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EUI Working Paper ECO No. 93/4

Empirical Studies of Product Markets

ALAN KIRMAN
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LOUIS PHILIPS

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EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

ECONOMICS DEPARTMENT

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BADIA FIESOLANA, SAN DOMENICO (FI)

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Printed in Italy in February 1993
European University Institute
Badia Fiesolana
I - 50016 San Domenico (FI)
Italy

EMPIRICAL STUDIES OF PRODUCT MARKETS

Alan Kirman and Louis Phelps

Department of Economics
EUROPEAN UNIVERSITY INSTITUTE
Badia Fiesolana
I-50016 S. Domenico di Fiesole (Fi)
ITALY
Tel.: +39-55-50921
Fax: +39-55-5092.202

October 1992

Abstract

This is a survey paper on recent empirical studies, based on explicit theoretical modelling, of product markets. — The topics covered are: 1. The relevant market 2. The demand for products 3. Conjectural variations and market power 4. Price discrimination 5. Tacit collusion and the "Folk Theorem" 6. The lemons principle and efficiency 7. Auction markets.

INTRODUCTION

In their introduction to the *Journal of Industrial Economics*' special issue on "The Empirical Renaissance in Industrial Economics", Bresnahan and Schmalensee (1987) recall that Industrial Economics started as a distinct field of economics with a series of book-length case studies of particular industries under the impulse of Edward Chamberlin and Edward Mason. The idea was that the profession would learn about imperfectly competitive markets by induction from an accumulation of detailed studies of particular product markets. Knowledge of the facts would lead to theoretical hypotheses. These hopes did not materialise.

After the war, the availability of simple econometric techniques and government-supplied data (mainly census data) led to a long wave of studies of industry-level cross-section studies "testing" the structure-conduct-performance paradigm and a virtual disappearance of case studies. The search was for general objective relations between profits, prices, wages, and so on and market structure. In the 1970s, however, dissatisfaction became widespread: It was gradually recognized that these studies lacked sound theoretical foundations, that the industry-level data at hand were not appropriate and that more sophisticated econometric techniques would not suffice to uncover the basic truths one was looking for (see Schmalensee, 1988).

Then, in the 1980s, came the invasion of the field by game theorists. As a result, "Industrial Organization has become a fairly theoretical field in recent years. At first sight, even a theorist should regret the very high ratio of theory to evidence in a field in which theoretical models are often lacking in generality and in which practical implications are so crucial." (Tirole, 1988, p. 3). The overflow of theoretical papers was perhaps an inevitable reaction. At any rate, it is beginning to show its usefulness for the analysis of actual markets: In the last few years, there is indeed an "empirical renaissance", characterized by empirical work based on explicit theoretical modelling, using new sets of data (especially data on individual firms) and exploiting the latest advances in econometric method.

This survey is devoted to some of these new developments. As its title indicates, we shall focus on studies of particular product markets and completely neglect papers that study multiple industries. To keep our topic within limits, we also exclude agricultural products and natural resources, whether exhaustible or renewable. (This eliminates crude oil, but not gasoline, and does not eliminate salt, which is a manufactured product.)

1 THE RELEVANT MARKET

"Let producers A and B be located in the same geographic market". "Let producers A and B produce two varieties of the same product". That is about all duopoly theory has to say about the market or the products for which it is supposed to be relevant. The determination of the real world "market" or "product" is supposed to be an empirical question. Yet, this determination is a condition sine qua non for any empirical study of a product market.

Anybody who got dirty hands trying will agree with Horowitz (1981) that "the market concept is indeed imprecise, and that economists are far better equipped to discuss markets than they are to discover them. [...] The problem of discovering the relevant geographic market is at least as vexing as that of discovering the relevant product market". Admittedly, spatial price theory defines neat market areas for geographically dispersed firms. However, price discrimination allows oligopolistic or monopolistic firms to invade their competitor's market areas, so that the high degree of overlap and cross-hauling tends to obviate the usefulness of this literature for practical applications. (See Elzinga and Hogarty (1973) for an early discussion, and Thisse and Vives (1988) for a recent game-theoretic approach.) In practice, the best guide is still good common sense and a detailed institutional knowledge.

Some statistical tests are available, though. They concentrate on the analysis of price data, since the basic principle is still Cournot's: in a market prices should take the same level throughout with ease and rapidity. The problem is how to translate this in terms of observed prices.

A natural thing to do is to examine price correlations between varieties of the same (supposedly) commodity or two geographic areas. This was done as late as 1985 by Stigler and Sherwin. The pitfalls are too numerous however. First, correlation may be spurious, if there is a common trend, for example. Second, small correlations do not imply that there is not a single market: Consider the case where the two prices tend to equality but may differ at any point in time. Third, high correlations may be observed between separate markets, for example if the price in one market is a ceiling to the price in the other. Clearly, the time dimension (in particular lagged reactions) has to be taken into account. That is why Horowitz (1981) and Howell (1982) use a first-order autoregressive model of the price differences allowing adjustment to a common long-run price.

Slade (1986), however, sees no reason to suppose that price differences are stable or that a particular adjustment process is followed. She proposes a test that is not based on a particular model of price formation but simply formalises the idea that two areas (or product varieties) are not common when the price in one area (or for one variety) is exogenous to the other.

In the simple case where there are two regions ($j = 1, 2$), the test implies running the following four regressions:

$$p_t^j = \sum_{i=1}^{n_1^j} a_{ij} p_{t-i}^j + g_1^j(z_t) + \varepsilon_t^j \quad (1)$$

$$p_t^j = \sum_{i=1}^{n_2^j} c_{ij} p_{t-i}^j + \sum_{i=1}^{n_3^j} d_{ij} p_{t-i}^k + g_2^j(z_t) + \eta_t^j \quad (2)$$

where $j = 1, 2$, $k = 2, 1$, ε^j and η^j are disturbance terms with zero means such that each is uncorrelated with the right-hand-side variables in its respective equation and z_t is a vector of exogenous variables whose exogeneity is not to be tested. The joint hypothesis to be tested is that (1) the coefficient vectors d are zero; (2) p^1 and

p^2 are not contemporaneously correlated and (3) the covariance between η_t^1 and η_t^2 is zero. The $g_m(z_t)$ are specified as quadratic functions of time.

Slade uses this test pairwise on the wholesale prices of gasoline in cities in Southeastern US, the Northeast and between the East and West coasts to conclude that the Southeast is a local geographic market that is loosely connected to the Northeastern seaboard but entirely separate from the West coast.

Spiller and Huang (1986) allow to go one step further. They propose a maximum-likelihood methodology to estimate the probability of arbitrage and the required arbitrage costs for a pair of regions. Two regions belong to the same market if, when the price in one region exceeds the other, given prices in the two locations are linked by binding arbitrage conditions such that, if one price increases, arbitrage would take place. Arbitrage costs thus reflect the maximum differential that can develop between prices. When the price differential is smaller, prices can vary independently of each other. The wholesale gasoline prices in the Northeast of the US turn out to be such that a) city-pairs with high probability of being in the same market are those that are nearby; b) city-pairs with low probabilities are more distant and c) city-pairs requiring arbitrage in a north-to-south direction have lower probabilities of being in the same market than city-pairs requiring arbitrage in the opposite direction.

Tests such as those discussed are clearly most useful to give an objective answer to the vexing problem, which pervades most antitrust discussions, of determining the relevant market.

2 THE DEMAND FOR PRODUCTS

There is a long tradition in economics of estimating demand equations for specific products or groups of products. In the nineteenth century there was a very active debate over the nature of demand and little concern about its estimation. Until Marshall, there was considerable discussion as to the correct definition of demand for a single commodity. However, in the more formal literature there was convergence on the rather abstract Walrasian notion that demand simply represented the quantity that an individual would purchase at given prices which he was unable to influence. The subsequent theoretical literature concentrated largely on the extension of the analysis to interdependent markets and the problem of demand systems rather than single demand equations still maintaining the abstract Walrasian approach. Until recently, the idea that demand should be treated in this way has not really been challenged neither in the economic nor in the econometric literature.

Once the twentieth century literature had converged on this precise theoretical definition econometricians concentrated on more sophisticated techniques for the estimation and identification of demand systems (for a detailed account of this evolution see Morgan (1990)). The agreed definition, that of competitive demand, concerning the quantities of goods an individual would buy at a given price were he only constrained by his income, was retained. In Working's (1927) paper the

conceptual nature of demand and supply are not questioned. The only real problem for him is that of which is changing.

Let us return now to the implicit assumptions underlying the usual empirical analysis based on Walrasian demand theory. The first of these arises if one accepts that the market in question can essentially be thought of as functioning "competitively". The problem is then one of identification, in this case, separating out supply changes from demand changes. In a truly Walrasian, or Arrow Debreu world such a distinction could, of course, not be made, since all transactions over time represent one supply and one demand decision taken in some initial period. However this problem is usually circumvented in the empirical literature by making an implicit assumption of stationarity, i.e. that the market is somehow repeated over time. This should, of course, be tested but does mean that one can talk of successive observations. However, in this case the appropriate theory is that referred to as temporary general equilibrium theory. The problem with this is that short run demand loses many of the properties of its Walrasian counterpart. It does not satisfy homogeneity or the Weak Axiom of Revealed Preference for example (see e.g. Grandmont, 1983).

However, one may also question the appropriateness of treating purchases as being a direct expression of competitive demand. This clearly depends on the organisation of the market. In particular, in many of the markets discussed in this paper, there is no obvious reason to believe that transactions reflect anything corresponding to the standard theoretical idea of competitive demand. If successive lots of a good are auctioned, for example, there is no theoretical reason to believe that the average price will correspond to the competitive price that would have cleared the same market. There are many examples of markets in which trades are made after pair-wise bargaining or in which traders are dispersed geographically or have imperfect information. In all of these the idea of a single equilibrium price makes little sense.

There are further difficulties with trying to estimate empirical demand functions based on standard utility maximisation. The first of these is the problem of aggregation. Even if individuals' demand functions satisfy certain properties it is by no means necessary that these properties carry over to the aggregate level (see e.g. Sonnenschein, 1972, Mantel, 1976, and Debreu, 1974). Indeed there is no direct, formal connection between micro and macro demand behaviour without extremely restrictive assumptions (see e.g. Deaton, 1986). A second difficulty is that the data for most empirical demand estimation is not obtained at the consumer level. If the purchaser of a good is not in fact the final consumer then one would have to show that properties of individual demand carry over to properties of quantities purchased by an intermediary at different prices. If one considers the simple case of a purchaser who has a monopoly locally of the product that he buys, then it is easy to construct examples in which this will not be the case. This question was raised by Working (1927) and mentioned again in the classical studies of the demand for individual products by Schultz (1938), who although using individual properties of demand made his estimations using data for farm prices and not shop prices.

All of this suggests that one should view efforts to use empirical demand estimation as a way of testing specific characteristics of microeconomic utility maximising behaviour with a great deal of scepticism. As Keuzenkamp and Barten

(1991) show, and as one might expect from the discussion above, the track record of attempts to “verify” such a basic condition as the homogeneity requirement for demand systems is very poor. Marschak’s (1943) study of the demand for meat is an early example of the rejection of the hypothesis of homogeneity and increasingly sophisticated analysis has done little better. Yet, as Samuelson (1947) predicted, the consequences of this for economic theory have not been significant.

A more pragmatic approach is to look at empirically estimated “demand equations” as revealing interesting properties of consumption expenditure rather than as tests of particular tenets of utility theory. In particular, estimates of own and cross price elasticities and of income elasticities are of interest for a variety of reasons. With this in mind a number of recent studies are worth mentioning.

In studying the consumption of, and expenditure on tea in the U.K. using over sixty years of pre-war data, Nguyen and Rose (1987) found evidence of price inelasticity and of steadily decreasing income elasticity. They attribute this to a variety of factors such as demographic and organisational changes and changes in social habits and point out the obvious consequences for the expansion of tea production in the developing countries. This study produces more evidence for one of the main explanations for the apparent decline in the terms of trade of the developing countries that the elasticity of demand for their products is low and declining.

Another reason for being interested in demand elasticities is that, if they differ across groups they can be used as a basis for price discrimination, something we shall come back to in a later section. As an example of this, Tremblay (1985), by estimating a firm demand function for U.S. beer producers, was able to show the existence of demand asymmetries across “strategic groups” which could account for differences in the strategic behaviour of regional and national beer producers.

The way in which the evolution of demand for a particular product in a particular country affects the development of the producing industry is of considerable interest but often requires long time series. A striking example of such a study is Larsen and Nilsson’s (1984) examination of the production and consumption of bicycles in Denmark over ninety years. They document extensively the various factors which have influenced the purchase of bicycles during that time and, as is sometimes the case, their historical analysis provides insights which a more sophisticated econometric analysis might not have revealed.

A number of policy measures depend crucially for their effect on the responsiveness of demand. A good example of this is the recent concern with the evolution of diet, its impact on health and the use of policy measures to modify that evolution. A series of studies, often using a rather restrictive specification for the demand system, the so-called Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980), has tried to analyse the nature and source of changes in the relative demand for meat and chicken products, Eales and Unnevehr (1988), Braschler (1983), Haldacher *et al.* (1982), Hudson and Vertin (1985) and for food fats and oils, Gould *et al.* (1991). In all these contributions the changing demographic structure seems to have played an important role but to what extent this is due to the differential impact of health considerations on different segments of the population is difficult to assess. An earlier study which seemed to point in the opposite direction to those

mentioned is that by Luttrell (1969) where demand for meat was found to be “accelerating” and although costs were decreasing, both prices and consumption had increased. This could be claimed to provide evidence for the later shift in demand resulting from greater awareness of health problems in the '80s.

One further example of an investigation of the structure of the demand for a particular product which has quite general implications is Planting's (1982) look at the explanation for the changing seasonality in the consumption of gasoline in the U.S. He emphasises the importance of seasonal differences in price elasticities and suggests that these have been too frequently ignored in the analysis of economic time series.

In concluding this somewhat cursory examination we concur with Gilbert (1991) in suggesting that one of the important roles of empirical studies of demand is in measuring certain parameters, such as elasticities, and that undue priority has been given in the literature to the testing of often intrinsically untestable theoretical propositions. The very use of the term “demand” itself may have contributed to the sterility of the debate and may help to explain the relative paucity of empirical studies of the consumption of specific goods in the major economic journals.

3 CONJECTURAL VARIATIONS AND MARKET POWER

A “conjectural variation” is a conjecture, made by a firm, that a one unit change in its output leads to a change of γ in its competitors' total output. A value of $\gamma = -1$ indicates that the firm is a price taker, while $\gamma = 0$ indicates Cournot behaviour. Collusion implies $\gamma = N - 1$, where N is the total number of firms. A methodology that assumes firms maximise profits under the assumption that their rivals will react according to their conjecture is an attempt to model dynamic interactions in a static framework. From a game-theoretic point of view, such a methodology is not satisfactory, since in a static game firms cannot react to one another by the very timing and information structure of the game (Tirole, 1988, p. 244). Nevertheless, conjectural variations are often used in practice and sometimes interpreted as reduced form parameters¹ from the equilibrium of some unknown dynamic game (Schmalensee, 1989, p. 650).

We wish to emphasize that, whatever their theoretical interpretation, empirical measures of conjectural variations have a different meaning. They do not measure what firms believe will happen but how firms actually behave (possibly as a result of their expectations). As explained in great detail by Bresnahan (1989) in his extensive survey of empirical studies of industries with market power, they are measuring departures from perfectly competitive behaviour, that is, the extent of market power. As such, they are directly related to the Lerner index.

Bresnahan's argument is as follows. (We simplify his notation to abstract from problems of econometric estimation.) Let $p_i = p(q_i)$ be the instantaneous inverse market demand function, with $q_i = \sum_i q_{it}$ ($i = 1, \dots, N$). Then the equality of firm i 's marginal revenue and marginal cost can be written as

$$p_t = c_{it} - \frac{dp_t}{dq_t} q_{it}, \quad (3)$$

where c_{it} is marginal cost. To allow for price-setting or quantity-setting conduct, (3) is generalised to

$$p_t = c_{it} - \frac{dp_t}{dq_t} q_{it} \theta_{it}, \quad (4)$$

where $\theta_{it} > 0$ is a parameter that measures the competitiveness of oligopoly conduct. As θ_{it} moves farther from 0, the conduct of firm i moves farther from the conduct of a perfect competitor. Particular specifications of θ_{it} correspond to particular theories. For example, $\theta_{it} = 1$ is implied by Cournot-Nash equilibrium in a one-shot game (or monopoly if there is only one firm in the market). As θ_{it} rises, the price-cost margin ($p_t - c_{it}$) and the Lerner index rise. During periods of collusion, θ_{it} is larger than during price wars.

The crucial point is that θ_{it} can be redefined as

$$\theta_{it} = 1 + \gamma_i, \quad (5)$$

where γ_i may be a function of the firm's own quantity, all other firms' quantities or other relevant variables. Consequently, $\theta_{it} = 1$ corresponds to $\gamma_i = 0$, while $\gamma_i = -1$ indicates perfectly competitive behaviour.

Many difficulties in the literature arise from a failure to understand the preceding argument. No harm is done when $\gamma_i = 0$ is identified with Cournot-Nash equilibrium, or when $\gamma_i = -1$ is called perfect competition. But what if it turns out that $\gamma_i = N - 1$? This corresponds to collusive joint profit maximisation of N identical firms and $dq_j/dq_i = 1$. What is measured is the collusiveness of conduct, not how other firms react when firm i deviates from a collusive equilibrium. Note that, in a collusive equilibrium, there are no deviations: expectations about the reactions of other firms deter i from deviating, so that these reactions are not observed.

Geroski et al. (1985), Bresnahan (1989) and Martin (1993) discuss the estimation procedures of the empirical contributions by Iwata (1974) on the Japanese flat glass industry, Cubbin (1975) on the U.K. car industry, Gollop and Roberts (1979) and Roberts (1984) on firms in the U.S. coffee roasting industry, Bresnahan (1980, 1981) on the American automobile industry, Appelbaum (1979, 1982) on textile, rubber, electrical machinery and tobacco, Porter (1983b) on railroads, Spiller and Favaro (1984) on the Uruguayan banking sector, Suslow (1986) on aluminium, Martin (1988) on four medical-surgical supply companies and four U.S. motor vehicle producers and Liang (1989) for the U.S. breakfast cereal industry.

The main conclusions are that a) there is substantial market power in the industries studied, which are typically highly concentrated industries or markets with dominant firms, and b) this power results from anticompetitive conduct. These conclusions cannot be generalised, however. Indeed, these industries were selected either because cartels were known to exist or because good statistical data were available, which in turn may be the result of the presence of anticompetitive conduct.

How the detected market power can be explained in terms of the evolution of (or differences in) market structure remains an open question: Here, cross-sectional studies in the spirit of Sutton's 1991 book may be called for.

4 PRICE DISCRIMINATION

Price discrimination, unlike some of the topics dealt with in this survey, has given rise to a substantial body of empirical literature, including a number of studies of specific markets, and a full account of both the economic theory and details of business practices may be found in Philips (1983). Price discrimination can be defined, in general terms, as the sale of units of goods to different customers at prices which differ by more than the difference in the delivered cost of those units. From a strictly formal point of view, such a definition is devoid of content since only units of a homogeneous good delivered at the same time and place are considered as the same commodity and therefore in a competitive framework should have the same price. However, in practice, a much less tight definition of good is used and, for example, price discrimination is said to occur if two versions of the same car are sold at prices which differ by more than the differences in the cost of producing and delivering those two versions. The practical difficulties with this are obvious and arise frequently when discriminatory practices are challenged in the courts. Returning, for a moment, to the strict definition, the existence of discrimination is incompatible with first best efficiency. The recognition of this has led to legislation (such as Article 86 of the Treaty of Rome) against discriminatory practices, particularly by "dominant" firms. As a result of this there is a large number of case studies of price discrimination in different markets. The main aim of many of these studies has been to establish whether in the particular case in question practices corresponding to those defined in law as discriminatory are present (for a discussion of this type of problem see Posner, 1974, 1976, and Bork, 1978). We however shall confine our attention here to those papers which apply economic theory, and particularly recent development of that theory to empirical markets. Furthermore not only will we consider the classic situation in which consumers are divided into groups according to their different demand characteristics and different prices are charged to different groups, but we will also consider cases in which firms may charge different prices to separate but identical groups of consumers. In the latter case the discrimination may arise from the structure of the supply side rather than that of the demand side.

The standard classification of discrimination by a monopolist is due to Pigou (1932) and is based on the degree of subdivision of the market and the possibility of extracting consumer surplus. Another is that given by Schneider (1952) who distinguishes between discrimination on the basis of the type of user, the use to which the product is put and geographical location, changing by country of destination, for example. More recently, considerable attention has been paid to the possibility of price discrimination in oligopolistic and monopolistically competitive situations. (For theoretical analysis with a duopoly see for example Jaskold-Gabszewicz and Thisse, 1980, Shaked and Sutton, 1982, and for the multi-firm case Katz, 1984, Borenstein, 1985, and Holmes, 1989.)

A first class of empirical contributions is that which looks at the discrimination between users or consumers of some good or service provided by a monopoly such as a public utility. The electricity industry has been the subject of extensive investigation in this regard. An essential problem for such an industry is that of spreading its fixed costs between users. Neufeld (1987) gives an account of how the demand charge rate structure was introduced. This principle which relates an individual's charge to his own peak consumption has been considered as a misapplication of the peak-load pricing scheme and thus representing an inefficient discrimination between different users. However, Neufeld argues that it was actually sustained as a sophisticated system for profit maximising price discrimination in the face of competition from isolated plants. Eckel (1987) criticises peak-load pricing itself (see Bailey, 1972, Boiteux, 1949, and Wenders, 1976) and rate of return regulation as being socially inefficient. She claims that social efficiency requires that differences in customer class demand patterns be taken into account. However, it is by no means clear that the particular schedules actually charged to different customer classes by utilities achieve efficiency rather than profit maximisation, and how this should be decided is discussed by Eckel.

Similar problems arise in other fields and the sophisticated systems for pricing for telephone calls (see Billera *et al.*, 1973) or for airport landing charges (see Littlechild and Thompson, 1977) based on the Shapley value from cooperative game theory provide a "fair" attribution of overheads in determining different prices for the same good to different consumers. Of course, it can be argued that a landing by a 747 has a higher marginal cost than that of a light aircraft but there is still discrimination in the technical sense since the differentials in the Shapley prices far exceed the differences in marginal cost. In industries where marginal costs are low relative to fixed costs almost all solutions proposed necessarily contain an element of discrimination.

Another area in which price discrimination is claimed to exist extensively is that of international trade. Where markets can be effectively separated by legal or non-tariff barriers, it is common to find the same physical product being sold at very different prices in different markets. This has been a source of interest in the E.E.C. since such practices are, in principle, ruled out under the Treaty of Rome.

The pharmaceutical industry has been frequently cited as an extreme example of such practices. Schut and Van Bergeijk (1986) claim that there is a close positive correlation between per capita G.N.P. and the price charged for a given drug. Zanon (1981) discusses the use of discounts for large scale purchases which effectively allows companies to discriminate through exclusive importers.

A second industry which has attracted interest is automobile manufacture. Price differentials are maintained in many countries by the existence of voluntary export controls. However, even within the E.E.C. substantial differences exist between pre-tax prices for the same car. A number of explanations have been advanced for this. Arbitrage is by no means trivial for the individual and professional arbitrageurs who both import and service cars are ruled out by the exclusive dealership arrangement. Although simple discrimination by demand is suggested by many authors, Kirman and Schueller (1990) suggest that the price differences reflect, in part, the market structure with domestic producers playing the role of leader in

their own country. Thus countries with higher cost domestic producers have higher prices, even with identical demand. In addition, countries with no domestic producers have lower prices and pre-tax prices are lower in countries with higher taxes, a conclusion also reached by Murfin (1983, 1987). All this follows from the analysis of a simple one-shot non-cooperative game. Mertens and Ginsburgh (1985) confirm that price differences are not due to product differentiation but are mainly the result of discrimination. However interestingly Davidson *et al.* (1989) show that the welfare effects of lowering discrimination in this market are highly ambiguous and this reflects other theoretical results.

A further question raised here is to what extent do car manufacturers or other exporters discriminate by not passing exchange rate changes through to prices. Mertens and Ginsburgh (1985) and Kirman and Schueller (1990) both show that prices do not reflect, even in the longer term, exchange rate changes and are fixed with respect to local cars in domestic currency terms. Knetter (1989) shows that both U.S. and German exporters maintain price differentials and that there is incomplete pass-through. All of this confirms the theoretical findings of Hens, Kirman and Philips (1991) who show that, in an oligopolistic situation, exchange rate changes may actually result in perverse price changes, i.e. an increase in the price of the exports of a devaluing country. This leads to a serious problem in predicting the effects of a devaluation in the presence of oligopolistic competition.

In other areas also, attention has been focussed on price discrimination in multi-firm settings. Shepard (1991) shows how price discrimination is practised by service stations offering both full service and self service gasoline and suggests a method for detecting which part of price differences is due to discrimination and which to cost. Her analysis raises the question of what happens if the choice of full service, self service, or dual functioning is made endogenous rather than exogenously given. Wolinsky (1987) gives a theoretical explanation of the empirical fact that manufacturers market the same good under different brand names and price discriminate in so doing. He cites the selling of "own brand" products by chain stores as an example.

An interesting example of price discrimination, which directly concerns the academic economist is that practiced by scientific journals. Joyce (1990) confirms an old argument that photocopying has increased price discrimination and shows that the more copied a journal is, the greater is the discrimination between institutions and individuals.

In concluding this section, it should be noted that there is a strong school of thought, represented by a recent paper of Lott and Roberts (1991), which argues that much of apparent price discrimination can be cost explained. Some of their arguments are persuasive, others less so. The observation that Consumers Reports finds Sears tires manufactured by Michelin of lower quality than those marketed by Michelin itself may, in reality, say more about the tests used by Consumers Reports than about product differentiation. Although these reserves should be noted, few would doubt empirical evidence for the existence of price discrimination on a large scale.

5 TACIT COLLUSION AND THE "FOLK THEOREM"

As we have said, it would not be possible to give an adequate account of empirical work on product markets without taking into consideration the theoretical revolution that has occurred in recent years in the field of industrial economics. Sophisticated models derived from non-cooperative game theory have been developed to characterise the behaviour of agents and firms in different market structures. Furthermore, and this is what concerns us here, the analysis has been made dynamic through the use of repeated games, supergames, and differential games. However, the empirical verification of some of the major theoretical results of the "new industrial economics" has developed remarkably slowly, though there are obvious reasons for this. In most cases the empirical testing of a theoretical proposition using a repeated game for example requires the use of extremely precise data on prices for a particular product of a specific industry. Furthermore, this data has to be collected over a relatively long time period. There are not many examples in the literature of the construction of such data sets.

To see what form empirical verification of theoretical propositions might take and the difficulties involved, we shall consider a standard problem, that of tacit collusion among producers or sellers. A standard argument has been that the existence of profits, in an oligopolistic situation, above those which would be obtained in the Nash equilibrium of the corresponding one-shot game, is *prima facie* evidence of collusion. Some such argument underlies much antitrust legislation, although the reference point, even in explicitly oligopolistic situations, is often referred to, misleadingly, as the "as if competitive" one. (An explicit account of the empirical problems involved in using this approach for specific markets such as that for synthetic fibres is given by Albach, 1977, for example.)

However, as soon as the game in question is considered in a dynamic setting, the theoretical basis for this conclusion is undermined by the well known "Folk Theorem" from game theory. Put very loosely, a version of that theorem is that in a stationary oligopolistic situation in which players are impatient, that is they discount the future, all the "cooperative" solutions of the one period game are Nash equilibria of the overall non-cooperative game.

There are many models which use one-shot games, but for a lot of economic situations these are inappropriate. The advantage of the repeated game, or in the case where the one-shot game changes from period to period, of the supergame approach, is that short-term punishments can be used to enforce more cooperative solutions. Thus one would observe outcomes in the dynamic approach which achieve better pay-offs for all parties than the security levels guaranteed at the mini max solution of the one-shot game. As has been mentioned, the empirical testing of certain characteristics of the strategies involved in markets to see whether they correspond to those predicted in the theory is an awesome task, if only because of the types of data required.

In two recent papers Slade (1991, 1992) has done this. In the first she studies the market for saltine crackers in a small U.S. town. She uses weekly data to test two

standard simplifying hypotheses used in dynamic differential games. These are that competition can be studied in terms of single strategic variables such as prices or advertising. Secondly, the class of equilibrium studied is often restricted, to Markov-perfect, or memory-less equilibria for example. Using modified versions of standard causality/exogeneity tests, she strongly rejects the strategic independence of choice variables. Thus it is not, as one might expect, acceptable to study competition from an individual choice point of view. As to the memory-less assumption, she finds that it is appropriate for price chosen but not for advertising. The finding for pricing choices is in part one of interpretation. When the lagged variables do have an effect this is attributed to the fact that prices are not changed in every period. The latter problem is a standard one in many econometric examinations of empirical price data. The choice of when to change prices should be made endogenously (see Cecchetti, 1986, for a study of the frequency of magazine price changes). Secondly, the discrete nature of these changes might lead one to doubt the appropriateness of the differential game approach.

In the second paper Slade (1992) studies price wars amongst gasoline stations on a stretch of highway in Vancouver. The assumptions made are that there are N firms selling a differentiated product, each firm i faced with a demand curve

$$q_{it} = a_t - b_t p_{it} + d_t \sum_{j \neq i} p_{jt}.$$

All have a common discount factor d and are assumed to choose strategies of the form

$$p_{it} = p_t^* + R_t \sum_{j \neq i} (p_{jt-1} - p_t^*), \quad (6)$$

where R_t is the slope of the intertemporal reaction function and p_t^* the stationary equilibrium price corresponding to the period t parameters. If all the parameters were constant it is easy to see that the subgame perfect stationary equilibrium price for all players would be

$$p^* = \frac{a + bc - (N-1)\delta d c R}{2b - (N-1)d(1 + \delta R)}.$$

In this case with $R_t = R$ then $R = 0$ corresponds to Bertrand-Nash, while $R = d = 1$ corresponds to joint monopoly or perfect collusion.² This work is closely related to an earlier paper of Slade (1987) in which she came to the conclusion, using the same data, that the reaction function approach was more appropriate than using discontinuous punishment strategies.

The essential problem tackled by Slade is that of allowing for changes over time in the demand parameters. Thus her work differs from the literature already discussed in "Conjectural Variations ...", where the models are static, the data corresponds to stable demand and the purpose is to test the deviation of prices from non-competitive and competitive norms. Slade's purpose is to examine those

periods, "price wars", which correspond to the triggering of punishment strategies and are the result of exogenous demand shocks.³

Her findings are that the parameters of firms' strategies do change over time but that the process generating these changes is stationary, that firms react asymmetrically to other firms' price changes and finally that the steady state equilibrium pay-offs are above those for the Bertrand-Nash solution.

Two comments are in order. Firstly, if the distribution of the demand shocks were stationary, as her analysis suggests, allowing a richer strategy set might have eliminated price wars altogether. Thus one is led to wonder as to how much the results depend on that restriction. Secondly, the asymmetry of the reactions evoke the old "kinked demand" curve notion which, as Slade points out, has been revived in repeated game models by Anderson (1983) and MacLeod (1985).

Another empirical study of tacit collusion in a repeated game context is that by Rees (1991). He studies the salt duopoly in the U.K. in which the two participants have fixed capacity constraints and imports are effectively excluded. He found that profits were above those of the Nash equilibrium for the one-shot game and suggests that the strategies employed be assimilated to those involving retaliation which can sustain one of the equilibria of a repeated game. He rejects the hypothesis that the two salt firms had arrived at a Nash bargaining solution or at the joint monopoly solution of the one-shot game. It should be pointed out, however, that neither of these possibilities would be inconsistent with the Folk Theorem type of result (see Abreu, 1986, 1988, and Fudenberg and Maskin, 1986). The problem with Rees' analysis is that there are only five annual observations. Much of his discussion is based on additional information supplied by the report of the Monopolies and Mergers Commission. He mentions that price changes were always closely synchronised, though neither producer was directly identified as a "leader".

This brings us to a last observation on the problem of tacit collusion. A number of empirical studies have postulated the existence of a leader-follower situation. Two classic studies by Tennant (1950) and Nicholls (1951) of the interwar U.S. cigarette industry revealed a picture of fluctuating prices followed by a situation of price leadership and stable uniform prices. Strategic behaviour later seems to have been confined to advertising (see Schmalensee, 1972). A modern analysis of this situation would have insisted on the repeated game aspect of this situation. Furthermore it would point out that price leadership can itself be an equilibrium situation (see e.g. Deneckere et al., 1992, who introduce customer loyalty as one possible endogenous determinant of a price leadership equilibrium).

The same observation applies to other empirical analyses where price leadership is assumed rather than explained. Examples are Merrilees' (1983) examination of the Australian newspaper industry, Gisser's (1986) study on price leadership in U.S. manufacturing industries, and Kirman and Schueller's (1990) investigation of the European car market.

From the evidence of this section, one might be led to the conclusion that the Folk Theorem type of result is very negative for empirical work. Since almost any situation can be sustained as an equilibrium of a repeated game, and many such situations can be sustained by a variety of strategies, the only criterion seems to

be that profits should exceed those of the security level or the Nash equilibrium of the one-shot game where that equilibrium is unique. Thus not even joint profit maximisation is evidence of explicit collusion. In particular, players may be using very sophisticated strategies which will never actually be observed. Thus it may well be that the industry remains in a steady state with punishment only existing as a threat. The way round this in some of the papers already cited is to postulate external shocks which initiate changes in behaviour thereby revealing the strategies in use. This, however, raises the difficult question of how to distinguish between equilibrium strategies and adjustment to those strategies.

Although it is difficult to envisage what it is that one might observe that would be inconsistent with even relatively simple equilibria of a repeated or super game, this does not mean that we cannot learn anything from the actual outcomes observed empirically. A first step is to follow Slade in the papers cited and to test some of the simplifying assumptions used by game theorists to restrict the class of strategies allowed.

Secondly, from the welfare point of view, one positive aspect that might seem to emerge from all this is that welfare diminishing highly profitable outcomes are only a subset of the many possible equilibria. However, as Salop (1986) points out, citing several specific empirical examples, there is a growing awareness in the legal and in the economic literature of the existence of contractual arrangements between buyers and sellers to facilitate oligopolistic coordination. These arrangements may therefore provide evidence of deliberate collusive selection of particular outcomes, and this in turn may provide the empirical way to eliminate some of the excessively large class of solutions produced by the Folk Theorem type of result. This will, in turn, depend on our ability to identify econometrically particular collusive equilibria and a step in this direction has been made recently by Gasmi *et al* (1992), using the soft drink market as an example.

6 THE LEMONS PRINCIPLE AND EFFICIENCY

Bond (1982) provides what seems to be the first empirical test of Akerlof's (1970) Lemons Principle, according to which bad products drive out good products as the result of asymmetric information, because buyers only know the average quality but not the quality of an individual product. Bond considered the (American) market for used pick-up trucks, because there the demand is mainly non-commercial. Trucks were from one to five years old, to give time for the lemons effect to occur.

The measure of quality chosen is the amount of maintenance required on a truck, with a lemon being a truck that requires significantly more maintenance. Buyers should have difficulty in evaluating future maintenance from inspecting the truck and the lemons principle implies that the proportion of trucks that required major engine maintenance should be higher for trucks that have been purchased used than for trucks that have been purchased new, after controlling for lifetime mileage and model year. Tests on group means indicated almost no support for the lemons

principle in any of the model years and equally strong support for the hypothesis that trucks in the used market are superior. A logit model relating maintenance and lifetime mileage was also estimated, but no significant differences between new and used trucks were found.

Two years later, Pratt and Hoffer (1984) introduced two refinements to Bond's analysis. First, they notice that the survey used by Bond does not contain expenditure for maintenance data, so that the relative cost of repairs could not be taken into account: only differences in frequencies of maintenance were accounted for. Second, Bond treated the lemon characteristic as permanent, in that he compared trucks acquired new with trucks acquired used. To the contrary, a comparison of trucks purchased used during a specific time period with those held during that period (whether acquired as new or used) would capture a basic feature of a lemons market, namely the fact that the owner of a good-quality product is less likely to sell it. The latter group should contain relatively more of the good-quality trucks. With this sort of grouping, it is no longer necessary to correct for lifetime mileage or vehicle age which are known to the buyer and thus do not affect the buyer-seller informational asymmetry.

The appropriate test is then to check whether average maintenance expenditure is larger on vehicles that were recently traded within a period than on trucks that were not traded recently. The null hypothesis that there is no difference, that is, that the market for used trucks is not a lemons market, was rejected: the market for used pick-up trucks now appeared as a lemons market!

Bond's reply was immediate and challenged this conclusion, criticising Pratt and Hoffer for throwing away information on age and lifetime mileage that is available to the buyer. Bond's argument is this: "If 3-years-old trucks with average usage vary widely in quality and the variations cannot be observed by potential buyers, then those of lower quality will obtain the same price as those of higher quality and adverse selection will result. However, the fact that a 4-years-old truck becomes too costly to operate and is sold by its owner, while a 3-years-old truck owned by the same owner is not, is not necessarily related to the market for lemons because the buyer can observe the difference in age and anticipate costlier repairs." (Bond, 1984, p. 801.)

Reestimating this model using the Pratt-Hoffer definitions, but correcting for differences in age and lifetime mileage, Bond (1984) finds no difference in maintenance for trucks less than 10 years old. But he found more frequent repairs among trucks more than 10 years old that have been traded recently. The differences found by Pratt and Hoffer thus arose from the inclusion of very old trucks in their sample and from their failure to control for differences in characteristics that buyers can observe.

Very old trucks are generally not sold by dealers, while most trucks in the 1-10 years old category are sold by dealers. This tends to confirm Bond's earlier conclusion that the absence of a lemons market can be explained by the existence of counteracting institutions, such as warranties, that reduce or eliminate the asymmetry in information.

A logical next step is to ask whether, in the absence of adverse selection,

equilibrium prices of consumer durables such as cars reflect all available information about future service flows and maintenance cost, as suggested by the user cost approach to the pricing of durables (see Stokey, 1981, for example). Emons and von Hagen (1991) test this idea for the German automobile market where public information about the reliability of all cars of the same vintage class and make is available. They find that the hypothesis that consumers rationally use public information cannot be rejected empirically and thus corroborate related findings by Daly and Mayor (1983), Hartman (1987) and Kahn (1986), who demonstrated that used car prices in the U.S. reflect market information about increasing energy and fuel cost and product recalls.⁴ Another finding is that, while economic depreciation of a new car amounts to about one third over the first two years of its life, the depreciation is negligible between the ages of two and four years. Novelty effects are completely exhausted after two years and the services of cars of these vintages are regarded as perfect substitutes.

The underlying theory can be summarized as follows. Utility is derived from the flow of services of a car rather than the car itself. Therefore demand depends on the user cost (rental price) of these services, which measures physical decay and loss of novelty effects. This cost, γ_t , differs from type to type but is the same for all cars i of a given type. The equilibrium price a consumer is willing to pay is the price p_{it} such that

$$\gamma_t = p_{it} - \delta E p_{it+2} + \delta E c_{it}. \quad (7)$$

The right-hand-side of (7) is the cost of holding a car for 2 years, which is the sum of the expected capital loss $(p_{it} - \delta E p_{it+2})$ and the expected cost of maintenance $\delta E c_{it}$, where the discount factor is $\delta = (1 + r)^{-2}$.

Prices of different vintage classes of the same type are related through the depreciation factor ρ_t , such that

$$\gamma_t = \rho_t \gamma_{t-2}. \quad (t = 2, 4, \dots, T) \quad (8)$$

Consumer expectations of the selling price obey

$$E p_{it+2} = p_{it+2} + \varepsilon_{it} \quad (9)$$

where p_{it+2} is the observed current average price of all vehicles of the same type which are two years older than the car a consumer considers to buy. The term ε_{it} is the expected individual deviation, due to the consumer's particular way of driving and is zero on average. Consumer expectations of the cost of maintenance depend on the available public information about the reputation of the various brands and on regularly published official indices of technical quality. Private information again leads to individual deviations which sum to zero.

Under these assumptions, the structure of the observed quality indices is shown to induce a distribution of equilibrium capital losses and thereby of equilibrium prices. This is tested empirically using a regression of capital losses on the linearised cost expectation function per type.

7 AUCTION MARKETS

Economic theory distinguishes two polar cases: "independent-private-value" auctions on the one hand, and "common value" auctions on the other hand. In the former, also called Vickrey auctions, each buyer is supposed to know with precision how much the object being auctioned is worth to him or her, but is ignorant about the others' private values. The individual private values are independent and thus convey no information about any other buyer's value. In common value auctions, the item to be auctioned has a single objective value, but no one knows it. Bidders have differing estimates based in part on private information but also on publicly available information. Recent advances in the integration of formal theory and empirical analysis are most noticeable in the study of common value auctions. To these we turn first.

The work on US federal auctions of drilling rights on the Outer Continental Shelf (OCS) is exemplary. In their 1987 paper, Hendricks, Porter and Boudreau collect statistical regularities about these auctions for which a very rich data set is available.⁵ These numbers provide considerable support for the assumptions and predictions of the first-price,⁶ sealed bid, common value model. Hendricks and Porter (1988) go one step further and build a formal bidding model with asymmetric information,⁷ whose empirical predictions are tested.

The emphasis is on "drainage sales", that is, the simultaneous auction of tracts which are adjacent to tracts on which oil (or gas) deposits have already been discovered, as opposed to "wildcat sales" of tracts in areas that have not been drilled. In the latter, information is symmetric, since bidders only have seismic information which has essentially the same precision across firms. In the former, firms which own adjacent tracts can obtain information about the drainage tract that is being auctioned from their own on-site drilling on neighbour tracts. A neighbour firm is therefore better informed than non-neighbour firms.

A naive model might predict that non-neighbour firms will not bid in drainage sales. If this were the case, however, the neighbour firm would correctly anticipate this strategy and bid the reservation price (announced by the government) when worthwhile. But then the non-neighbours could bid slightly more and earn positive profits on average. In equilibrium, therefore, non-neighbour firms must participate in the auction. However, since neighbour firms know their estimates of the true value of the tract, the non-neighbour firms must use mixed strategies (pure strategies would be predictable and imply a certain loss) in order to have positive expected profits on some tracts. On average, though, their expected profits are zero in equilibrium, and this condition determines the equilibrium strategy of the neighbour firms.

The equilibrium properties of the model imply a number of empirical predictions:

1. The event that no non-neighbour firm bids occurs more frequently than the event that no neighbour firm bids. In fact, at least one neighbour firm participated in 83 percent of the auctions, and at least one non-neighbour firm participated in 68 percent of the auctions.

2. The neighbour firm wins at least one-half of the tracts. In fact, it won 62 percent of the tracts it bid on, paying about 56% of the *ex post* value of the tracts.
3. Expected profits to non-neighbour firms are zero. Average profit on non-neighbour winners was in fact virtually zero. As predicted by the model, it was positive on tracts which received a neighbour bid and significantly negative on tracts which received no neighbour bid.
4. Being better informed, neighbour firms should make earnings above average. That is what happened.
5. If only public information is taken into account, so that tract valuations are symmetric, then the distribution of the bids by the neighbour firm and that of the maximum of the bids by non-neighbours should be approximately the same. Maximum likelihood estimates of the joint distribution of these bids confirm this.
6. The estimates also show that the informed bid (by the neighbour firm, that is) is essentially independent of the number of uninformed bids, as predicted by the model.
7. The informed bid is an increasing function of the public signal (when a larger signal is good news), that is, of the profitability and the value of the adjacent tract.

Further findings are compatible with the hypothesis that neighbour firms did not compete against each other. Two-thirds of the sample of drainage sales had multiple neighbour firms. Competition among these should have tended to eliminate information rents. Yet, these rents were positive and large. There were 74 tracts with multiple neighbour firms, but only 17 tracts had multiple neighbour bids. Furthermore, net profits were not significantly lower on tracts with multiple neighbours than on tracts with one neighbour firm. Finally, bids of the neighbour firms are strictly decreasing in the number of neighbour firms. All this suggests that neighbour firms coordinated their bidding decisions and submitted one serious bid on tracts considered worthwhile.

Before turning to private-value auctions, a word should be said about the "winner's curse" which is said to occur frequently in common auctions. One way of defining it is to say that the winner is nearly certain to have overestimated the true value and therefore to have bid too high. Some descriptive studies of offshore leases⁸ suggest that in this sense the winner's curse does exist. This in turn suggests that winners were not able to correct their profit maximising bids for it, that is, did not optimize correctly. Consequently, to evaluate the existence of the curse and to evaluate the size of the overbidding empirically, there is a need for an equilibrium bid function that can be estimated econometrically.

Thiel (1988) works out such a function on the assumption that the winner overbids because he overestimates the true value (not because he overestimates the opponents' bids). Any bidder avoids the curse in equilibrium using a valuation

function whose expectation, conditional on winning, is an unbiased estimate of the value. Thiel uses the theory of order statistics to derive a functional form that is linear in the parameters and estimates this by linear least squares on data for highway construction auctions. Unfortunately, Levin and Smith (1991) show that this potentially most useful approach applies only in special cases that are of limited practical interest and arise only under circumstances that are unlikely in the real world.

In the area of private-value auctions, solid links between theory and estimation have also been slow to emerge. Until the end of the 1980s, empirical work mainly aimed at testing basic rather commonsense propositions, as emphasized by McAfee and McMillan (1987). This may result from the fact that each prediction of auction theory is based on a set of restrictive assumptions, which are not likely to be satisfied simultaneously in reality. For example, Vickrey's result that the expected revenue is the same for English, second-price sealed bid, Dutch and first-price sealed bid auctions⁹ disappears if there is risk aversion, or if the private values are correlated. Revenue equivalence has been tested using U.S. Forest Service sales of contracts for harvesting timber, since during one year both sealed bid and open auctions were used. Mead *et al.* (1981) find that sealed-bid auctions yield significantly greater revenue. Correcting for selection bias and making a distinction between the actual number of active buyers (which is known) and the number of bidders as defined by theory, Hansen (1985, 1986) finds that revenue equivalence cannot be rejected. What, however, if the valuations were in fact correlated, as is likely to be the case? Then theory predicts that the open auctions should have yielded the highest revenue!

Another favourite proposition is that the winning bid increases with the number of bidders. This is indeed the case in auctions for tax-exempt bonds, timber and off-shore drilling rights, according to Brannman *et al.* (1987). Note, however, that individual bids may decline as the number of bidders rises, if it were true that firms try to avoid the winner's curse: the more bidders, the more each bidder may want to correct his bid downwards — see Gilley and Karels (1981), and Hendricks, Porter and Gertler (1986).

Several interesting issues arise that are outside standard auction theory. One such issue is information acquisition in auctions that are repeated. Consider the common case of a government procurement agency that buys equipment or awards projects through first-price sealed-bid auctions at regular time intervals. Typically, it is badly informed about the evolution of production costs and about the number of active bidders in any period. On the other hand, it has an incentive to buy more or less today, depending upon whether the current price is lower or higher than tomorrow's expected price. To hold auctions frequently is a way to acquire relevant information. Feinstein, Block, and Nold (1985) show that bidders, once they become aware of this, have an incentive to collude in order to misinform the agency, thus skewing its intertemporal allocation to their advantage. To show this, Feinstein *et al.* first describe how the agency uses past data to improve its forecasts. They then show by which means a cartel can manipulate these forecasts to its advantage, and derive the optimal short-run and long-run cartel policy such that the cartel's presence will remain undetected. It is possible for a cartel to follow a policy that takes the profit of intertemporal demand allocation away from the agency and yet

confirms its belief that it faces a competitive market! Three strategic variables are identified about which the cartel misinforms the government: 1) the mean of the sealed bids submitted by cartel members; 2) the variance of the sealed bids submitted by cartel members; and 3) the number of long-run market suppliers. A case study of highway construction contracts shows that cartels increase this mean, reduce this variance and reduce the number of actual bidders. The details of a practical procedure used to this effect by a cartel of Belgian firms that supply the government through first-price sealed-bid auctions can be found in Philips (1988, pp. 120–121).

Corresponding mechanisms used in English and second-price sealed-bid auctions by cartels (called “rings”) are analysed by Graham and Marshall (1987). Interviews of bidders who regularly participate in rings and of auctioneers who regularly fight rings provided the following description of collusive behaviour: “First, a member of a ring never enters a truly competitive bid against another ring member. Second, rings employ procedures that ensure that the ring will win an item more highly valued by a ring member than by any non-ring bidder. Third, an item won by a ring becomes the property of the ring itself; the ultimate ownership of the item is determined in a secondary auction commonly known as a “knockout”, which is separate from the main auction and involves only ring members. Fourth, the gains obtained by the coalition are shared by all ring members rather than accruing to only the winning bidder or some subset of ring members. Fifth, auctioneers respond to the presence of coalitions by establishing higher reserve prices.” (pp. 1218–19) The collusive strategies of the coalition are shown to represent a noncooperative equilibrium.¹⁰

To fight rings, auctioneers have other means. In his study of wine auctions, Ashenfelter (1989) notes two practices that are unexplained by auction theory. One is that auctioneers are very secretive about whether and at what level they may have set a reserve price. Another is that the identity of the purchaser is not revealed. The secrecy about reserve prices may serve to thwart rings: some sellers may prefer not to have their goods sold later rather than risk a ring bidding to depress the price. By not revealing the identity of the purchaser, the auctioneer creates incentives for the ring members to deviate from the collusive agreement.

Finally, a breakthrough on the econometric front has to be mentioned. Laffort, Ossard and Vuong (1991) developed a general simulation-based econometric methodology for the empirical study of theoretical auction models, both private-value and common-value. They apply it to daily sales on the Dutch auction of eggplants in Marmande, France and are able to provide estimates of the parameters that characterize the distribution of the unobserved private values. In particular, an estimate is given for the (unknown) number of bidders, i.e. the size of the market, as opposed to the (observed) number of active participants.

8 CONCLUSION

In concluding it is worth reiterating what we said at the outset. Progress in applying recent developments in theory to empirical studies of product markets has been

far outstripped by those developments themselves. While there are many obvious reasons for this, model limitations, unrealistic assumptions about consumer characteristics or market structure, inappropriateness of definitions, and in particular, difficulties in obtaining data, none of these can justify the failure to pursue the two missions of empirical work, to confront the theory with the facts, and to simply establish salient facts about the way in which economies actually work. As should be apparent from this survey, however, there are encouraging signs of efforts to bridge the, until recently, widening gap between theory and empirical work in the area that we have considered.

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NOTES

¹Cabral (1991) shows that, in linear oligopolies and for an open set of values of the discount factor, there exists an exact correspondence between the conjectural variations solution and the solution of a quantity-setting repeated game with minimax punishments during T periods.

²Compare the discussion in the section on "Conjectural Variations ...".

³In her model, unlike that of Porter (1983), and Green and Porter (1984), all relevant variables are observable and price wars are not triggered by cheating, which cannot be directly detected.

⁴Other applications of the user cost approach include Berkovec (1985), Bresnahan and Yao (1985), and Wykoff (1973).

⁵For each tract, this set includes: date of the lease sale; location, water depth and acreage; which firms bid and the value of their bids; number and data of any wells that were drilled; and the annual production if any oil or gas was extracted. The drilling and production data can be used to calculate *ex post* value for each tract. Tracts are typically in a square grid pattern but vary in size.

⁶In a "first-price" auction, the highest bid is the price paid by the winner.

⁷Based on Engelbrecht-Wiggans, Milgrom and Weber (1983).

⁸See Capen, Clopp and Campbell (1971), Hendricks, Porter and Boudreau (1987), and Thaler (1988). Other studies suggest that oil firms avoid falling victims to the curse: see Mead *et al.* (1984), and Hendricks, Porter and Gertler (1986). See also Ashenfelter and Genesove (1992) on real-estate auctions.

⁹In an English auction the bids are publicly made and are ascending. In a second-price auction, imagined by Vickrey (1961), the player with the highest bid is the winner but pays the second highest bid. In a Dutch auction descending prices are announced and the winner is the first who accepts the current price.

¹⁰See also the recent paper by Porter and Zona (1992) on detection of bid rigging in procurement auctions. The data indicate that the bids of non-cartel firms were related to cost measures while the higher cartel bids were not.



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