive joint profit-maximising behaviour on the part of all firms. At the other extreme, we might observe a value close to the long-run elasticity of demand facing the individual firm. This would imply a fairly long time horizon and the Bertrand-Edgeworth or Chamberlin's "large numbers" type assumption by each firm that the other firms' pricing policies were independent of its own. Now the industry elasticity is probably well below 2, so we can dispense with the first possibility, and the long-run elasticity facing the firm is somewhere in the region between approximately 6.5 and 8, (see Table V) so the other extreme case does not apply either. Thus the price-cost margin does confine itself to what might be termed the oligopolistic region.

CHAPTER 7Pricing Behaviour

Any price-cost margin observed can be considered either representative of a long-run, equilibrium, situation or transitory - as the step in the move from one equilibrium to another.

In this chapter we shall examine the price-cost margins introduced in Chapter 6 from both points of view; first as a static equilibrium phenomenon and then as a possible reflection of the dynamics of oligopoly behaviour.

1. The Static Approach

In this section the trend of the data series shown in column (2) of Table VIII will be ignored. These changes in the price-cost margin will be treated as part of a cyclical deviation about an average value which represents "the" equilibrium price-cost margin for this industry. The average price-cost margin works out at 23.6% and this figure will be used for the calculations in this section.

This is in the region which the theoretical considerations of Chapter 2 would lead us to expect. The minimum equilibrium price-cost margin would be $-\frac{1}{\eta^f} \times 100\%$, where η^f is the long-run elasticity of demand. This would occur only if the firms in the industry either ignored or failed to take any advantage of their oligopolistic interdependence. The two estimates of η^f that are available are -7.07 (Chapter 5 above, p. 109) and -7.06 (Cowling and Cubbin, {1971a}).

These suggest a minimum mark-up of 14.2%, lower than any observed here.

The margin is also less than the joint monopoly margin, given by

$-\frac{1}{\eta^I} \times 100\%$ where η^I is the industry elasticity of demand at the monopoly price. No estimates of the latter are available since price does not typically fall in this region. The estimates that are available for the industry elasticity of demand, (Chow, {1957}, Roos and Von Szeliski, {1939}, Suits {1956}, Wykoff, {1973}) fall into two ranges, $|0.4| - |0.6|$ or $|1.5| - |1.7|$. These are all based on American data and cover different periods of time. To take the latest example, Wykoff finds that when the explanatory variable used is purchase price, the elasticity is in the higher range, but when the total monthly running costs are used the elasticity is in the lower range. The seller is interested in the elasticity of demand with respect to purchase price and not with respect to total cost. Since purchase price is only a part of the total cost, we should expect the price elasticity to be even smaller than the "cost elasticity". Wykoff argues that the use of price as the explanatory variable is a misspecification since the rational consumer takes all costs into account.

If Wykoff's arguments are accepted it would appear that those studies which used price as the explanatory variable without taking account of the other components of what Jorgenson calls "user cost" may be subject to serious biases. This includes all the studies which calculate the price elasticity of demand as being in the $|1.5| - |1.7|$ region. Thus it would appear that price elasticity at prices which have prevailed in the past is in the region of -0.5 .

However, it is a very well-known theorem in economics that a profit-maximising monopolist produces in the elastic portion of his

demand curve; so the figure of -0.5 is no use in predicting the price which would rule in monopoly. We can only say that the ruling price must be fairly well below the profit-maximising monopoly price.

(If we accept the figure of -1.6 for the elasticity and assume it is constant, this would lead us to expect a monopolistic mark-up of 62.5% , well above anything observed.)

The other upper bound which has been suggested for oligopoly price is the entry-limiting price - i.e. that price which will just forestall entry, (Modigliani, {1958}.) This is not a wholly persuasive theory in its most uncompromising form, but it is highly suggestive. Stigler, ({1968} p. 21) argues that it may not be profitable to exclude all potential entrants, and Needham, ({1969}Ch. 7) suggests that firms can charge more than the limit price if they can successfully threaten potential entrants with ruinous competition. In Chapter 3, p.64 , it was argued that on the assumption of equal costs abroad, the limiting price-cost margin was given by the level of import duty. Table III,(p. 100), shows that the import duty was 30% from 1956-62 when it fell to 25.2% until 1968, after which it fell still further. These figures are quite consistent with a loose version of the limit price hypothesis which sees it as an upper limit on oligopoly price. This is only an isolated piece of evidence, however, and is not very persuasive on its own.

The appendix to Chapter 2 suggests a measure of the behaviour of oligopolists, called the "measure of apparent collusion", which takes on the value 1 for oligopolies which attain the joint monopoly price and 0 for those which fail to take any advantage of their interdependence.

$$\alpha = \frac{\eta_i^f + p_i / (p_i - dC_i / dq_i)}{\eta_i^f - \eta^I}$$

where α = measure of apparent collusion

$|\eta^f|$ = absolute value of firm price elasticity

$|\eta^I|$ = absolute value of industry price elasticity

$p / (p - MC)$ = reciprocal of the price-cost margin.

This was calculated assuming that $|\eta^f|$ is 7.1 and $|\eta^I| = 0.5$, which gave a value for α of 0.434. When the alternative hypothesis was adopted, that $|\eta^I| = 1.6$, the calculated value of α changed to 0.521. Both of these estimates can be regarded as being in the middle of the range. α does not appear to be too sensitive to the assumed value for η^I . Unfortunately since this is the first industry for which α has been calculated, it is not possible to compare it with any results for other industries. The theory of Chapter 2 does not produce a precise prediction for α , but taking into account the level of barriers to entry the fewness of firms and the possibility of quality competition "the middle of the range" is about where one might expect the motor industry to lie.

A measure similar in spirit to α may be derived for advertising rivalry, (see p.31). It is given by the formula

$$\beta = \frac{\mu_i^f - (A_i / p_i q_i) (p_i / (p_i - dC_i / dq_i))}{\mu_i^f - \mu^I}$$

where μ_i^f = elasticity of demand with respect to advertising facing the individual firm.

μ^I = elasticity of demand with respect to advertising facing the industry.

$A_i/p_i q_i$ = the ratio of advertising expenditure to sales revenue.
 $(p_i/(p_i - dC/dq_i))$ = the reciprocal of the price-cost margin.

$\beta = 1$ implies that firms manage to restrain advertising to the joint monopoly level and $\beta = 0$ implies that firms act as if they ignored the interdependence of their advertising activity. Cowling and Cubbin ({1971a} p. 392) estimate that $\mu_i^f = 0.3087$ in the short-run and, under certain assumptions, 0.914 in the long-run. Making the most extreme assumptions, that $\mu^I = 0$ and $\mu_i^f = 0.3087$ we obtain a value for β of 0.896. If μ^I is assumed positive the calculated value of β is increased. $\beta = 1$ when $\mu^I = 0.032213$. If we assume that the long-run advertising elasticity is 0.914 the value of β becomes 0.965 for an assumed value of $\mu^I = 0$. The level of apparent collusion over advertising expenditure is therefore, on the basis of these calculations, very high, and substantially higher than apparent collusion over the price-cost margin. Consideration of the relative size of the retaliation lags for advertising and quality competition would lead us to expect a result of this nature, although not perhaps such an extreme degree.

2. The dynamic approach

This section is concerned with the processes underlying the evolution of a particular price-cost margin. The starting point is movements in the margin, which are strongly dominated by an apparent trend, (which may, of course, be part of a longer cycle). The marked tendency for the price-cost margin to fall is a significant finding. It may be confirmed by comparing the profits and sales figures in 1956 and 1966 in which very similar trading profits were earned (£30m.). In

1956 this was achieved on sales of 708,000 cars, whereas in 1966 it took 1,606,000 sales of cars to achieve the same profits figures.

There can be no unique answer as to why the margin fell. Penetration by foreign firms did not really become significant until about 1968 so it is unlikely to be retaliation against foreign firms. However, one interpretation might be that this is an entry-forestalling price. The tariff on imported cars fell from 30% to 25.2% in 1962, but the fall in the margin starts in 1960. The idea that car manufacturers deliberately and in anticipation of a tariff cut set a price that would prevent entry by imports implies a higher level of sophistication and co-ordination amongst them than has previously been supposed.

An alternative explanation might go in terms of the change from a sellers' to a buyers' market. Until 1956 there was a general shortage of cars, so much so that for some classes of car, secondhand price was higher than new price. It was not really until 1960 that industry capacity was able to cope with normal demand. Until that time new cars were rationed by queuing. On July 26th, 1960, The Times newspaper quietly heralded in a new era without realising it when it announced that dealers were having difficulty in selling new cars, "in fact waiting lists have shrunk if not entirely disappeared for many cars". (Waiting lists did reappear again in the 1963-4 pre-election boom.) By October the mean percentage mark-up over marginal costs had fallen five points, and although there was a slight rally the following year it did not reach the previous level again within the period.

When we come to analysing how the change took place, we are on

surer statistical ground. To a certain extent it is possible to allow price-cost margins to fall by failing to compensate fully for cost increases. This undoubtedly did take place to some extent. Yet if we look at graphs of quality-adjusted price series they show a considerable fall from 1961-4. If a purely passive policy of not compensating for cost increases had been followed then we should expect quality-adjusted price to remain the same. The evidence, then, points to the existence of active price-quality competition in the period (particularly 1960-67) and it is to investigating the manner of this competition that we now turn.

3. Price Flexibility and Quality Change

In Chapter 2 it was claimed that retaliation lags ought to be an important determinant of the tendency towards collusive or competitive behaviour, and that retaliation lags will be different for each policy variable (price, quality, advertising, etc.). The argument has been developed at length in Nicholson, ({1972}), especially Chapter 6). Brems, {1958} produced a model drawing attention to retaliation lags as an explanation for quality competition in cars.

The argument starts from the consideration that price reductions can be followed very quickly; but quality changes take some time (see Chapter 3, p. 14). Therefore the gains from price-cutting may only last a short time since rivals are likely to respond to price cuts by almost immediate retaliation if they feel threatened by the first firm's cut. However, rivals cannot respond immediately to a threat created by a quality improvement by doing likewise because modifying the design of the product takes, at least in the case of motor cars, quite a long time. Where a new model has to be produced the lead time may be several years, and even minor changes

will take several months. Consequently the potential gains from improving quality may last a significant length of time. Conversely, the losses from not indulging in quality competition when the other oligopolists are doing so could be considerable.

When firms wish to increase price, however, they will wish rivals to follow as quickly as possible. Indeed, they often announce price increases well in advance. Therefore we should expect firms increasing their quality-adjusted price to use price which can be followed quickly rather than quality which cannot, as their instrument. (The exception occurs where the firm wishes to disguise a price increase from its customers. They are less likely to be able to get away with this in the case of the motor car than, say, for chocolate bars.)

Maxcy and Silberston, {1959} have also drawn attention to the phenomenon of "model-price competition" as they call it. They emphasise its importance in the history of the industry and suggest that it was responsible for the elimination of many firms in the 1930's. (p.). It is described as a substitute for price competition but no reason is suggested as to why it should supplant price competition. All the emphasis is put on the introduction of new models. Without the hedonic technique being available to them they were rather limited in their formal analysis of the phenomenon.

However, as a result of the estimation of price-quality relation described in Chapter 5, we were able to analyse all changes in quality-adjusted prices of extant models from 1956-68. Out of 147 changes in W_1 46 were decreases and 101 were increases. A contingency table (Table IX)

shows the breakdown between those changes which involved changes in quality and those which did not. By no means all of the quality changes occurred on the announcement of a "model change", since some models were slightly revamped from year to year by means, for example, of a moderate horsepower increase or the inclusion of a heater as standard rather than as an optional extra. The table shows quite clearly (and this is verified by a χ^2 test) that decreases in quality-adjusted price are significantly associated more with quality change than are increases in quality-adjusted price. The inference is clear; if a firm wished to decrease its price it was more likely to do so implicitly (involving quality change) rather than explicitly. On the other hand, this does not imply that quality change is invariably or even probably linked to price decreases rather than increases. Of 69 quality changes only 38 involved decreases rather than increases in W . This proportion is not significantly different from $\frac{1}{2}$ at the 5% level. This result is interesting in the light of the finding that new models do not show any significant tendency to have either mainly positive or negative quality-adjusted prices. If one includes the dummy variable "new model" in price-quality regressions the coefficient is sometimes positive, sometimes negative, but rarely significant depending on the exact specification of the equation. The same result applies for the dummy variable "model change". In addition one can examine the sign of V or W for newly-introduced models. Of the 25 new models in the sample V was positive for 15 and W was positive for 16. This sample is not very large and therefore not many conclusions may be confidently drawn from it. However, consider the following calculation: of 147 changes in W for extant models, 101 were increases. Therefore if new models were neutral with respect to whether they encouraged price increases or decreases, we should expect to observe quality-adjusted price to be positive in 101/147

TABLE IX.a. Analysis of Changes in Quality-Adjusted Prices

	Increases in quality-adjusted price	Decreases	Total
Quality changed	31	38	69
Quality not changed	70	8	78
Total	101	46	147

$$\chi^2 = 34.2$$

The null hypothesis, that quality change is randomly distributed between increases and decreases in quality-adjusted price, is rejected at the 1% level of significance.

TABLE IX.b.

	Increases in quality-adjusted price	Decreases	Total
(List) Price increased	94	21	115
Price not changed	7	15	22
Price reduced	0	10	10
Total	101	46	147

= 68.7% of the time. The observed proportion is slightly less than this, but not significantly so. This, whilst not refuting the null hypothesis that new models have no effect on prices, is consistent with our hypothesis of the use of quality change as a substitute for price reductions.

It is interesting that the sort of quality change which appears to be important for this phenomenon is not particularly, as was thought when this study was commenced, the introduction of new models but model changes and the slight year-to-year changes which tended to occur in the British car market in this period. Examples of it are the increase in brake horsepower of the engine, fitting a heater, finding a way to increase leg-room by a few inches, or improvements in fuel economy. Often these changes were not enough to rate the designation of "model change" or "new model", (which usually required some non-trivial modification to the body pressing) and the detection of them retrospectively required careful comparison of one year's specification with the next.

The asymmetry suggested in the opening paragraphs of this section between increases and decreases in quality-adjusted price is evident when list-price changes are examined. Of 101 increases in quality-adjusted price none involved a cut in the list price, seven involved price staying the same and the other ninety-four involved increases in the list price. In contrast, of the 46 decreases in quality-adjusted price, only ten (i.e. 22%) involved a change in list price in the same direction. Fifteen (33%) were associated with no change in list price and twenty-one (46%) with an increase in list price. See Table IXb.

Table X shows the distribution through time of these quality-adjusted price cuts. The average is about 4 per year but 58-59, 61-2 and 62-3 seem noticeably higher and 56-7, 57-8 and 65-66 seem noticeably lower than this. The two years with most quality-adjusted price declines (62-3-4) also happen to be the years in which the quality-adjusted price indexes fall by most, perhaps not surprisingly.

TABLE X . The Distribution of Quality-adjusted Price Cuts

Year (Oct - Oct)	Number Observed	Year (Oct - Oct)	Number Observed
1956-7	1	1962-3	7
1957-8	1	1963-4	4
1958-9	6	1964-5	4
1959-60	3	1965-6	1
1960-61	4	1966-7	4
1961-2	7	1967-8	4

Given these results, it is of some theoretical interest to know how this general decline in profit margins is transmitted from one firm to the other. If one firm reduces its quality-adjusted price it will often pay the others to retaliate by reducing theirs. They may do this either simultaneously with the original price decrease, in direct response to the price decrease or with a lag depending on the length of time it takes the original price decrease to make inroads into their own sales. The same possibilities arise in the case of a quality-adjusted price increase which

other firms decide to follow.

We should not necessarily expect the same behaviour to occur in the case of price increases and decreases. Whereas a firm may wish to disguise its reductions from its competitors, it will generally wish its competitors to be fully informed about increases in the hope that they will do likewise. On this assumption there will be a tendency for price increases to be transmitted directly and immediately, but we should expect a lag in the transmission of reductions.

These considerations lead to the hypothesis that price increases for different firms are related to each other and hence to changes in the current level of quality-adjusted price whether the observed increases represent leads or responses to other firms. On the other hand, for price decreases we should expect little correlation between firms' current behaviour, except insofar as this behaviour represents a response to a common stimulus.

To test this, the data were divided into two sets: one set where the price change was positive, the other set where it was negative. The following equation was estimated :

$$(W_t - W_{t-1}) = \alpha + \beta (D_t - D_{t-1}) + \epsilon_t \quad (6)$$

where W_t = quality-adjusted price,

D_t = coefficient on year dummy price-quality regressions,

$D_t - D_{t-1}$ is an index of the overall change in quality-adjusted prices.

Table XI shows these results. The explanatory power of these regressions is very poor; but the estimate of β for price increases is the right sign and significant at the 5% level, whereas that for price decreases is not significant and the wrong sign. This is consistent with our hypothesis.

TABLE XI.

Showing the extent to which changes in the quality-adjusted prices of individual models are associated with changes in the general level of quality-adjusted car prices. Coefficients and 't'-values.

Sample	Constant	$D_t - D_{t-1}$	R^2	\bar{R}^2
Price increases	22.68 (8.61)	0.407 (2.18)	0.057	0.033
Price decreases	-38.9 (-7.35)	-0.174 (-0.369)	0.038	-ve

Price-quality competition compared with advertising competition

In a previous paper (Cowling and Cubbin, {1971 a}), it has been shown that the share of advertising expenditure responds in the short-run to changes in market share by changing in the opposite direction, i.e. increases in advertising appeared to be the immediate result of decreases in market share and vice versa. This might be seen as an attempt to deal with unexpected changes in the balance between planned production and sales.

In the long-run the firms in the motor industry have been able to change their production plans by laying off workers, or taking them on and at times increasing physical capacity. In this long-run they readjust their advertising shares to the equilibrium level given by the positive long-run relationship between advertising and market share.

It is conceivable that price-quality competition be used in a similar way. Unfortunately, oligopoly theory gives no firm a priori expectations about the use of quality change as a short-run tactic. The large gestation period involved rules it out as a deliberate response to an unexpected change in sales; but given that quality change was a continual process, new and improved models appeared frequently, and the price to be charged for the new car did not have to be decided until shortly before it was launched. This gave some scope for some short-run adjustment to changes in demand.

Even so, it is not clear what the optimal response should be. If the firm is producing at less than full capacity so that marginal costs are constant, and if the elasticities of demand remain constant, then there seems to be no reason for the optimal level of price (or quality) to change. However, it is possible that marginal cost is not exactly constant or that the elasticities of demand are changing. This could lead to a change in optimal price, but as there are not strong a priori beliefs about the direction of change of these parameters, the optimal direction of change in quality-adjusted price becomes uncertain. The response of quality-adjusted price to changes in sales then becomes an empirical matter.

To examine this question, two alternative dependent variables were

used, namely $W_t - W_{t-1}$ and $W_t - W_{t-2}$, i.e., the change in absolute quality-adjusted price over the past one and two years respectively.

Four different measures of sales were used - model sales, model share of the total market, total firm sales and firm's share of market segment.

For each measure of sales, three different ratios were computed :

S_t/S_{t-1} , S_t/S_{t-2} and S_{t-1}/S_{t-2} where S = measure of sales as above.

This procedure yielded 24 different combinations of changes in W and lagged changes in S to be correlated. These calculations were carried out and regression coefficients calculated - in no case was a significant coefficient obtained. This would suggest that on the whole car manufacturers did not use changes in quality-adjusted price to regulate changing sales or market share.

This overall picture, however, hides some differences between individual manufacturers. Every firm has rather different specialised factors and so has slightly different cost functions. Their products have rather different characteristics and vary in their degree of substitutability with the products of other firms and so their demand functions are rather different. Since they differ in size and financial vulnerability they will also differ in the threat they represent to the other firms. These factors alone might be expected to lead to different behaviour by the different firms. In addition, given the indeterministic elements in oligopoly, we should expect accidents of personality and organisation to play their parts in creating differences in firm behaviour. There also exists the possibility that differences in the motivations of dominating personalities in the firm might cause it to pursue different goals or adopt different attitudes towards risk.

The possibility that the overall lack of response hid differences between firms was tested by considering each firm separately. Because of the lack of adequate theoretical specification a "blunderbuss" approach was adopted - all variables which might be important were included in what was considered their most appropriate form (see Table XI). W_t was the dependent variable, and its lagged value was included as one of the "explanatory" variables. It was included to allow for the possibility of a partial adjustment mechanism. In no case does its coefficient turn out to be significant. (Introduction of a lagged dependent variable can produce autocorrelation of the residuals and bias the Durbin-Watson statistic towards 2. I feel this is unlikely in the present instance.)

The coefficient on D_t shows the extent to which the pricing policy of the firm in question conforms to that of other firms, since D_t is in effect the (weighted) average quality-adjusted price of all models in that year. This coefficient is biased since D_t is a function of W_t , as well as W_t being a function of D_t , so there is a simultaneous equation problem which is likely to be greatest for those firms with the largest market shares, (i.e., Ford and B.M.C.). This makes interpretation of the resultant coefficients difficult. One might argue, taking into account the sizes of the coefficients and standard errors, that B.M.C., Ford and Chrysler were more apparently collusive in their price changes than Triumph and Vauxhall. Alternatively, it might be simply that B.M.C. made the biggest changes in quality-adjusted prices followed by Ford, etc..

For the sales variable, a quadratic function was employed. This was to allow for the possibility of a U-shaped marginal cost curve, which would give a negative coefficient on sales and a positive one on $(\text{sales})^2$.

The possibility that adjustment of W would be easier at a model change was allowed for by including the interaction terms Mx sales and $Mx(\text{sales})^2$ where $M = 1$ when a model is revamped, and $M = 0$ otherwise.

The firm's market share was included as a variable to allow for the possibility that the firm might retaliate against incursions on its market share by reducing quality-adjusted price - or perhaps that the firm might increase its quality-adjusted price when its market share increases so as to avoid provoking retaliation by the other firms. The interaction term Nx firm's market share, where $N = 1$ for a new model, 0 otherwise, was used to allow for the possibility that a firm might find it easier to do this upon the introduction of a new model.

The variable net pretax profits was included to allow for the possibility that both sales and profits enter the short-term objective of the firm. In this case price would normally be below the short-run profit maximising price, and in case of a profitability crisis, quality-adjusted price could be raised to generate more short-run profits. Conversely, when profits were high, the firm could afford to cut quality-adjusted price in order to pursue sales maximisation for its own sake or to consolidate the position of the company for the sake of long-term profits.

Simultaneous equation bias, whilst not being ruled out entirely, should not be too much of a problem (except for the variable D_t). This is because W_t is observed in October of the calendar year to which the sales variables refer and is not likely to have a great deal of influence

on sales for that year. The direction of any bias (if it exists) should be downwards.

Table XII shows the results. The small size and nonsignificance of the lagged dependent variable is a surprise. One interpretation is that most of the adjustment to the desired quality-adjusted price takes place within a year. The coefficients on D_t have already been discussed; nothing much can be made of them.

Comparing the estimated equations for the different firms it is clear that they differ widely. The explanatory power of the equations varies from 68% for Rootes/Chrysler to 17% for Vauxhall. It appears that B.M.C. responds to high sales and market share by raising W (or low sales and market share by reducing W), Ford seems to react to profitability but not to sales variations, Chrysler seems to have a U-shaped pricing function. W becomes a positive function of model sales at sales of 37,500 vehicles per annum and above. This would be an exceptionally high figure for Chrysler during this period, so we must postulate a negative relationship between W and model sales for Chrysler. This is supported by looking at the coefficient on "new model \times firm's market share" which is negative, suggesting that Chrysler put out new models more cheaply when they were doing well than they would otherwise have done. Through most of the period Rootes-Chrysler was in a difficult financial position. It seemed to have difficulty combining the maintenance of a respectable market share with making a profit on the vehicles it did sell. The equation suggests that this firm may have indulged in some sort of average cost pricing system.

TABLE XII Pricing Behaviour of Firms in the U.K. Car Industry, 1956-68.Coefficients and 't' values. Dependent variable:- quality-adjusted price (W_t)

	B.M.C.	Ford	Rootes/Chrysler	Standard/Triumph	Vauxhall
Constant	-232.1 (-4.78)	-52.04 (-1.07)	154.52 (2.11)	86.94 (4.66)	2.10 (0.07)
t-1	0.020 (1.24)	0.027 (0.74)	-0.014 (-1.15)	0.043 (1.19)	0.019 (0.69)
t	1.54* (4.37)	1.11* (4.32)	0.94* (2.10)	0.33 (0.67)	0.34 (0.74)
Model Sales	9.37×10^{-4} * (2.33)	3.07×10^{-4} (0.79)	-6.65×10^{-3} * (-4.86)	-4.01×10^{-3} (-1.65)	1.19×10^{-3} (1.72)
Model Sales) ²	-5.49×10^{-9} (-1.78)	-2.52×10^{-9} (0.80)	8.85×10^{-8} * (3.11)	1.27×10^{-7} (1.76)	1.09×10^{-7} (-1.56)
x Model Sales	2.05×10^{-4} (0.20)	-4.22×10^{-5} (-0.090)	3.73×10^{-4} (0.16)	1.12×10^{-3} (2.41)	1.05×10^{-3} (0.74)
M x Model Sales) ²	-8.52×10^{-10} (-0.05)	3.92×10^{-10} (0.10)	2.05×10^{-8} (-0.37)	4.97×10^{-7} * (-2.63)	2.08×10^{-7} (-0.74)
Firm's Market share	554.35* (4.27)	117.25 (0.76)	-164.50 (-0.29)	16.68 (0.41)	-30.88 (-0.12)
x Firm's Market share	-41.87 (-0.88)	-71.27 (-1.13)	-311.42* (-2.18)	-127.20 (-1.41)	-228.02 (-0.86)
Net Pre-tax profits	-1.01 (-1.66)	-0.71* (-2.08)	0.005 (0.27)	data not available	-0.42 (-0.31)
	0.356	0.322	0.684	0.302	0.173
	0.263	0.198	0.619	0.092	-0.122
Durbin-Watson statistic	0.756	1.15	0.822	0.946	1.09
F statistic	(9,69) 4.24*	(9,55) 2.90*	(9,48) 11.57*	(8,30) 1.62	(9,28) 0.65

Notes : 1. The centre of the period of observation of the sales variable is lagged approximately 3 months behind the date of observation of W_t .

2. M = 1 for a change in the specification of an extant model, 0 otherwise.

3. N = 1 for a newly introduced model, 0 otherwise.

4. Figures in brackets before F statistic refer to degrees of freedom.

5. * indicates significance at the 5% level for a two-tailed test.

Standard-Triumph seems to have reacted to changes in market share by changing the quality-adjusted price of its revamped models as if facing a U-shaped marginal cost curve. The minimum of the curve is at 21,300 vehicles per annum. Some of their more popular models sold more than this. For these an increase in sales was associated with an increase in W .

Vauxhall's pricing seems to have been insensitive to any of the variables used here.

The lesson to be learned from these equations is not that a particular firm prices its cars in a certain way. The theoretical specification of these equations is very loose and I have not sufficient faith in their interpretation to make any definite statements of that nature. But I think one can deduce that different firms behave differently. It may even be the case that firms change their behaviour so that predictions even for one firm over time are liable to be inaccurate.

This conclusion is reinforced by an examination of the test statistics of Table XII. On the whole very little of the variation in W has been explained. The Durbin-Watson statistics suggest serious autocorrelation, which may cause the significance of the regression coefficients to be overstated. Three of the F -statistics denote significance at the 1% level. This is likely to be an overestimate of the significance because of the elements of simultaneity present.

CHAPTER 8

Conclusions

(1) The first section of this chapter will deal with the main theoretical and empirical findings of the earlier chapters; the second will discuss some of the doubts and qualifications in the interpretation of the evidence; the third will adopt a more speculative approach and look at the possible implications of the findings for the welfare aspects of quality-change raised in Chapter 1.

1. Main findings

The approach to oligopoly theory was adopted which examines the determinants of the success of the oligopolists in raising the price towards the joint monopoly price and away from the Cournot or Chamberlin "large numbers" price. These determinants were found to be many, including the traditional variables of seller and buyer concentration, barriers to entry and degree of product differentiation. These were not the only important variables, however. In fact a list of fourteen was finally drawn up. Of the less traditional variables considered, the most relevant for the present study was the gestation period of any competitive strategy - the longer the gestation period the more similar the situation of oligopoly became to that of the Prisoner's Dilemma, and less like the multiperiod empirical games of Lave and others. Therefore the longer the gestation period (sometimes also called retaliation lags) the more likely are rivalistic strategies to dominate than co-operative ones. Since price changes have a short gestation

period and quality changes a long one, we should expect price changes to be associated with co-operative strategies (raising quality-adjusted price) but quality change with rivalistic strategies (lowering quality-adjusted price). The evidence of Chapter 7 supports this view.

(2) Lancaster's new theory of consumer behaviour in its rigorous form was found to be too unrealistic to be useful in imposing any restriction on the form of the price-quality relations. The hedonic technique and Lancaster share the same inspiration but not the same formulation.

(3) The theory of the hedonic technique is still not complete. For example, the question of possible bias from using weighted regression in price-quality relations cannot be properly answered until it is stated in more detailed terms how this bias arises. It is hoped that Chapter 4 will provide some basis for discussion.

(4) However, the approach does seem fruitful in yielding quality-adjusted prices with some meaning as long as care is taken over the specification of the price-quality relation. The quality-adjusted prices derived in Chapter 5 could explain a significant proportion of the variation in market share.

(5) An alternative method of estimating the price-cost margin was developed and the estimated margin found to be in the region predicted by the theory of Chapter 2.

(6) The price-cost margin fell over the period.

- (7) Whilst some of this can be attributed to cost increases, the fall in the quality-adjusted price index suggests that quality competition was a contributory factor.
- (8) Quality variation was used to decrease quality-adjusted price significantly more than to increase it - whereas price was used to increase quality-adjusted price significantly more than it was used to decrease it.
- (9) Competition over quality-adjusted price was not in general used in retaliation against falls in market share (although B.M.C. was a possible exception to this rule).
- (10) Individual firms differed in their short-run pricing reaction behaviour.

2. Limitations

- (1) This was a study of a specific industry at a specific time and one should therefore be wary of generalising any conclusions to other industries, other countries, or other times.
- (2) The hedonic approach cannot take into account all quality variation. Its success depends on the nature of the product.
- (3) Therefore the quality-adjusted price is measured subject to error. On its own this might be expected to lead to a downward bias in the estimated price elasticity. In addition, however, there is a lagged dependent variable

in the equation to estimate the long-run elasticity. On its own this also leads to a downward bias in the elasticity, but if it introduces autocorrelation into the error terms in the regression equation, the total effect may be an upward bias (Johnston, {1963}, p. 215). If knowledge of the elasticities themselves were thought important, another approach to their estimation really ought to be adopted.

(4) In the estimation of price-quality relationships the residuals represent quality-adjusted prices. Yet in an oligopoly, quality-adjusted prices cannot be assumed independent. Ordinary least squares may therefore be inefficient. This point was made to me by D. Leech. To examine the importance of this consideration work is currently being done on a Generalised Least Squares approach.

(5) There may be other explanations of the connection between quality change and falls in quality-adjusted price. For example, suppose quality changes arise because of the reduced costs of implementing quality improvement. In other words, quality is improved because it is now cheaper. Naturally this results in a reduction in the quality-adjusted price, and this may account for some of the association between quality-change and reductions in quality-adjusted price. On the other hand, there is no evidence for reduced costs of quality improvements, especially as raw materials and labour costs rose substantially over the period.

3. Implications

In this section we shall assume that the conclusions are substantially

correct and speculate on the possible wider implications. The qualifications made necessary by the shortcomings of the work will be assumed to be understood.

First, it appears that oligopoly theory need not be a series of unconnected models as it is in the average micro-economics textbook. There is a coherent framework available even if all its parts have not been thoroughly tested and it is rather messy. It may be that oligopolists are like that and it is necessary to know far more about a particular industry to know how it will behave than its cost and demand curves.

Second, most of the empirical work on structure-conduct-performance relations omits many variables of potential importance. Those variables that are added to the standard ones (concentration and barriers to entry) are often added on an ad hoc basis rather than on general economic theorising.

Third, quality competition may to some extent serve as a substitute for price competition. Whether it fulfills all the hopes and dreams of Abbott (see p. 2 above) is another matter. One of the most important determinants of quality change is the gestation lag. But profitability must be another consideration. This will depend on the cost of the change and its effect on demand. Superficially, this opens the way for consumer sovereignty and no doubt this is the case for some aspects of quality.

Theoretically, for some goods the gestation period of quality for some commodities may be as short as for price changes, (e.g., the opening times for shops?). Quality competition might then be no more likely than price competition. The long-run effects on demand for the industry's product

might prove unacceptable as in the case of ensuring a long product life for durable consumer goods. So quality competition, whilst occurring for some aspects of quality, may fail to occur for other, possibly more fundamental, aspects of quality. The existence of some quality competition does not ensure that firms compete over all the aspects of quality that consumers might be interested in.

On the other hand, I feel that Ferguson somewhat overstates his case: "...there is a strong presumption (based upon purely empirical grounds) that oligopolists push all forms of nonprice competition beyond the socially desirable limits." (p. 366). The empirical grounds are not made explicit. The statement would be acceptable if it referred to only advertising or spurious profit differentiation activities. But as we have seen it is possible that some aspects of quality may not be pushed far enough.

Sometimes this may take the form of insufficient variety. For example, by the 1960's (partly as a result of the "horsepower race" of the late 1950's) there was a distinct gap at the low-priced end of the American car market. None of the big three, however, chose "not to break the shared-monopoly ranks through innovation into the low-priced markets..... During 1968, imports rose to over 10% of domestic sales. It has taken such sharp inroads to draw a response, finally and belatedly." (Shepherd, {1970 }, pp. 240-241).

When quality competition is used as a substitute for price competition and there is no one to supply the bottom end of the market, both price and quality may be too high. Taking all these considerations

into account, I am inclined to agree with Ferguson's verdict that, "buyers in oligopoly markets would be better off if there were more active price competition and less nonprice competition." (p. 366).

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