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ECONOMETRIC ANALYSIS OF IMPERFECT COMPETITION AND IMPLICATIONS FOR TRADE RESEARCH

by

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In this paper, modern techniques for conducting market power studies are contrasted to traditional methods and then suggestions are made as to how these techniques can be applied in trade studies. Most of the emphasis in the paper is on the use of the new methods to identify and measure market power.

With the development of new industrial organization theory, innovations in econometrics, reduced costs of computing, and the availability of better data, new empirical techniques based on formal models of maximize behavior are replacing traditional approaches. Typically, in the traditional Structure-Conduct-Performance (SCP) approach, an accounting measure of profits or other measure of market power or structure is regressed on a variety of endogenous variables that are thought to reflect conduct using data from many industries. The link between these conduct variables and market structure is rarely made formal. In contrast, in a typical modern approach, market power is estimated directly using formal models that reflect exogenous institutional features of a particular industry. Because most of these modern studies use structural econometric models, parameter estimates are obtained that cannot be identified in the SCP reduced-form models, and more complex hypotheses can be tested.

This survey of the existing empirical literature, is limited to studies that address two major questions:

1) How much market power does a firm exercise?
2) What are the major factors that determine this market power?

The standard SCP paradigm is compared to two new approaches based on static and dynamic models.

The modern static approach is about two decades old, though most of the applications are less than ten years old. There are two major types of modern static models, both of which are based on a single period game model. They can be divided into full structural models and reduced-form or nonparametric models, both of which employ comparative statics to identify market power.

The more common approach is to estimate a full structural model of simultaneous equations for a particular industry, whereby estimates of an index of the market structure and of the marginal cost curve are obtained. Explanations of the causes of this market power are built directly into the structural model and institutional factors directly taken into account. This approach has been used with both firm-specific and industry level data.[1]

In the other static approach, reduced-form or nonparametric models are used to either directly measure market power, bound it, or test whether the data are consistent with one market structure versus another. In most of these studies, little attempt is made to examine the causes of the market power. One might choose this simpler approach rather than the richer structural models because of limits on data or as a way to avoid the specification bias due to choice of functional form.

The other dozen or so modern studies, henceforth loosely referred to as "dynamic," which are based on either repeated games or formal dynamic models with nonzero adjustment costs, date from the mid-1980s. Most of the repeated game studies are based on the "trigger-price" model, which is used to explain the formation and break-down of cartels or price wars.[2] To date, most empirical applications of this model concern a turn-of-the-century rail

[1] As this discussion is not intended for lawyers, "industry" and "market" are used interchangeably.

[2] Other new approaches based on game theory are beginning to appear. However, except for the trigger-price, repeated games and adjustment cost models, there are few such studies so describing a pattern among them is difficult.

road cartel. Although these studies concentrate on answering the second question, they provide an answer to the first question as well. The game-theoretic, dynamic models based on adjustment costs are of an even more recent vintage. Because they are based on a structural model, this approach also can be used to answer both questions.

There are, of course, hybrid and other approaches that do not fit neatly into these categories and are not discussed here. For example, another class of empirical industrial organization studies indirectly examine the second question by determining which industries have high rates of entry (showing either a lack of barriers to entry or unusually high profits).

Recently, Bresnahan (1989) thoroughly summarized most of the modern static approaches and Schmalensee (1989a) thoroughly summarized the SCP literature.[3] To avoid redundancy, and not because I disagree with them, I categorize the studies in a slightly different way, emphasize different issues, and compare and contrast the SCP and modern approaches, and discuss future applications to agriculture and trade.

In the first section, the two basic questions are described. In the next section, the traditional SCP paradigm is reexamined. The third section contains a discussion of identification in the modern static models and a brief survey of existing studies. In the fourth section, an analogous analysis of dynamic model is presented. Existing and future applications of these approaches to international agricultural markets and the new strategic-trade theory are discussed in the fifth section. The paper is then, mercifully, brought to an end with a final summary of my prejudices about these models.

The Basic Questions

Although all industrial organization economists probably would agree that "market power" is a meaningful logical construct, there is significant disagreement as to how best to measure it. For simplicity, in the following discussion, it is assumed that the appropriate measure is the gap between price and marginal cost.

If the n firms in an industry produce a homogeneous output ($q_1 = ... = q_n \equiv q$), industry output is $Q \equiv nq$; there is a single price, p; and the inverse market demand curve is

$$p = p(Q, Z), \tag{1}$$

where Z is a vector of other variables, such as income and the price of substitutes, that may affect demand. The *ith* firm's cost function is $C_i(q_i)$, and marginal cost (MC) is $C_i'(q_i)$. If we can directly measure MC, we can directly answer the first question: how much market power does a firm exercise? The answer is p - MC: the ability of a firm to raise price above marginal cost. To make this answer independent of the units of measurement of p and MC, we can use Lerner's (1934) measure,

$$L \equiv \frac{p - MC}{p}. \tag{2}$$

This construct answers the question, "How much market power does a firm exercise?" and not the question, "How much market power does a firm (in theory) possess?"

What determines this market power? Many of the answers given in the literature turn crucially on the elasticity of the residual demand curve facing a firm. All else the same, a firm's market power is a decreasing function of the elasticity of its residual demand curve. For

[3] See also the June 1987 issue of the *Journal of Industrial Economics*, entitled *The Empirical Renaissance in Industrial Economics*, edited by Bresnahan and Schmalensee, which contains a number of the most important recent papers and a brief summary of the literature by the editors (Bresnahan and Schmalensee, 1987). See also Geroski, Phlips, and Ulph (1985), which surveys the literature on measuring conjectural variations and monopoly power.

example, a farmer facing a nearly perfectly elastic demand is a price taker; whereas a firm facing a less elastic residual demand curve can set its price above its marginal cost.

The elasticity of the residual demand curve depends on the elasticity of the market demand curve, the number of firms in an industry, firms' cost functions, and the degree of product differentiation. To illustrate these effects, we start with a simple model of an oligopoly with a fixed number of identical firms, n, where the firms are playing Nash-in-quantities (Cournot), and then generalize the model as needed.

The profits facing a typical firm are

$$\pi = pq_i - mq_i,$$

where m is the constant MC. The first-order condition, given the Nash assumption, is

$$MR = p + p'q_i = m = MC,$$

which can be rewritten as

$$L \equiv \frac{p - m}{p} = -\frac{1}{n\varepsilon} = -\frac{s_i}{\varepsilon}, \tag{3}$$

where $s_i \equiv q_i/Q$ is the share of output of the *ith* firm. According to Equation (3), Lerner's measure equals the elasticity of the residual demand curve facing a firm, which can be written as $n\varepsilon$ or as s_i/ε, where $\varepsilon \equiv -(dQ/dp)(p/Q)$ is the market demand elasticity. That is, the residual demand elasticity is a function of the market demand elasticity, ε, and the number of firms, n, or, equivalently, the output share of each firm. As Cowling and Waterson (1976) have noted, this expression holds for each firm, so the weighted average price-cost margin for the industry equals

$$\sum s_i \frac{p - m}{p} = -\sum \frac{s_i^2}{\varepsilon} = \frac{HHI}{\varepsilon}, \tag{4}$$

where HHI is the Herfindahl-Hirschman Index. Thus, the markup depends on the market elasticity and the number of firms, n, or a measure of concentration in an industry (such as firms' output shares or the HHI).

If the industry is monopolistically competitive and firms enter until the marginal firm earns zero profits, then n depends on the average cost function of the firms. That is, both fixed and variable costs matter. Actions by governments or others that prevent firms from entering the industry (e. g., licensing laws, taxi medallions), similarly increase the residual demand elasticity and hence firms' market power. Actions by a firm to physically differentiate its product or to convince consumers that its product is different through advertising, raise the elasticity of demand the firm faces and hence its market power. Thus, these "explanations" for market power can be built directly into the demand curve, the cost curve, or a market equilibrium equation in a full-structural model.

The Structure-Conduct-Performance Paradigm

The now traditional SCP approach to empirical industrial organization research was a revolutionary change when first introduced by Edward S. Mason (1939, 1949) and his colleagues at Harvard. Most of the earliest work dealt with case studies of single industries (e. g., Wallace 1937).

The SCP model, for the first time, used inferences from microeconomic analysis to discuss industrial organization. In the SCP paradigm, an industry's performance depends on the conduct of sellers and buyers, which depends on the structure of the market. The structure, in turn, depends on basic conditions such as technology and demand for a product. The exact connections, however, are not normally specified in detail. Although this approach is much more rigorous than the purely descriptive tradition that it replaced, it is often attacked as being more descriptive than analytic.

For years, George J. Stigler (1968) and others have argued that one should, instead, use price theory models based on explicit, maximizing behavior by firms (and governments). Mason's colleague Edward H. Chamberlin (1933) provided one theoretical approach that is widely used today in empirical work. In recent years, others have suggested replacing the SCP paradigm with analyses that emphasize transaction costs (Williamson, 1975) or game theory (Von Neumann and Morgenstern, 1944).[4]

The original empirical applications of the SCP theory were by Mason's colleagues and students, such as Joe S. Bain (1951, 1956). In contrast to the earliest SCP industry studies, these studies made comparisons across industries. In these early studies, industry-level data were used (largely because, until recently, firm-specific data were not available).

There are two stages to a typical SCP study. First, a measure of market power is obtained through direct measurement or calculation rather than through estimation. Second, that measure is regressed on a number of variables that are thought to "explain" the difference in market power across industries.

Direct Measurement

If a researcher has adequate data, a measure of the degree of market power can be obtained directly. For example, an expert witness in a law case who has detailed information about a firm's marginal cost and price can calculate Lerner's measure directly by simple arithmetic.

Unfortunately, academic researchers rarely have such detailed information about marginal costs.[5] As a result, other approaches to directly measuring market power have been used. Most such studies use measures of profits, rates of return, book value (stock prices or Tobin's *q*), and price-cost margins.[6] Most of these measures are significantly and fundamentally flawed due to data and conceptual problems (Leibowitz, 1982; Fisher and McGowan, 1983; Benston, 1985; Fisher, 1987; Carlton and Perloff, 1990).

There are several common problems. For example, many, if not most, measures of price-cost markups actual used are based on average variable cost (excluding capital and advertising costs) and not marginal cost measures. Except for competitive firms in long-run equilibrium, there is no reason to think that average cost measures are good approximations of marginal cost. These measures are biased and the bias may depend on the rental value of capital, the value of output, and other factors.[7] The use of average cost, of course, has even more problems.

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[4] A more detailed discussion of the various modern theories and a comparison of the SCP approach and the new industrial organization are presented in Carlton and Perloff (1990).

[5] A few studies have tried to measure marginal costs by estimating cost functions. See, for example, Keeler (1983) and Friedlaender and Spady (1980).

[6] Examples of studies that use Tobin's *q* include Thomadakis (1977); Lindenberg and Ross (1981); Salinger (1984); and Smirlock, Gilligan, and Marshall (1984).

[7] Suppose that MC is constant and that $MC = AVC + (r + \delta)K/Q$, where K/Q is the capital to output ratio and AVC is the average variable cost. If AVC is used instead of MC, the approximation to Lerner's measure, L', is

$$L' = (p - AVC)/p = -1/\varepsilon + (r + \delta)K/(pQ) = L + (r + \delta)K/(pQ).$$

The extra term added to L is the rental value of capital divided by the value of output (Carlton and Perloff, 1990, pp. 367-8).

Measures of the market value of a firm's assets can be obtained by summing the values of the securities that a firm has issued (stocks and bonds); however it is much more complicated to obtain an estimate of the replacement cost of its assets, especially if used equipment markets do not exist. Most researchers who construct Tobin's *q* ignore the replacement costs of these intangible assets (hence *q* could exceed 1 even in the absence of market power).

Most measures of profits or rates of return suffer from even more problems. Most use business as opposed to economic definitions of costs, employ arbitrary depreciation rules, do not treat costs of advertising and research and development reasonably, ignore or inaccurately measure tax rates, and only crudely deal with risks. These measures are particularly subject to bias if the industry is out of equilibrium (Brozen, 1971). Nonetheless, SCP economists have often found that these flawed measures are the only ones available.

SCP Regressions

In the typical empirical implementation of the SCP theory, a reduced-form analysis is used to show the relationship between the calculated measure of market power and various "structural" factors that are hypothesized to be related to barriers to entry (e. g., advertising), concentration (e. g., market share), and costs (e. g., capital-labor ratios).

As shown above, there is a theoretical relationship between a measure of concentration, the HHI, and Lerner's measure. Most SCP studies include a measure of concentration on the right-hand side, though, the four-firm concentration ratio, C4, is more commonly used. In most SCP studies, the main result is said to be the statistical significance (or lack thereof) of the coefficient on the concentration term.

A number of measures that are supposed to reflect "barriers to entry" are also included, such as the efficient firm size, advertising intensity, capital intensity, and various subjective measures. Unfortunately, most SCP studies do not carefully distinguish between short-run and long-run barriers to entry, and hence may of these measures could be challenged on theoretical as well as measurement grounds (Carlton and Perloff, 1990). Other less commonly used measures include buyer concentration and unionization (Ruback and Zimmerman, 1984; Salinger, 1984).

Weiss (1974) found that most early SCP studies reported a relationship between these measures of market power and concentration and barriers to entry. More recent studies, however, find that this correlation has diminished or disappeared over time.

For example, in a recent study, Domowitz, Hubbard, and Petersen (1986) regress a measure of (p - AVC)/p on C4, K/Q (the ratio of the book value of capital to the value of output), and other variables. For a typical industry in 1958 with a K/Q of roughly 40% and a C4 of 50%, there regression implies that price was approximately 30% above average variable cost. If however the concentration ratio doubles so that C4 = 100%, price rises to only about 40% above variable costs. More importantly, they find that the relationship between industry-level price-cost margins and industry concentration weakened substantially over their time period (1958 to 1981).

Problems with the SCP Approach

There are at five major problems with most SCP studies (Carlton and Perloff, 1990). First, the proxies for market power and right-hand-side variables have conceptual and measurement problems. For example, many studies fail to including the costs of capital and advertising in the market power measure. Some studies then use those variables on the right-hand-side of the equation to try to control for this measurement error. As a result, the coefficients on those variables are biased. Some of the right-hand-side variables suffer from measurement errors as well. For example, U. S. Census concentration ratios do not include imports. Further, many of the studies have difficulties with multiproduct firms. Because the Census assigns firms to industry categories based on the primary products they produce, total value of production data may include output from unrelated lines. This problem is largely eliminated by looking at lines of business data, which some studies have done in recent years.

Second, a correlation between market share and profits may not imply inefficiency. High short-run profits can occur in even highly competitive industries if entry takes time. Thus, one should use a long-run profits measure; yet short-run measures are typically used.[8] Moreover, a very concentrated industry should not show much market power unless there is also a barrier to entry, as the contestability literature argues (Baumol, Panzar, Willig, 1982). Further, as Demsetz (1973) and Peltzman (1977) note, a link between profits and concentration may only show that the largest firms are more efficient or innovative than others. If this reasoning is correct, a firm's success may be explained by its own market share and not by industry concentration. Some recent SCP-type studies give some support to that view (Kwoka and Ravenscraft, 1985). Thus, the result that SCP studies highlight — the relationship between a profits measure and a concentration measure — tells us very little if anything.

Third, cross-sectional comparisons that relate profits, price-cost margins, or Tobin's *q* across industries to differing levels of concentration in these industries may have serious biases due to violations of the symmetry of industries assumption. SCP studies of these industries implicitly assume that the relationship between market power and concentration is the same in all industries. That is, the demand elasticities are the same in all industries. Thus the SCP results may reflect only differences in elasticities of demand. It is, therefore, much safer to examine one industry over time as its degree of competition changes (say due to government intervention), which is the approach used by most of the modern studies.[9]

Fourth, most SCP studies assume an implausible linear relationship between concentration and performance. An S-shape relationship is more likely (as an industry approaches complete concentration, profits must approach the cartel level). White (1976) and Bradburd and Over (1982), however, examine whether there is a critical level of concentration below which price is less likely to rise as concentration increases.

The fifth problem, is that most studies incorrectly implicitly assume that all the right-hand side variables are exogenous and use ordinary least squares. That assumption is completely inconsistent with the SCP theory (and reality). Performance, structure, and conduct are *simultaneously* determined. For example, high short-run profits may induce entry and thereby lower concentration. Thus, using ordinary least squares to regress a measure of performance on a concentration ratio is not right.[10] Because the structural variables are simultaneously determined, a SCP equation should be viewed as a quasi-reduced-form and not a proper reduced-form equation (analogous to a Phillips Curve). Great care, therefore should be exercised in interpreting the SCP results. It does not make sense to say that an endogenous variable "causes" another endogenous variable. Rather, one should examine how exogenous variables affect endogenous variables, as is done in most modern studies.

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[8] A number of studies look at the rate at which profits are eroded to show this erosion of profits over time as entry occurs. Stigler (1963), Connolly and Schwartz (1985), and Mueller (1985) find that high profits often decline slowly in concentrated industries. By analyzing both the level of market power and the rate at which it changes, an analyst can distinguish between short- and long-run effects.

[9] There are a few SCP studies that examine a single industry. Most of these deal with regulated industries such as banking, airlines, and railroads (see the survey in Carlton and Perloff, 1990, pp. 383-385).

[10] Weiss (1974), however, reports estimates of SCP equations using instrumental variables techniques that produce qualitatively similar results to the ordinary least squares estimates. Similarly, Graham, Kaplan, and Sibley (1983) test for the exogeneity of their concentration measures. Although they cannot reject exogeneity, the coefficients change substantially when they are treated as exogenous.

The Value of SCP Studies

There can be little doubt that the original SCP studies were very important, very useful, and a major step forward when first introduced. One might wonder, however, why they are still being used. With a few important exception, most recent SCP studies merely apply the same time-honored approach to one more data set.

The main benefit of the SCP studies is that they have made cross-industry comparisons; whereas most modern studies have not. The use of cross-industry comparisons is a two-edged sword. As discussed above, the symmetry across industries assumption necessary to make such comparisons may be false. If it is not, however, cross-industry comparisons can answer questions that studies of a single industry cannot, such as the role of entry barriers.

The key disadvantage (beyond the mere repetitiveness of these studies) is that they apparently involve regressing white noise on white noise. In a very interesting and reassuring recent paper, however, Schmalensee (1989a) has addressed the data quality issue. Because of the well-known flaws in various accounting measures of profitability, Schmalensee uses 12 different measures in a SCP type study. Strikingly, although these 12 measures are not highly correlated, many of his key SCP results hold over all measures. One of his conclusions, however, is that his work argues for the use of dynamic models.

Recently, Schmalensee (1985, 1987, 1989a, 1989b) has made other important contributions as well. For example, he uses a SCP-type approach (in some cases, apparently, because limited accessibility to the data prevented the use of more complex structural models) to distinguish between intra-industry profitability differences and inter-industry behavioral difference. A few other researchers have recently made important improvements in the original SCP cross-sector approach by testing formal theories. For example, Domowitz, Hubbard, and Petersen (1987) use an SCP-like method to examine trigger-price game theory predictions.

Some recent papers have also started using more disaggregate, better quality data. Instead of using Census industry-level data, some studies (e. g., Schmalensee, 1987, and Cubbin and Geroski, 1987) have used Census line-of-business data or industry-level data from other sources. Similarly, others have looked at cross-section studies of similar markets that are geographically close using a measure of price (which is conceptually cleaner than the profits measures) such as Lamm (1981) and Cotterill (1986) on retail food and Marvel (1978) on gasoline suppliers.

Modern Static Models

In the last two decades, relatively complete structural econometric models based on formal profit-maximizing theories have been used to examine market power. This new approach has two key advantages over the traditional approach. First, in the modern approach, marginal costs and market power are estimated from a structural model rather than employing a seriously flawed approximation. Second, using a structural model, one can formally model how various factors affect the market power, unlike in a reduced-form model.

Apparently, the first "modern" study that used a formal model of imperfect behavior to estimate a model based on firm-specific data in a single industry is Rosse (1970). The six other most influential early studies are Iwata (1974), Applebaum (1979, 1982), Gollop and Roberts (1979), Just and Chern (1980), and Bresnahan (1981).[11] These studies are all based on formal profit-maximizing models and structural econometric models. Some use firm-level data and others use industry-level data. The key insight of this general approach is that market power can be identified by exogenous shifts in demand or cost curves.

[11] The other major early conceptual work was Rohlfs (1974); however, it did not contain an empirical application. Iwata's study is not a pure example of this new approach because it uses accounting data.

Identification

Market structure is identified by comparative statics results. Typically, a researcher knows the equilibrium price and output and can estimate the demand curve but does not, initially, know the marginal cost curve. With this initial information, one cannot determine the market structure. If a shock occurs (a shift in an exogenous variable) that would have a different effect depending on the market structure, then the structure can be identified. This idea of using comparative statics, of course, has been well-known to theoretical public finance economists, who have examined the differential effects of taxes on equilibria depending on market structure, but empirical industrial organization applications are recent. Articles have used shocks that affect the residual demand curve facing a firm and those that affect costs to identify the market structure. Residual demand curves are affected by shifts in the market demand curve and other factors such as tax rates and the supply of other firms.

Market Demand Information

Although the same story can be used whether one uses industry-level or firm-specific data, it is easier to present the basic story using a model with aggregate data.[12] Suppose that an industry consists of a number of identical firms that produce a homogeneous product, Q. The market demand curve is equation (1): $p = p(Q, Z)$, where p is the single price in the market, and Z is a vector of other factors that affect demand such as income and the price of substitutes. Industry revenues are $R \equiv p(Q; Z)Q$.

Let

$$MR(\lambda) \equiv p + \lambda p_Q Q, \tag{5}$$

be called effective (or perceived) marginal revenue, where λ is a parameter to be estimated and $p_Q \equiv \partial p/\partial Q$. If there is one firm in the industry that acts like a monopoly, $\lambda = 1$ and effective MR(1) is the usual MR measure: $p + p_Q Q$. If the firms in the industry act like price takers, then $\lambda = 0$ and effective MR(0) equals price. That is, these firms act as though they face a horizontal demand curve at an exogenously determined price.

The aggregate marginal cost curve facing the industry is MC(Q; W), where W is a vector of various exogenous factors that influence cost such as weather and factor prices. In the (possibly) noncompetitive equilibrium, effective marginal revenue equals marginal cost:

$$MR(\lambda) \equiv p + \lambda p_Q Q = MC(Q; W). \tag{6}$$

By estimating equation (1), we can obtain an estimate of the slope of the demand curve, p_Q. Based on that estimate and an estimate of the "optimality" equation (6), we can then, if everything is identified, obtain an estimate of λ and MC.

This approach can be illustrated using a linear example. Suppose that the demand curve, equation (1), is[13]

$$p = \alpha_o + \alpha_1 Q + \alpha_2 Z + \alpha_3 ZQ + \varepsilon_1. \tag{1'}$$

If so, optimality equation (6) is

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[12] The following discussion on the role of market demand shocks is based on Just and Chern (1980), Bresnahan (1982), and Lau (1982).

[13] This linear example and Figures 1 and 2 are analogous to those in Bresnahan (1982). Unlike in Bresnahan, however, price is written as a function of quantity rather than the other way around because that leads to a simpler expression in the optimality equation.

$$MR(\lambda) = p + \lambda p_Q Q = p + \lambda(\alpha_1 + \alpha_3 Z)Q = MC. \qquad (6')$$

If the marginal cost curve is linear,

$$MC = \beta_0 + \beta_1 Q + \beta_2 W + \varepsilon_2,$$

the optimality equation (6') can be rewritten as

$$p = \beta_0 + (\beta_1 - \lambda\alpha_1)Q - \lambda\alpha_3 ZQ + \beta_2 W + \varepsilon_2. \qquad (7)$$

Thus, by regressing p on a constant, Q, ZQ, and W, we obtain an estimate of $-\lambda\alpha_3$ for the ZQ term.[14] Dividing that term by the estimate of α_3, $\hat{\alpha}_3$, from the demand equation (1'), we obtain an estimate of the market structure parameter, λ. The reason that λ is identified is that the demand curve rotates with Z, due to the ZQ interaction term, tracing out the MC curve. Once we know MC, we can use the information about price from the demand curve to determine λ.

If we do not have a ZQ term (that is, if $\alpha_3 = 0$), λ may not be identified. The only remaining term with a λ in equation (7) is $(\beta_1 - \lambda\alpha_1)Q$. Although we know α_1 from the demand equation (1'), that is not enough to identify λ because the estimated coefficient also depends on β_1 (the slope of the MC curve).

The need for the demand curve to rotate is illustrated in Figure 1. Initially, we observe the market equilibrium, E_1, price and quantity. The researcher can estimate demand curve D_1 (and, hence, can infer the marginal revenue curve, MR_1) but does not directly observe costs. The observed equilibrium, E_1, is consistent with a competitive industry structure and a marginal cost curve MC_c, where the equilibrium, E_1, is determined by the intersection of MC_c and D_1. It is also consistent with a cartelized market structure and a lower marginal cost curve, MC_m, where E_1 is determined by the intersection of MC_m and MR_1 (as indicated by a hollow circle).

If $\alpha_3 = 0$, and Z increases by ΔZ, the intercept of the demand curve shifts up by $\alpha_2\Delta Z$, as shown for the new demand curve, D_2. The new equilibrium, E_2, is still consistent with either of the two marginal cost curves. Thus, we cannot determine from this shift in Z if the industry is competitive or cartelized.

In contrast, if $\alpha_3 \neq 0$, a shift in Z allows us to determine the market structure. In Figure 2, when Z increases, the new demand curve, D_3, rotates around the original equilibrium. As shown, if the industry is competitive and the marginal cost curve is MC_c, the equilibrium associated with D_3 remains E_1; whereas, if the industry is cartelized and the marginal cost curve is MC_m, the new equilibrium is E_3.

Lau (1982) gives conditions for shifts in a demand curve to identify λ.[15] Virtually any functional form for the demand curve leads to identification except the two most commonly used forms: linear or log-linear. If one wants to use a basically linear specification, one must add an interaction term, a squared term in output, or something else that adds some nonlinearity and allows the demand curve to rotate. The problem with the linear or log-linear forms, as Lau points out, is that they are separable in a function of Z, which leads to the parallel shift of the demand curve discussed above, which does not allow us to identify λ.

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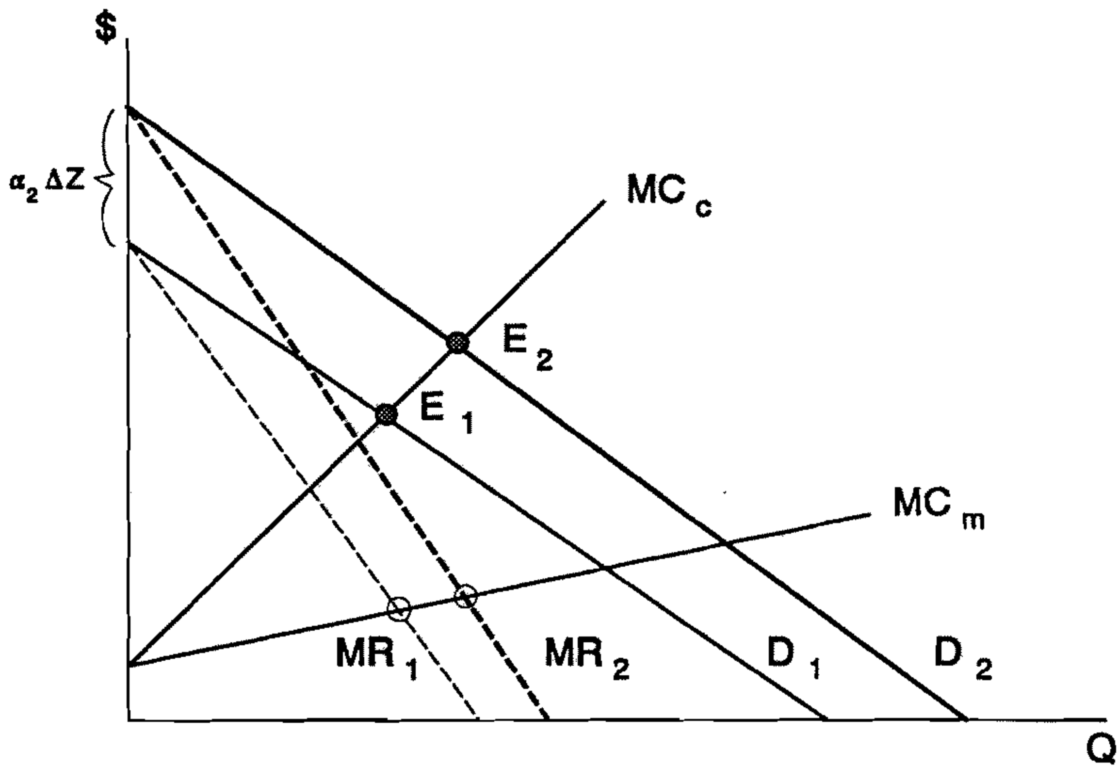
14 Instrumental variables techniques must be used, treating Q and ZQ as endogenous variables.

15 Lau shows that if the industry inverse demand and cost functions are twice continuously diferentiable, λ cannot be identified from data on industry price and output and other exogenous variables Z and W alone if and only if the industry inverse demand function $p = D(Q, Z)$ is separable in Z but does not take the special form $p = Q^{-1/\lambda}r(Z) + s(Q)$.

Figure 1
Not Identified: Parallel Shift of the Demand Curve



Residual Demand Information

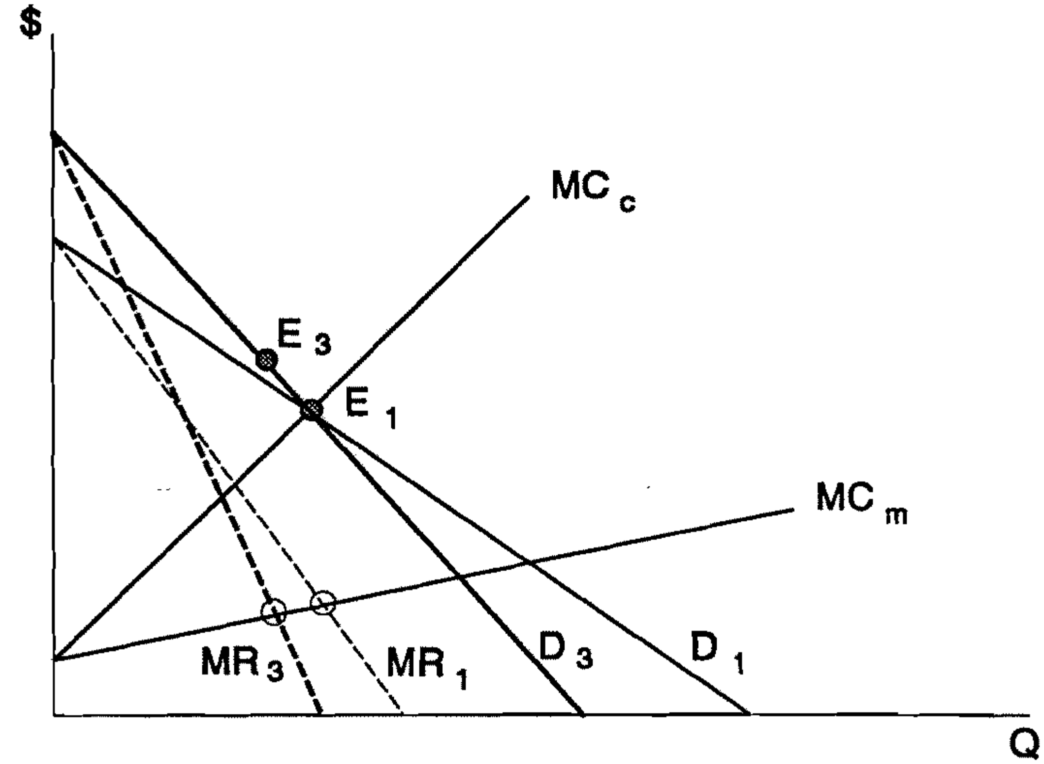
Anything (not just variables in the market demand curve) that cause the residual demand curve facing a firm to rotate can identify λ. For example, a dominant firm's residual demand curve is the market demand curve minus the supply of a competitive fringe. If the fringe supply curve rotates, the residual demand curve rotates even if the market demand curve does not (Buschena and Perloff, 1991).

Similarly, a shift in an ad valorem tax rate, t, can identify the market structure, as shown in the linear example in Figure 3. The original demand curve is D and the original equilibrium is E. After the tax is imposed, the effective demand curve facing the firms is (1 - t)D. If the market is competitive, the new equilibrium is E_c; whereas, if the market is cartelized, the new equilibrium is E_m. Thus, price rises less in a noncompetitive market. Even with a linear demand curve with no interactive terms ($\alpha_3 = 0$), the imposition of an ad valorem tax identifies the market structure because it causes the after-tax demand curve to rotate so that $E_c \neq E_m$.

Cost Information

Cost information can also identify the market structure. For example, it is still possible to identify the market structure parameter, λ, even if the demand curve does not rotate ($\alpha_3 = 0$), if the marginal cost curve is constant in Q ($\beta_1 = 0$): $MC_Q = 0$. Because $MC = \beta_0 + \beta_2 W$, marginal cost is a constant in any given period, but that constant shifts with exogenous factors W over time. The coefficient on the Q term is now $(\beta_1 - \lambda\alpha_1) = -\lambda\alpha_1$, so by knowing α_1 from the demand curve, we can identify λ. Thus, $\beta_1 = 0$ is a sufficient condition for identification. The

Figure 2
Identified: Rotation of the Demand Curve



use of cost information to identify is discussed further below.

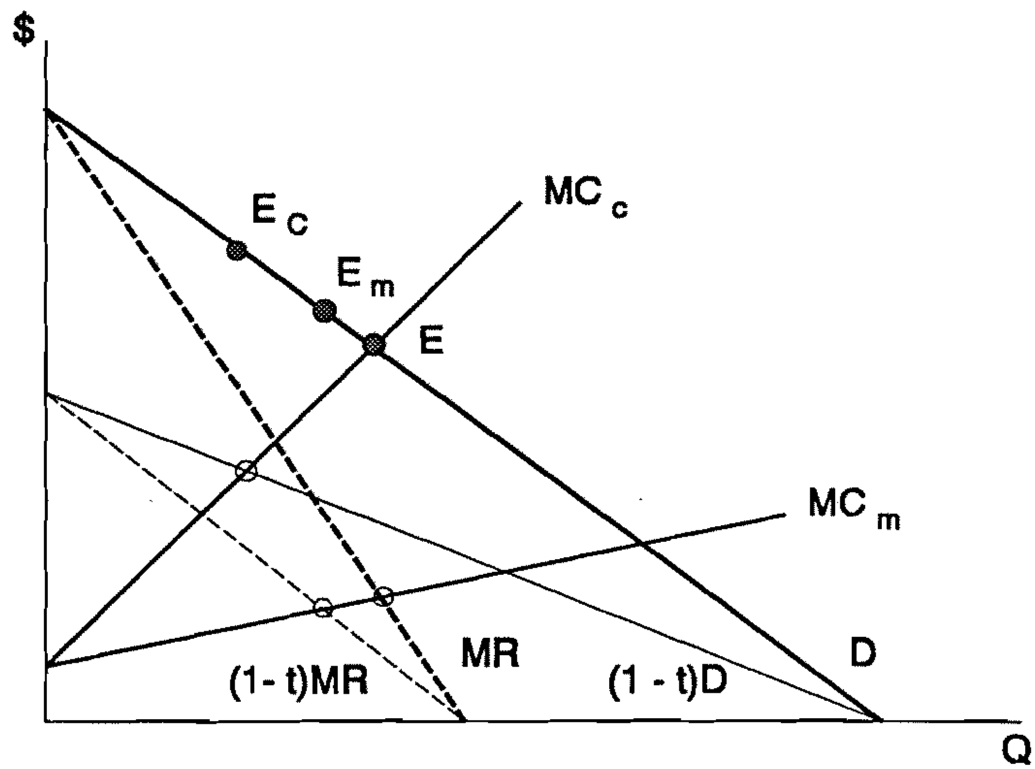
Interpretation

These models can be interpreted in at least two ways.[16] In the more general way of interpreting the econometric results, the gap between marginal cost and price is determined without explicitly modelling the behavior of firms. That is, one remains agnostic about the precise game the firms are playing and only attempts to measure the amount of market power in the equilibrium. An alternative approach is to assume that firms use conjectural variations and to estimate these variations. This difference, however, is only one of interpretation; the same equations are estimated in either case.

The general interpretation of λ is a measure of the gap between price and marginal cost: $p - MC = \lambda(\alpha_1 Q + \alpha_3 + QZ) = -\lambda p_Q Q$. In the linear example, $\lambda = -(p - MC)/(\alpha_1 Q)$. Lerner's measure is

[16] The discussion of the two interpretations of the results follows Karp and Perloff (1991) and Bresnahan (1989).

Figure 3
Identified: Shift Due to an Ad Valorem Tax



(8)
$$L \equiv \frac{p - MC}{p} = -\frac{\lambda p_Q Q}{p} = \frac{\lambda}{\varepsilon}.$$

That is, λ takes on the role of n, s_i, or HHI in equations (3) and (4). It can, therefore, be interpreted as an index of market power or structure.

Alternatively, some economists interpret λ as a conjectural variation. If all n firms have same cost function $c(q_i)$, Firm i's optimality condition is

$$p + p'q_i(1 + (n - 1)v) = MC \tag{6"}$$

or

$$p + p_Q Q\left(\frac{1 + (n - 1)v}{n}\right) = MC,$$

where v is its conjectural variation about each of its rivals. Because, from (6), we know that $p + p'Q\lambda = MC$, it follows that

$$\lambda = \left(\frac{1 + (n - 1)v}{n}\right)$$

In a duopoly with identical firms, $\lambda \in (0, 1)$, $v \in (-1, 1)$, and $L \in (0, 1/\varepsilon)$:

λ	v	L	Market Structure
0	-1	0	Competition
½	0	$1/(2\varepsilon)$	Cournot-Nash
1	1	$1/\varepsilon$	Cartel

If data for individual firms exist, separate optimality equations may be estimated for each firm. Moreover, if time series data are available, one can estimate separate conjectures by Firm i for each Firm j, v_{ij} (e. g., Spiller and Favaro, 1984; and Gelfand and Spiller, 1987). For example, Gollop and Roberts (1979) and Roberts (1984) use differences between firms to examine whether large firms are leaders and small firms are followers.

Indeed, if time series data exist, one can allow these market structure coefficients vary over time: in Just and Chern (1980), shifts occur due to change in technology and other factors; and, in Buschena and Perloff (1991), shifts occur because of changes in institutions and laws. Similarly, one can allow the estimated coefficients to be functions of various exogenous variables. For example, Slade (1986) allows for conjectures varying with firm characteristics. Some studies, however, inappropriately make λ a function of firm size, which is an endogenous variable.

Game theorists argue strenuously against using conjectural variations models because they are not logically consistent. It is for that reason that, increasingly, empirical studies refer to λ or v as measures of market power or structure rather than as conjectural variations, but this distinction is purely a matter of terminology. Thus, it is due to intimidation by game theorists that I refer to "static structural" models instead of "conjectural variations" models, unlike most of the literature.

Applications

Very lucky (or, perhaps, very hardworking) economists who obtain firm-specific data can simultaneously estimate a structural model for all the firms in and industry. In these models, firms may (but need not) behave differently. Two of the earliest studies, Iwata (1974) and Gollop and Roberts (1979), estimated models of behavior of some or all of the firms in an industry using a conjectural variations interpretation.

Applebaum (1979, 1982) and Sumner (1981) showed that one could estimate conjectural variations models using aggregate data, if one is willing to make some heroic symmetry assumptions about firms. Just and Chern (1980) showed, however, that one need not use a conjectural variations interpretation to estimate aggregate (or, for that matter, firm-specific models).

One can also estimate hybrid models that use both firm-specific data and market data. For example, in Karp and Perloff (1989a), data on some firms and for the aggregate industry were used. In Buschena and Perloff (1991), data for a dominant firm and for a competitive fringe were combined.

Some of the more interesting recent applications have used Hotelling rather than Chamberlinian models. That is, product differentiation is taken explicitly into account, which can help identify market structure. See, for example, Bresnahan (1981, 1987).

As discussed above, the crucial factor that one needs to examine the degree of market power is the elasticity of the residual demand curve. Thus, a number of more recent studies have explicitly concentrated on estimating the residual demand curve and have used the more general interpretation of λ. For example Baker and Bresnahan (1988) show that one can estimate the elasticity of a single firm's residual demand without having to estimate the demand cross-elasticities by substituting equations for the prices of other firms (i. e., using a quasi-reduced-form approach). Spiller and Favaro (1984), Suslow (1986), Gelfand and Spiller (1987), Slade (1987) also esimate residual demand curves. In these studies, based on estimates of the elasticities of demand, supply, and competitive interaction, the market power of any particular firm can be calculated, even where products are differentiated across firms.

Most of the applications to date concern manufacturing or agricultural markets. Some of the static agricultural market applications (oligopoly and oligopsony) include:

Gollop and Roberts (1979)	coffee roasting
Just and Chern (1980)	tomato harvesting
Sumner (1981)	cigarettes
Lopez (1984)	Canadian food processing
Roberts (1984)	coffee roasting
Sullivan (1985)	cigarettes
Ashenfelter and Sullivan (1987)	cigarettes
Lopez and Dorsainvil (1988)	Haitian coffee
Schroeter (1988)	beef packing
Baker and Bresnahan (1988)	breweries
Schroeter and Azzam (1990)	beef and pork
Azzam and Pagoulatos (1990)	meat packing/live animals
Buschena and Perloff (1991)	coconut oil

Non-Parametric and Reduced-Form Models

Starting with Rosse and Panzar (1977), industrial organization economists have developed a variety of new empirical approaches that use comparative statics properties to identify market structure without estimating complete structural models of an industry by using reduced-form or nonparametric models. The advantages of this approach are that it requires less data and fewer functional form assumptions.

Panzar and Rosse (1987) show that comparative statics yield testable restrictions on firms' reduced-form revenue equations that depend on the market structure. In their examples, the sum of the factor price elasticities of a firm's reduced-form revenue equation must be nonpositive for a monopolist, less than or equal to one in a symmetric Chamberlinian equilibrium, and equal to one in a long-run competitive equilibrium. Using this result, one can determine the effect of an increase in costs without having cost data. To actually estimate the degree of market power, however, turns on having additional information or making some strong assumptions. This methodology is used in Rosse and Panzar (1977) and Shaffer (1982).

Ashenfelter and Sullivan (1987) use a revealed preference approach to construct a nonparametric test of market power. Because this methodology is nonparametric it is not subject to specification bias due to the choice of a functional form. Changes in excise taxes are used to identify market structure by allowing us to assess firms' reactions to exogenous variations in marginal cost. That is, whereas the Panzar-Rosse approach asks about the comparative statics effects of an equal proportional change in all factor prices, this approach examines what happens as only one factor (taxes) affecting after-tax marginal cost changes. Rather than explicitly estimating a market structure parameter, they obtain a bound on the market structure parameter. That is, they determine which market structures are consistent with the data. As in Panzar-Rosse, they have a one-sided test in the sense that they only can test a structure against a more competitive alternative.

Hall (1988) uses a comparative statics approach to examine the relationship between changes in inputs and outputs. He concludes that because the cyclical variations in labor inputs are small relative to the cyclical changes output, "U. S. industries have marginal costs well below price" (p. 921). He is forced to test the hypothesis of competition subject to the maintained assumption of constant returns to scale. Thus, he may reject the joint null hypothesis due to failures for either reason. His key test can be viewed as nonparametric; however, to estimate the actual market structure parameter, a reduced-form model is used. The strength of his approach is that it is easily applied because it has relatively few data requirements, an estimate of λ is obtained, and one need not carefully estimate both demand and optimality equations. It's key disadvantage is that one must maintain the assumption of constant returns to scale.

Both the structural and nonstructural models are based on the same theoretical models and make use of comparative statics. The nonstructural models, however, are more likely to emphasize shifts of costs than are the structural models. For example, in the discussion of identification of the static structural models (Bresnahan, 1982, and Lau, 1982) a shift in the demand curve was used to identify and measure the market structure parameter. Similarly, Just and Chern (1980) use a shift in technology to identify the degree of monopsony power. Panzar and Rosse (1987), Hall (1988), and Ashenfelter and Sullivan (1987) use cost shocks to distinguish between market structures.

Proponents of the nonstructural approach sometimes criticize the structural model approach because it requires testing a hypothesis about market structure under the maintained hypothesis about functional form. It should be pointed out, however, that these type of joint hypotheses are not avoided in the nonparametric comparative statics literature. Typically, one must make even stronger assumptions to be able to identify the market structure parameter. For example, assuming constant returns to scale (as Hall must) is stronger than assuming marginal cost is linear.

Consider, for illustration, a study that uses a change in an ad valorem tax to identify the market structure. With a structural model, where one estimates a demand curve and a marginal cost curve, a tax shock, such as an increae in an ad valorem tax rate, could identify the market structure, as shown in Figure 3. How much the new equilibrium price rises depends on the shapes of the demand and marginal cost curves as well as the market structure. For example, it can be shown that, with imperfect competition and enough curvature of the demand curve or increasing returns to scale (Wright, 1985; Seade, 1985; Karp and Perloff, 1989a), the observed price may increase by more than 100% (incidence on consumers exceeds 100%). The right combination of demand curvature and returns to scale can produce virtually any possible change in price for any given market structure. Thus, if the implicit assumptions made to use the nonparametric or reduced-form approach are wrong (e. g., constant returns to scale), a false inference about market structure will be made. In a full structural model with flexible function forms is used to estimate the demand and marginal cost curves, such an error would not be made.

It appears that both the static structural models and the reduced-form or nonparametric comparative statics models are very similar and that the choice between them turns on two factors. First, the reduced-form or nonparametric comparative statics models typically require less data than the full structural models, which allows them to estimate and test fewer coefficients. Whereas the structural model estimates a market structure parameter, some nonparametric approaches are only able to bound the market structure. Second, the models require different heroic assumptions. Typically, the structural model requires specifying the functional form; whereas, and the reduced-form or nonparametric models require more assumptions about underlying economic relationships (e. g., constant returns to scale) and may have to ignore the stochastic nature of the underlying problem (see, e. g., Ashenfelter and Sullivan, 1987, p. 485).

Value of Modern Static Approaches

Both the structural and nonstructural modern static approaches have three key advantages over the SCP approach. First, they are based on formal maximizing models so that hypotheses can be directly tested. Second, they estimate the market structure rather than use a crude accounting proxy. Third, they use exogenous variables (comparative statics results) to explain variations in market structure rather than endogenous variables such as concentration ratios and advertising.

One advantage of examining a single industry is that industry-specific institutional factors can be taken into account and heroic assumptions about symmetry across industries (as made in the SCP approach) can be avoided. The structural models can identify a particular market structure, whereas the nonstructural models may only be able to reject certain structures.

The chief benefits from nonstructural approaches are ease of use, low data requirements, and lack of functional form specification bias. Where the structural models are difficult to estimate and require a great deal of data, some of these comparative statics methods require relatively easily obtained data and may not require any econometrics. One of the reasons the structural models have not been used for cross-sectoral comparisons is the difficulty of applying them.[17] In contrast, because Hall's comparative statics method can be easily applied to many sectors, one can use its estimated λ to conduct the type of cross-sectoral investigations in the SCP approach without using traditional, flawed measures of market power (Domowitz, Hubbard, and Petersen, 1988).

Modern Dynamic Approaches

Almost all real world markets last for many periods. As a result, using static models is inappropriate if 1) firms, in setting strategies, take previous behavior into account; 2) there are adjustment costs, so that costs in this period depend on decisions in previous periods; and 3) demand today depends on the past quantities.

In recent years, two approaches to estimating dynamic oligopoly models have been developed. The first is based on repeated (static) games and the second uses dynamic games with adjustment costs. This section is divided into three parts: a discussion of how repeated games are used to study collusive behavior, a particular application of repeated games involving a trigger price mechanism, and a discussion of dynamic games with adjustment costs.

Collusion and Repeated Games

Stigler (1964) argues that conjectural variations models of oligopoly ignore the main underlying concept that should drive an oligopoly model: the tendency of firms to collude (at least tacitly) to maximize joint profits.[18] According to Stigler, cartel theory provides a good basis for explaining all oligopoly behavior. Oligopolists try to behave cooperatively as a monopolist would, but sometimes they cannot fully enforce the cartel. In particular, some firms behave noncooperatively and engage in secret price reductions that are undetected by other firms. This "cheating" keeps the average price below the monopoly level. If cheating is widespread at all prices above the marginal cost, the cartel is completely unsuccessful in raising the price above the competitive level.

This imperfect-collusion theory has the advantage of avoiding arbitrary assumptions about firms' conjectures, but has many of the same implications as the conjectural variations models. For example, according to cartel theory, the more firms an industry includes, the harder it is to detect cheating by any one firm, so more cheating occurs, and the average price is lower, as with conjectural variations models.

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[17] In the structural approach, it is very difficult to obtain data and estimate a model for a particular sector; hence applying this approach to many sectors is a major undertaking. Nonetheless, some researchers are starting to conduct such studies.

[18] This section is based on Carlton and Perloff (1990, Chapters 9 and 10).

Recently, game theory has been revived as a way to analyze successful and unsuccessful collusive behavior more formally using repeated (multiperiod) games. In multiperiod games, a firm can have a strategy over many single-period games, thereby allowing for more complex and realistic interactions between firms than in a single-period model. These multiperiod games are, therefore, referred to as supergames. In a single-period, Nash game, each firm takes its rival's strategy as given and assumes it cannot influence it. If this game is repeated, however, each firm can influence its rival's behavior by signaling and threatening to punish. Firms have an incentive to communicate to avoid the prisoner's dilemma problem, which stems from a lack of trust. Because antitrust laws make direct communications illegal, firms may try to communicate through their choice of strategy if (and only if) the game is repeated. For example, a firm can use a multiperiod strategy of setting a high price and taking losses for several periods to signal its willingness to collude.

All repeated games do not result in collusion, however. The type of equilibrium in a repeated game depends on a player's ability to effectively threaten other players who are not cooperative. The effectiveness of a threat depends on the discount rate, the length of the game, and the credibility of the threat.

At the beginning of a game, each firm chooses a strategy to maximize its present discounted profits. If discount rates are so high that profits in future periods are worth substantially less than profits in the current period, future punishment is inconsequential and hence has no effect on current behavior. Lower discount rates, therefore, make the threat of punishment more effective. The more periods left in the game, the larger the total punishment that can be inflicted on a transgressor, because the punishment can be applied for more periods. However, if the threat is not credible, in the sense that Firm 2 does not believe that Firm 1 will actually inflict the punishment in future periods, then Firm 2 ignores the threat altogether.

Much of the recent research in multiperiod games only considers equilibria that result from credible strategies. That is, this research places a refinement or restriction on the possible equilibria. One widely used refinement is to consider only *perfect Nash equilibria*: those Nash equilibria in which threats are credible (Selten 1975). An equilibrium is perfect if the strategies of the firms are credible. A strategy or threat is credible only if the firm will stick to that strategy in any subgame from period t forward. That is, if the original strategies would still be best responses in any game that started in period t and ignored what had happened in previous periods, then these strategies are called a perfect Nash equilibrium, or *subgame perfect Nash equilibrium*. For example, if Firm 1 threatens to punish Firm 2 in the second period if Firm 2 produces too much in the first period, the threat is only credible if the punishment is in Firm 1's best interest in the second period.

An infinite number of other subgame perfect Nash equilibria are possible in games with an infinite number of periods and little or no time discounting. The *folk theorem* describes this set of subgame perfect Nash equilibria in infinitely long games (Fudenberg and Maskin 1986). It says, loosely, that any combination of output levels (imperfect or perfect collusion) could be infinitely repeated so long as each firm's profits at those levels are at least as great as the minimum each firm could earn in a one-period game. As a result, in addition to the collusive solution, another perfect equilibrium in the infinitely repeated game is for each firm to produce the Cournot-Nash output each period. Much current research is directed at further refining these results to provide better explanations of which equilibria occur. Without further refinements almost any output level is a sustainable equilibrium, which makes this theory difficult to test because it is consistent with any estimated λ ranging between the competition and cartel.

Trigger Prices

Random fluctuations in price due to fluctuations in demand or supply costs could make "cheating" by cartel members hard to detect. It may be possible to prevent firms from cheating by using a "trigger price" mechanism, whereby all cartel members agree that if the market price drops below a certain level (a trigger price), each firm will expand its output to the precartel level (Friedman, 1971). That is, all firms will abandon the cartel agreement if the trigger price is hit. If firms expect other firms to stick to this agreement, a firm that cut its price might gain in the extremely short run, but would lose in the end due to the destruction of the cartel by this predetermined punishment mechanism.

If firms were to permanently revert to the competitive level of output (or at least some output level greater than the cartel level) whenever they detected a fall in price, the cartel could be destroyed by a random fluctuation in price (rather than price-cutting by one firm). Instead, if the firms agreed to produce their precartel levels of output only for a predetermined length of time and then to revert to the cartel level of output, a random fluctuation in price would not destroy the cartel permanently (Green and Porter, 1984). One attraction of this scheme is that even if the agreement temporarily breaks down, it can be reestablished without further meetings. In a market in which random price fluctuations can obscure price-cutting by particular firms, such an agreement could lead to recurrent sharp declines in price and cartel profit levels. When a random drop in price occurred, cartel members punish themselves "unnecessarily."

Nonetheless, this mechanism may be attractive to the cartel because if the punishment period (when all firms produce large levels of output) is long enough, it is never in a firm's best long-run interest to cut its price. Thus, cartel members realize that the price only falls below the trigger price because of random fluctuations (because no firm ever engages in price cutting). The cartel must keep punishing itself, however; if it stopped, price-cutting would occur.

Many observers, seeing large price fluctuations in a market, argue that the firms in that industry are trying to form a cartel that keeps breaking apart. They conclude that no government intervention is required because competitive forces keep destroying the cartel. Instead, these fluctuations could be part of a rational, long-run cartel policy involving trigger prices. This trigger-price argument holds that price wars are more likely during business cycle downturns (recessions and depressions) when price is likely to decline in response to lowered demand. Thus, we expect that cartels would terminate during such conditions. Other economists have argued that price wars should occur in periods of high demand (Rotemberg and Saloner 1986). They reason that the benefit from undercutting the cartel price is greatest during booms.

Suslow (1988) and Domowitz, Hubbard, and Petersen (1987) test implications of this theory without explicitly estimating a market power parameter.[19] Porter (1983), Lee and Porter (1984), and Hajivassiliou (1989) estimate full structural models based on this theory using data from an 1880s railroad cartel.[20] A switching equation approach is used, whereby a different structure is used depending on whether the firms are using cartel or punishment strategies in a given period, where the strategies are determined endogenously.

Dynamic Models with Adjustment

Single period models are also inappropriate where there are substantial adjustment costs in training, storage, or in capital accumulation, or where there is learning over time. Similarly, a dynamic model should be used if demand in one period depends on the past sales. The game-theoretic literature abounds with dynamic models of oligopoly that are too general to be usable in estimation. To practically estimate these models, further restrictions

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[19] To see whether either the Green-Porter or Rotemberg-Saloner theories are realistic, Valerie Y. Suslow (1988) investigates the stability of cartels over the business cycle by examining 72 international cartel agreements covering 47 industries during the period 1920-39. Suslow estimates the probability that a cartel would fall apart at a specific time, given that it survives until that time. Controlling for other factors, she found that cartels are relatively more likely to fall during business cycle downturns (recessions and depressions), as is consistent with Green and Porter's trigger price theory.

[20] Hajivassiliou (1989) also rejects Rotemberg and Saloner's (1986) prediction.

have to be imposed. The Markov assumption is most common: firms' strategies in period t depend on only output of firms in the t and t-1 periods.

Two equilibrium concepts may be used. In the open-loop equilibrium, firms choose a path in the first period, which they follow thereafter. In the feedback equilibrium, firms choose subgame perfect strategies (rules) that express their output as a function of the state variables. The open-loop and feedback models are identical where firms collude or act as price takers. In other oligopolistic models, such as where firms make the Nash-Cournot assumption within a period, the two models imply different adjustment paths and steady-state output levels. In the open-loop model, firms do not expect to revise their strategies after an unexpected shock (such as bad weather) affects the output levels of various firms. This failure to anticipate revision is irrational.

The feedback equilibrium is difficult to estimate for general functional forms. To be able to estimate practically a feedback model, a linear-quadratic model (Starr and Ho, 1969) is used.[21] That is, it is assumed that demand is linear and adjustment costs are quadratic. The general open-loop model can be estimated.[22]

Although there are many dynamic empirical studies (e. g., Blanchard, 1983) where competitive behavior is assumed, in few studies has noncompetitive behavior been estimated. I am aware of papers by Roberts and Samuelson (1988) and Karp and Perloff (e. g., 1988, 1989a, and 1990a) that discuss estimating an dynamic oligopoly model, all of which deal with agricultural markets.

Roberts and Samuelson (1988) estimate a dynamic oligopoly model and test and reject the assumption of open-loop behavior in the cigarette market. They do not, however, estimate the model under the assumption that firms use fully rational Markov strategies (feedback) because of the complexity of the restrictions such a model implies when general functional forms are used. They concentrate on advertising (rather than quantity or price setting).

Karp and Perloff (1988) develops techniques to estimate both open-loop and feedback models of quantity setting with a linear-quadratic specification. Karp and Perloff (1989a) applies that model to rice exports and Karp and Perloff (1990a) applies that model to coffee exports. In principle, one can nest and test these two approaches; however, one would need more detailed cost information than is generally available to do so.

Using a dynamic model, one can use a nested hypothesis test to determine whether the static model is correct, because it is a special case of the dynamic model (Karp and Perloff, 1990a). For example, in a dynamic model, each Firm i has a linear marginal cost, $m_i + \beta_i q_{it}$, with respect to contemporaneous output, q_{it}, and a quadratic cost of adjustment, $(\gamma_i + .5\delta_i/u_{it})u_{it}$, where $u_{i,t}\varepsilon \equiv q_{it} - q_{i,t-\varepsilon}$ is the change in a firm's output level from period t-1 to period t. The test whether the static model assumption is correct, then, is the test whether δ_i equals zero.

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[21] The linear-quadratic cost-of-adjustment model has been used extensively (e.g., Sargent, 1978; Hansen and Sargent, 1980; and Blanchard, 1983). Hansen, Epple, and Roberds (1985) use the dynamic linear quadratic model to study different open-loop markets as well as the open-loop and feedback Stackelberg models, but do not compare the open-loop and feedback symmetric firms markets which is the focus of this paper. Fershtman and Kamien (1987) and Reynolds (1987) compare theoretically the open-loop and feedback linear-quadratic Nash-Cournot models.

[22] There are at least two alternatives to the open-loop, linear-quadratic model. One uses instrumental variables to estimate the game analog of the stochastic Euler equations (as in Hansen and Singleton, 1982; and Pindyck and Rotenberg, 1983). Similar methods could be used to estimate noncompetitive markets; but the Euler equations restrict the equilibria to be open loop. The second method uses dynamic duality (Epstein, 1981). Although, in principle, this method could be used to estimate both open-loop and feedback noncompetitive equilibria, it implies very complicated restrictions for the feedback case and may be of limited practical use.

These papers are analogous to the modern static models in that an index of market structure is estimated. In an open-loop model, this index could be given a conjectural variation interpretation as in a static game (as Roberts and Samuelson do). Where firms use feedback strategies, however, this index cannot be given a conjectural variations interpretation — the more general interpretation must be used. The dynamic collusive, price-taking, and Nash-Cournot models are special cases of this more general specification. Other solutions could be viewed, for example, as folk-theorem equilibria. Thus, estimation of the market structure only requires the estimation of this index, as in the static models.

The actual price-quantity margin varies over time for any given structure depending on whether open-loop or feedback strategies are used and how far from the steady-state current output levels are. As Pindyck (1985) shows, in a dynamic setting, a mechanical application of the Lerner index can be very misleading. In particular, unlike in the static case where the elasticity of demand determines this index, in the intertemporal case, neither that elasticity nor the Lerner index provides a meaningful measure of monopoly power. Thus, interpreting the index is slightly more difficult. One solution is to discuss the steady-state price-marginal cost gap or to compare the path of price or quantity with respect to the path under the price-taking assumption.

Analogous to dynamic models with adjustment costs are those where demand today depends on quantities in previous periods. Some marketing studies attempt to estimate demand curves with this property. Some studies of durable goods, such as aluminum, have elements of this issue (see, e. g., Suslow, 1986). Similarly, in pumping oil, the costs today depend on how much was pumped in the past and price is expected to rise at the rate of interest (according to the Hotelling formula), so empirical studies of oil should reflect these dynamic issues as well (Matutes, 1985).

Trade Applications

Increasingly, trade studies rely on industrial organization theory. As a result, the same econometric approaches used in industrial organization theory can be applied to trade problems. In the following list are some of the areas where these approaches could be applied relatively easily.[23]

International Export Markets

One obvious, and relatively straight-forward, application is to international export markets. In many such markets, some or all countries have exporting agencies that determine the amount exported. Thus, for practical purposes, these exporting agencies are individual firms. Whereas it is difficult to obtain firm-specific data within most countries, obtaining export data by country is often easy. Examples of such studies are Karp and Perloff (1989b) on rice and Karp and Perloff (1990a) on coffee.

Unfortunately, most such studies (including mine), make strong assumptions so that exchange rate and storage (stockpiles) problems can be ignored. In the next few years, it should be possible to deal with these issues empirically as new theories and empirical techniques are developed (see, especially, the theoretical work in Williams and Wright, 1991). Of course overlooking storage is a problem in domestic studies as well.

Differentiated Products: Reciprocal Trade

Another example of where the modern approach may prove useful is in explaining reciprocal trade. Why, for example, do U. S. firms ship automobiles to the United Kingdom and U. K. firms ship automobiles to the United States? If the products were homogeneous,

[23] I apologize for the over-reliance on my own work in the following discussion. It reflects my greater familiarity with my own works rather than any belief that mine are the most important or only works in this literature.

comparative advantage would rule out such reciprocal trade. Thus, the standard explanation for reciprocal trade is that the products are differentiated and market power may differ in the two countries resulting in price discrimination. By taking careful account of product differentiation, tariffs, quotas, and so forth, one could simultaneously study the causes of reciprocal trade and the degree of market power and price discrimination in several countries.[24]

Gray Markets

Similar questions are raised in the study of gray markets. One reason for the existence of gray markets is that manufacturers provide market power to dealers (retailers) by limiting the number of dealers so that they will provide services such as show rooms and local advertising, which increase demand for the product (Telser, 1960). This market power results in high prices that lead to entry by gray marketeers. The dealers' market power is undermined by gray market imports (typically the same physical product but sometimes lacking a U. S. warranty). Tariffs, quotas, and the behavior of the manufacturer (e. g., the willingness of the manufacturer to honor warranties on gray market items) affects the existence of gray markets.

So far as I know, there has been no empirical study of gray markets using modern techniques. A useful study might try to explain the degree of market power by manufacturers and dealers as a function of the existence of a gray market. Such studies may show in which industries it is in the manufacturer's best interest to encourage gray markets and price discrimination across countries (Fargeix and Perloff, 1989). The mere threat of gray market imports places an upper bound on the price that dealers can charge, giving the manufacturer an additional tool to control the dealers (in addition to setting the wholesale price and the number of dealers).

Dumping

One of the most active areas of trade research concerns allegations of dumping. Especially in the United States, firms often litigate to have tariffs imposed on foreign exporters on the grounds that they are dumping (selling below cost or, at least, below the price in their home market).

There are at least three explanations, each of which can be modelled differently. The standard story is that the foreign firm is price discriminating. This model could be handled as described above. For that story to make sense, the firm would need market power in at least the high-price country.

A second explanation is that the dumping reflects different adjustment behavior in the two countries (Ethier, 1982). Although Ethier's explanation is not inconsistent with the other stories, by itself, it requires no market power, but does require different responses to adjustments in the two countries.

A third scenario, alleged more in court than in the economics literature, holds that the foreign firm is predating. In this story, the foreign firm sets its price below marginal cost, drives out the domestic firm, and then raises its price to a high level. Because domestic firms usually can reenter the market, this explanation does not make a great deal of sense. It can be shown (Berck and Perloff, 1988 and 1990), however, that a similar price pattern could be observed if the foreign firm is a low-cost, dominant firm in a dynamic setting where domestic fringe firms enter and exist slowly. A dynamic model could be used to test whether the foreign firm ever prices below its marginal cost and could estimate its market power over time.

There is another reason why empirical studies may be conducted in dumping cases. Because of a peculiarity of U. S. law, to show that dumping has occurred, one must show that the price in the U. S. is less than the price in the foreign country minus the incidence that falls

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[24] There are a number of techniques that could be used to deal with product differentiation. See, for example, the Hotelling (1929) or Salop (1979) type model used by Bresnahan (1981). A more Chamberlinian type model could be employed as outlined in Perloff and Salop (1985 or 1986).

on consumers of the tax imposed in the foreign country that is forgiven if the product is exported. Thus, to conduct such a study, one must determine the incidence of ad valorem taxes in the foreign country.

The way most studies that have been conducted for court cases do this calculation is by assuming that the foreign firm is competitive and then calculating the incidence using the standard formula that depends on the elasticity of supply and demand. Yet, a firm that dump is likely to have market power. If so, the standard competitive calculation is biased. The appropriate analysis would estimate the incidence and the market power simultaneously, as shown in Figure 3 (Karp and Perloff, 1989a).

Information and Futures Markets

The existence of information has important impacts on the functioning of many international agricultural commodity markets. A refiner or processor in the United States, for example, may be able to use its superior information about the final goods market demand to profit from international futures or forwards markets, as some have suggested that Mars Candy has done with cocoa or that the major coffee processors have done. A simple empirical technique for conducting such a study is developed in Perloff and Rausser (1983).

Strategic Trade Policy

A new trade literature argues that strategic intervention by a government may benefit domestic trading firms and increase welfare. In these models, international exporting firms play a noncooperative Nash game. Now suppose only one government can intervene. That government selects the level of some policy (e. g., an export subsidy) and firms then choose output or price. Because the government acts first, export subsidies increase current welfare if firms sell in imperfectly competitive markets (Spencer and Brander, 1983; Dixit, 1984; and Brander and Spencer, 1985). The optimal policy depends critically on the specification of the game, how long a government can commit to a policy, and whether the foreign government retaliates (Krugman, 1984; Eaton and Grossman, 1986; Carmichael, 1987; Cheng, 1988; Gruenspecht, 1988; Markusen and Venables, 1988; Neary, 1989; and Karp and Perloff, 1990b, 1990c, and 1991).

If firms chose their investment levels (e. g., plant size, equipment, land, research and development) before the governments set output subsidies, optimal *ex post* (after investment) output subsidies may reduce *ex ante* (before investment) welfare. In a multiperiod economy, even if the government acts first in each period, the firms' current investment precedes the government's future subsidy unless the government can commit to a path of subsidies once and for all in the initial period. A government that cannot make such commitments may behave strategically in each period to obtain the *ex post* benefit and, as a result, may suffer an *ex ante* harm (Karp and Perloff, 1991). Thus, the effects of interventions by governments are unclear, depending as they do on whether governments move before firms, how long a government can commit to a policy, whether other governments retaliate, the games firms play, and the ability of firms to invest.

Because the welfare results from theory are ambiguous, empirical studies could be very valuable here. First, an analysis of the degree of market power actually exercised by firms in industries in which governments do not current intervene could be used to predict the success of intervention. Second, the industrial organization models could be expanded to allow for an extra set of players (governments), whose observed actions (taxes, subsidies, tariffs, quotas) can be explicitly built into the model and treated as endogenous, so that the degree to which actions of the government affect the monopoly power of the firms can be measured. Because of the time element involved (these theories turn on governments acting before firms), dynamic models should be used.

Conclusions

The development of new empirical approaches to estimating market power is a major step forward. It avoids the major limitations of the Structure-Conduct-Performance paradigm. Unlike in the SCP approach, in the modern approach market power (or structure) is estimated rather than approximated by crude accounting measures. The modern structural models allow us to formally introduce unique institutional features of markets into the analysis, test well-formulated hypotheses based on proper comparative statics predictions (i. e., test the effects of exogenous rather than endogenous variables), and to explicitly explore the mechanisms by which certain variables affect market power.

The major advantage of the SCP approach, the relative ease of conducting the studies, which allows us to conduct cross-sectoral studies, is rapidly evaporating. Modern reduced-form or nonparametric studies are as easy to implement as SCP studies and they allow us to conduct cross-sectoral studies. Further, studies are underway to use modern structural models in cross-sectoral studies.

The use of dynamic models, although new, is particularly promising. By using dynamic models, we can avoid many of the conceptual problems that theoreticians cite in criticizing the empirical literature.

Because these modern techniques are so new, they have not been widely applied to international trade problems. As is outlined here, such studies could be conducted using existing techniques or relatively straight-forward extensions of these techniques.

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