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APPLIED TO PETROLEUM PRODUCTS

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CAUSALITY TESTS FOR MARKET EXTENT
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I: INTRODUCTION

Economics is often defined as the study of markets. It is therefore somewhat surprising that economists have expended so little effort on market definition. Typically, microeconomics texts either ignore the subject, assuming that the student already understands the concept of a market, or they devote a paragraph to it.

Market definition has progressed little since the mid nineteenth century, when Cournot stated that a market is "the entire territory of which the parts are so united by the relations of unrestricted commerce that prices there take the same level throughout with ease and rapidity." (1960, p. 51). For example, Stigler in his price-theory text adds only one item to Cournot's definition when he states that a market is "the entire area within which the price of a commodity tends to uniformity, allowance being made for transport costs." (1970, p. 85). For many purposes, this rather broad definition is sufficient. However, there are other areas where failure to define markets more precisely leads to erroneous policy prescriptions.

If price tends to uniformity within a market area (allowance being made for transportation or other transaction costs), and if the market is defined broadly enough so that prices outside the area are independently determined, then a market is the area within which collusion must take place. By definition, firms within the market area can restrict output to raise price without setting off automatic forces (such as imports from other regions) that tend to bring the price back down. However, if firms choose too small an area within which to collude, their efforts will be ineffectual. It is for this reason that market definition has received much attention in antitrust analysis.

U.S. antitrust law makes market definition an integral part of court procedure. When violations of Section 2 of the Sherman Act (which deals with monopolization) or Section 7 of the Clayton Act (which deals with mergers) are alledged, it is necessary to define the product involved and the geographic region within which the violation occured. 1/ Unfortunately, this is rarely an easy task. For example, in delineating a product market, one must look for close substitutes. However, there is often a whole spectrum of substitution possibilities, some of which are perfect (red and blue cars of the same model), others of which are imperfect (compact and luxury cars), and still others that are substitutes only in a very broad sense (cars and bicycles). It is difficult to know where to draw the line.

Similar problems occur in delineating a geographic market. For example, it is almost certain that two grocery stores in the same shopping center compete, but as the geographic boundary is enlarged, it is difficult to state where competition ends. Because economists have had little to say on the subject, antitrust analysis relies on a set of increasingly more complex legal criteria for market definition, many of which bear little relation to economic analysis. 2/

The purpose of this paper is twofold. First, a procedure is proposed that can aid the market-definition process by introducing objectivity into the analysis. The statistical test outlined here makes use of the Granger (1969)/Sims (1972) work on causality that has been applied principally to the construction of macroeconomic models. Quantitative tests can never substitute for a thorough understanding of an industry and the economic, legal, and technical institutions that govern it. However, hopefully they can be used in conjunction with such an understanding to restore economic rationality to market definition.

Second, the test is applied to the problem of defining geographic markets for petroleum products. The recent wave of proposed mergers in the U.S. petroleum industry (Mobile-Marathon and Gulf-Cities Service, for example) make this an important and timely problem. Crude oil is traded in an international market. Therefore, the merger between two U.S. firms can be of little consequence to the market for crude. However, the market for petroleum products may be much narrower. If regional markets for gasoline exist, for example, such mergers can lead to a lessening of competition in these local markets.

The organization of the paper is as follows. In the next section, the use of time-series data for market definition is discussed and the proposed test is explained. In sections III and IV, the petroleum-product market is described and pricing practices are discussed. Section V contains the empirical results and section VI summarizes and concludes.

II: THE USE OF TIME-SERIES DATA FOR MARKET DEFINITION

IIa: Motivation

If a region is a local geographic market for a given commodity, there must be barriers to the entry of that commodity from surrounding regions. The most common barriers are high transport costs and legal restrictions such as tariffs and quotas.

In an ideal situation, trade within a market is unrestricted and costless. Therefore, if the product is homogeneous, the possibility of arbitrage implies that prices are uniform throughout the market. In contrast, the existence of high entry barriers for product produced outside the region implies that outside prices are independently determined. The difficulty of arbitrage across regions means that regional price differences can persist indefinitely. Under such idealized circumstances, it is a simple matter to determine geographic markets exactly.

Unfortunately, the real world is more complex and there are no sharp boundaries between regions. Therefore, market definition is always a matter of degree and not one of certainty. That is, it is never possible to say that trade is absolutely restricted and prices completely independent, but only that they are relatively restricted and relatively independent, respectively. The determination of markets should therefore lend itself to statistical analysis.

The information that will be used as an aid in defining a market is the behavior of product prices in different geographic regions over time. Price data are easier to obtain than data on profits or costs and price is a key item that economists predict will vary across markets. Therefore, if sensible analyses can be developed, it is an information source that should be more heavily relied on than is customary in antitrust cases. In what follows, I discuss how time-series data on prices can be used to delineate a geographic market. With obvious modifications, the same techniques could be used to define product markets.

IIb: Previous Work

The best known measure of the degree of association between two time series is the simple correlation coefficient which measures the degree of linear dependence between the two variables. When two series move together and in the same direction, their correlation coefficient is close to one. The fact that prices in different geographic regions are correlated has sometimes been used as evidence that the regions belong to a common geographic market. 3/ However, there are several reasons why high correlation coefficients may not be evidence that a single geographic market exists and vice versa.

First, two price series that are unrelated can have a high correlation coefficient. For example, any two series with a positive trend, even if otherwise unrelated, will be correlated. Because prices in early periods are below average whereas those in later time periods are above average, the series will appear to be related. With overall inflation, it might be the case that all price series are highly correlated. Similarly, any other systematic behavior common to both series, such as seasonality in demand, can lead to spurious correlation. 4/

Second, two price series that are closely related can have low correlation coefficients. Consider, for example, two regions A and B that are in the same geographic market. If demand increases in region A, price will rise in that region. Eventually, as product flows out of B and into A to take advantage of the high price, the price will rise in B and fall in A until the two are equal. However, adjustment may take time. When adjustment is slow, it is possible for prices in A and B to be perfectly correlated at a lag, but poorly correlated contemporaneously.

The unsatisfactory nature of the simple correlation coefficient has led others to search for more sophisticated geographic-market tests. Horowitz (1981) noted that prices of the same product in two spatially separated areas that form part of the same geographic market should tend towards differentials that are determined by the costs of transaction between the two regions. However, because the adjustment of prices to long-run regional differences may not be instantaneous, Horowitz proposed a dynamic model of price adjustment. If there is a price shock in one region that causes differentials to differ from their long-run values, prices will begin to change. Horowitz assumes that this adjustment conforms to a particular dynamic process -- that a constant fraction of the difference between the long-run (equilibrium) and short-run (disequilibrium) price differential will be closed in each time interval. In other words, price differentials conform to a first-order autoregressive process. Horowitz's hypothesis is testable and requires only regional time-series data on prices.

The Horowitz model is a step in the right direction. However, there are serious drawbacks. For example, Howell (1982) points out that if two price series are autocorrelated, the Horowitz test yields erroneous results. Similar problems occur if the price series have a trend or are characterized by systematic seasonal patterns. In addition, the Horowitz model is overly restrictive because it is assumed that dynamic adjustment follows a particular pattern (a simple first-order process), when all that is required is that price differentials exhibit dynamic stability. For these reasons, Howell proposes a geographic-market test that is more robust and less restrictive (and of which the Horowitz model is a special case). Howell's method makes use of techniques developed by Box and Jenkins (1976).

IIc: The Proposed Test

The test proposed here is based on the causality or exogeneity tests developed by Granger (1969) and Sims (1972). However, the test most closely follows the proposals of Geweke (1978). The basic idea developed by Granger and outlined below is well known. Let X^i be time-series vectors of equally-spaced observations, $X^i = (X^i{}_t)$, $t = 1,\ldots,T$, $i = 1,2$. X^1 is said to "cause" X^2 if it is possible to obtain better predictions of X^2 when using all available information than if only the information apart from X^1 had been used. That is, X^1 "causes" X^2 if X^1 provides useful information for forecasting X^2.

In practice, tests of causality are made after restricting the set of "all available information" to a few time series, often just X^1 and X^2 themselves (see Sims, 1972, for example). When the universe of information consists of just X^1 and X^2, it is said that X^1 "causes" X^2 if predictions of X^2_t based on lagged values of both X^1 and X^2 are better than predictions of X^2_t based on lagged values of X^2 alone.

The properties of causality tests are well known and will not be discussed here except as they relate to the geographic-market test. 5/ However, it should be noted that causality tests can be used to refute exogeneity but not to establish it. In terms of the geographic-market test, this means that it is never possible to establish conclusively that two regions are not in the same market.

The common geographic-market test is as follows. Suppose that a homogeneous product A is sold in two regions and that we wish to determine whether or not the two regions belong to the same geographic-market for A. Let P^i be time-series data on the price of A in region i, i = 1,2. If the two regions are in different geographic markets, prices should be independently determined. That is, P^1 should be exogenous to P^2 and vice versa. However, if the two regions belong to a common geographic market, each price series should provide useful information for forecasting the other. 6/

Let the null hypothesis be that the two price series are independently determined. The following equations are used to test this hypothesis:

$$P^1_t = \sum_{i=1}^{\infty} a_i P^1_{t-i} + g^1(Z_t) + \varepsilon^1_t \qquad (1)$$

$$P^2_t = \sum_{i=1}^{\infty} b_i P^2_{t-i} + g^2(Z_t) + \varepsilon^2_t \qquad (2)$$

$$P^1_t = \sum_{i=1}^{\infty} c_i P^1_{t-i} + \sum_{i=1}^{\infty} d_i P^2_{t-i} + g^3(Z_t) + \eta^1_t \tag{3}$$

$$P^2_t = \sum_{i=1}^{\infty} e_i P^2_{t-i} + \sum_{i=1}^{\infty} f_i P^1_{t-i} + g^4(Z_t) + \eta^2_t, \tag{4}$$

where ε^i and η^i, i = 1,2, are disturbance terms with zero means such that each is uncorrelated with the right-hand-side variables in its respective equation. The $g^i(Z_t)$ are linear functions of a vector Z_t of current and possibly lagged exogenous varibles whose exogeneity is not to be tested. 7/ For example, $g^i(Z_t)$ could be deterministic functions of time.

Corresponding to the coefficient vectors, a, b, c, d, e, and f, are their respective generating functions, A(z), B(z), C(z), D(z), E(z), and F(z), whose domains are the set of complex numbers, z. For example, the generating function corresponding to a is

$$A(z) = 1 - \sum_{i=1}^{\infty} a_i z^i. \tag{5}$$

It is assumed that the generating functions are analytic in the region $\{z:|z|\leq 1\}$. Then P^1 can be exogenous to P^2 only if the coefficients d are zero and P^2 can be exogenous to P^1 only if the coefficients f are zero. 8/

Tests of the null hypothesis depend on the stability of the autoregressive processes for P^1_t and P^2_t set forth in equations 1 and 2. If these processes are stable (i.e., if the roots of A(z) and B(z) lie outside the unit circle), then tests based on the usual normality assumptions are justified. However, when P^i do not follow stable autoregressive processes, little is known about the asymptotic distribution of the estimators (see Geweke (1978) for a discussion of the complications.)

To achieve finite parameterization, equations 1-4 are replaced by

$$P^1_t = \sum_{i=1}^{n_1} a_i^* P^1_{t-i} + g^{1*}(Z_t) + \varepsilon^{1*}_t \qquad (1')$$

$$P^2_t = \sum_{i=1}^{n_2} b_i^* P^2_{t-i} + g^{2*}(Z_t) + \varepsilon^{2*}_t \qquad (2')$$

$$P^1_t = \sum_{i=1}^{n_3} c_i^* P^1_{t-i} + \sum_{i=1}^{n_4} d_i^* P^2_{t-i} + g^{3*}(Z_t) + \eta^{1*}_t \qquad (3')$$

$$P^2_t = \sum_{i=1}^{n_5} e_i^* P^2_{t-i} + \sum_{i=1}^{n_5} e_i^* P^1_{t-i} + g^{4*}(Z_t) + \eta^{2*}_t, \qquad (4')$$

where parameters marked * depend on n_i, $i = 1,\ldots,6$ (as do parameters of functions marked *) and the *ed disturbance terms are uncorrelated with the right-hand-side variables in their respective equations.9/

The null hypothesis (that the coefficients d and f are zero) is tested in a three-step procedure.

Step 1: Estimate equations 1' and 2' separately by ordinary least squares (OLS) to obtain the generating functions A(z) and B(z). Then compute the roots of A(z) and B(z) to see if the autoregressive processes are stable. 10/ If so, procede to

Step 2: Estimate 3' and 4' separately by OLS, choosing n_i, $i = 3,\ldots,6$, large enough so that the residuals are serially uncorrelated. 11/ (In theory, this may not be possible but in practice, it is usually possible to choose lags long enough so that serial correlation is statistically indiscernible.) Standard techniques such as Portmanteau's test or the methods of Box and Jenkins (1976)can be used to test for the presence of serial correlation.

Step 3: Estimate 3' and 4' jointly (using the previously determined n_i) as a seemingly unrelated system (Zellner, 1962). 12/ An F-test can then be used to determine if the coefficient vectors, d and f, are zero.

In this procedure, the choice of lag lengths is somewhat arbitrary. It is therefore desirable to redo step 3, varying the n_i. If results of hypothesis tests are sensitive to the choice of n_i, methods such as those proposed by Parzen (1977) and Schwartz(1978) for testing nested hypotheses can be used to choose among alternative specifications.

III: WHOLESALE GASOLINE MARKETS

The test outlined in the last section is used to determine whether cities in the interior of the Southeastern part of the U.S. constitute a separate geographic market for gasoline or whether they belong to a larger Eastern seaboard or perhaps national market. In order to judge the reasonableness of the statistical results, it is necessary to know how petroleum products flow in and out of the region and how this region is related to other marketing areas. 13/

Virtually all of the petroleum products consumed in the interior portion of the Southeastern U.S. (hereafter called SE) are refined near the Gulf coast. Refined products are then shipped via one of two pipelines -- Colonial or Plantation. The Colonial pipeline originates in Houston, Texas and terminates in Linden, New Jersey. Plantation originates in Baton Rouge, Louisiana and terminates in the Washington, D.C. area. From Collins, Mississippi to Washington, D.C., the two pipelines cover the same route.

Product terminals along the pipeline service regional marketing areas. Terminals, which are owned by individual oil companies, are generally found in groups or clusters near urban population centers. Most companies that ship to one terminal site along the pipeline, ship to several. At the terminals, various grades of gasoline and other refined products are stored in large tanks. These products are transported by truck from the terminal to retail outlets. If product prices are equal at various terminal clusters, a wholesale buyer will go to the closest one (generally not more than fifty miles). However, a wholesale buyer may truck product as far as one hundred miles if conditions warrant. Though it is possible for a retail outlet to obtain gasoline from more than one terminal cluster, normally the competitors of a given oil company at a terminal are the other marketers at the same site.

Pipelines are the only economically feasible method of transporting petroleum products into SE. The cost of transporting by a combination of tanker/barge and rail/truck is so much higher than the cost of transporting by pipeline that the alternative route is not considered unless the pipelines are operating at capacity and are prorationed.

The situation in the Northeast (NE) is very different. Petroleum products consumed in this region come from three sources: local refineries near the major cities, Gulf-coast refineries (via Colonial), and foreign refineries located mainly in the Caribbean. It is uneconomical to ship product from the Gulf coast to NE via water because such shipments are subject to the Jones Act, which requires that cargoes moving from one U.S. port to another be transported by American-owned vessels. Higher labor costs and more stringent regulations mean that shipping rates for U.S. vessels are relatively high. In contrast, shipments from foreign ports are not subject to the Jones Act. For this reason, water-transported product from Caribbean refineries may be competitive with pipeline shipments from the Gulf and with locally refined product. 14/

Although sources of supply and modes of transportation differ between SE and NE, the two marketing regions are connected by a common pipeline. It is therefore not possible to say a priori whether the two areas are in the same or in different geographic markets. In contrast, there is virtually no transportation of product between the East and West coasts of the U.S. Petroleum products consumed on the West coast (WC) are either refined west of the Rocky mountains or imported. Oil companies that market in both areas generally coordinate operations west of the Rockies and east of the Rockies, but operate the east and west regions independently of one another. 15/ For these reasons, it is highly unlikely that SE and WC form part of a common geographic market for petroleum products.

Starting with SE and moving outwards, we thus find a range of possible geographic markets, each with decreasing probability. It is almost certain that marketers at the same terminal cluster compete with one another. And it is probable that marketers at different terminal sites within SE compete. It is still possible that sites in SE compete with those in NE, but highly unlikely that they compete with sites located in WC.

IV: PRICES AND PRICING PRACTICES

IVa: Practices

Gasoline refiners and marketers can be grouped into two classes -- majors and independents. Major-brand gasoline bears the trademark of one of the fifteen or so largest integrated oil companies (Exxon, Mobile, etc.). Majors distribute gasoline directly to branded retail outlets or to branded jobbers. Jobbers supply service stations which they may operate themselves or lease to independent dealers. Although independent retail outlets often market gasoline that originates in the refineries of majors, most gasoline refined by majors is retailed through branded outlets.

Independent refiners sell gasoline directly to their own retail dealers, to empolyee-operated outlets, and to unbranded jobbers. Independents tend to be smaller than majors, less fully integrated, and sell a much higher proportion of unbranded gasoline.

In addition to independent refiners, there are independent marketers that sell private-brand gasoline. Private-brand marketers generally rely on a low-price high-volume strategy and rarely have exclusive supply arrangements with particular refiners. They are often willing to shop around for the best price and are considered to be the most competitive force in retail markets. Independent refiners and independent private-brand marketers together account for about thirty five perecent of all gasoline sold in the U.S. today.

Major and independent refiners post prices at each terminal site. Posted prices fluctuate frequently and there is a wide spread among prices charged by different marketers at the same site (as much as ten cents per gallon for unleaded gasoline). On the average, the prices posted by independent refiners are several cents per gallon lower that those posted by majors.

Transactions prices are not always the same as posted prices. Major refiners often offer a discount off posted price to select customers. Eligibility for discounts is determined in a curious fashion. Generally, discounts are offered on purchases that excede some fraction of sales for the same month of the previous year but do not excede some larger fraction of those sales. For example, a discount of four cents per gallon might be given on volumes greater than seventy percent but not more than one hundred and thirty percent of previous purchases for that month.

This discounting practice has the effect of rewarding loyal customers (those with regular supply arrangements) and punishing those who shop around for the best price. It also has the effect of separating geographic markets -- making it more difficult for retailers to shop at more than one terminal site.

Independent refiners are less apt to offer discounts than majors. Therefore, the effect of discounts is to reduce the spread between the prices charged by the two groups. An unbranded retailer thus has two strategies to choose between -- selection of the lowest price offered on a particular day or commitment to a regular supply arrangement with its attendant rewards.

IVb: Data

Data on prices are published weekly by the Oil Price Information Service (OPIS), a private data-collection agency. 16/ Prices are refiner prices to resellers F.O.B. terminals, excluding taxes and discounts. Each week OPIS tabulates the prices posted by each retailer at selected terminal sites in various regions of the country.

The time period chosen for the geographic-market analysis is the entire year from March 2, 1981 to February 22, 1982. Earlier weeks were eliminated in an attempt to avoid periods of price controls and the immediate aftermath of deregulation. 17/

Prices for both leaded and unleaded gasoline are recorded. However, for any one refiner, the two price series are so highly correlated that only the price of unleaded gasoline was used.

Two cities in each of the three regions were arbitrarily chosen. The cities are Greensboro, N.C. and Spartanburg S.C. in SE, Baltimare Md. and Boston, Mass. in NE, and Los Angeles and San Francisco Calif. in WC.

For each city, the minimum price charged by any refiner that week was used. The minimum price was chosen for several reasons. First, the minimum price is the price that is most affected by arbitrage across regions. If a buyer is willing to transport gasoline long distances in order to minimize costs, he will almost certainly select the lowest-price seller at the distant site.

Second, empirical studies such as that by Marvel (1978) find that increased competition in a region (such as the existence of a large number of independent marketers) affects the minimum price charged and the price spread in the region but not the maximum price. Majors tend to compete less on price and more on services such as credit cards and are thus less affected by aggressive price competition.

Finally, the use of the minimum price avoids the difficulty inherent in dealing with list prices that differ from transactions prices. The refiner charging the lowest price each week is almost always an independent who does not discount.

V: EMPIRICAL RESULTS

Va: The Deterministic Functions $g(Z_t)$

Federal regulation of gasoline prices began in August of 1971, when prices of most commodities were frozen by Phase I of the Nixon administration's wage and price controls. When controls on other commodities were eliminated, oil-price controls were maintained or expanded. However, in June of 1979, the Carter administration initiated a gradual crude-oil decontrol program, and in January of 1981, all remaining petroleum-price controls were removed by an Executive Order issued by President Reagan.

In early 1981, in spite of softening world oil markets, U.S. petroleum-product prices were still rising to catch up with world prices. However, shortly afterwards U.S. product prices began to decline (in nominal terms) as prices fell worldwide due to a glut of crude oil. The fall in product prices began early in the year in the East but did not start until July on the West coast.

With these facts in mind, $g^i(Z_t)$, $i = 1,\ldots,4$, were chosen to be quadratic functions of time. 18/ Table I shows the estimated coefficients of these functions for each city. 19/ An examination of the table reveals that both linear and quadratic coefficients are significant at the 95 percent level of confidence. In addition, the inverted-U shape is least pronounced in the Southeast and most pronounced on the West coast.

Vb: Causality Tests

Before testing the null hypothesis of independent price determination at different terminal sites, it is necessary to choose the lengths of the lags, n_i, $i = 1,\ldots,6$. Five lags are sufficient to ensure that serial correlation is indiscernible in all equations. Though it would have been possible to use shorter lags in some equations, it seems preferable to be consistent across equations. 20/

All equations were estimated (by the method described in section IIc) in levels with a constant term and a quadratic trend. 21/ Table II gives the results of hypothesis tests. In the first column of the table, the notation $X \rightarrow Y$ stands for the alternative hypothesis that prices in city X "cause" prices in city Y. Acceptanceof the alternative hypothesis (rejection of the null hypothesis) implies that prices in city Y are not exogenous to prices in city X. The second column of table II shows results of tests of the null hypothesis for the first set of regressions.

An analysis of the tests shows that the hypothesis of independent price determination within SE must be rejected, implying that the two cities form part of a common geographic market.

Results for SE - NE pairs are mixed. Independent price determination is accepted in five cases and rejected in three. One might therefore conclude that there is some interaction between the regions, but that it is not nearly as

TABLE I

Deterministic Functions of Time

City	Coef. of t [a]	Coef. of t^2 [a]
Greensboro	.07* (2.1)	-.002** (-2.9)
Spartanburg	.09** (2.7)	-.002** (-3.5)
Baltimore	.11** (2.6)	-.002** (-3.1)
Boston	.19** (3.4)	-.005** (-4.3)
Los Angeles	.33** (2.7)	-.008** (-3.0)
San Francisco	.26* (2.1)	-.006** (-2.5)

a * denotes significance at the 95% level of confidence.
** denotes significance at the 99% level of confidence.

strong as within SE.

An alternative explanation for the mixed results is as follows. Products flow in only one direction, from SE to NE. Therefore, a high price in NE (a low price in SE) would cause product to flow out of SE which would raise the price in SE and lower it in NE. However, a high price in SE (a low price in NE) would not cause reverse product flows and might therefore persist. Causality tests can detect unidirectional causality ($X \rightarrow Y$ but $Y \not\rightarrow X$). However, they cannot distinguish asymmetric responses ($X \rightarrow Y$ when X is high but $X \not\rightarrow Y$ when X is low).

If the alternative explanation for the mixed results is accepted, it has important antitrust implications. Antitrust authorities are worried about producer price increases and output restrictions. If an increase in price in SE would not be counteracted by product flowing into the region from NE, the partial connection of the regions would be irrelevant for antitrust purposes, and SE would constitute a self-contained market.

Finally, table II shows that independent price determination between SE and WC is never rejected. It therefore seems highly unlikely that SE and WC form part of a common geographic market for gasoline.

The appendix gives results of hypothesis tests for all thirty city pairs (not just those involving cities in SE). It also shows estimates of equation 3' for the city pairs included in table II.

Some of the estimated autoregressive processes (equations 1' and 2') are near explosive (their associated generating functions have roots that are statistically indistinguishable from one in absolute value). Because the asymptotic distribution theory for the estimates of autoregressions of stationary

TABLE II

F-Statistics for Exogeneity Tests

City Pairs [a]	Levels [b]	Logs [b]	Filtered [b]	Frequency
Gr → Sp	2.5*	2.5*	1.9	
Sp → Gr	4.5**	4.8**	3.7**	
SE ↔ SE				.83
Ba → Gr	.89	1.0	1.0	
Gr → Ba	2.6 *	2.5 *	1.1	
Ba → Sp	.40	.40	.49	
Sp → Ba	5.1 **	4.9 **	2.3	
Bo → Gr	2.5 *	2.7 *	2.0	
Gr → Bo	1.0	1.1	.45	
Bo → Sp	1.2	1.3	.97	
Sp → Bo	1.3	1.4	.54	
SE ↔ NE				.25
LA → Gr	.73	.78	.60	
Gr → LA	.83	.97	.28	
LA → Sp	.82	.84	1.0	
Sp → LA	.76	1.1	1.3	
SF → Gr	.96	1.1	1.5	
Gr → SF	1.4	1.6	1.6	
SF → Sp	.53	.63	1.2	
Sp → SF	2.1	2.4	2.7 *	
SE ↔ WC				.04

a City abbreviations are: Gr -- Greensboro, Sp -- Spartanburg, Ba -- Baltimore, Bo -- Boston, LA -- Los Angeles, and SF -- San Francisco.

b * denotes significance at the 95% level of confidence.
** denotes significance at the 99% level of confidence.

series does not apply if the processes are in fact explosive, it is possible that, if the processes are near explosive, results of hypothesis tests will be sensitive to minor changes in specification.

In theory, causality tests are invariant with respect to strictly monotonic transformations of the data and with respect to the application of a stable linear filter. 22/ To test sensitivity to changes in specification, all estimates were redone after taking natural logarithms of the variables and after prefiltering the data using the filter

$$X'_t = X_t - .8X_{t-1}. \tag{6}$$

The results of hypothesis tests on the transformed variables are shown in columns three and four of table II. An examination of the tests shows that conclusions are basically unchanged. However, with the filtered data, the null hypothesis of independent price determination is accepted more frequently.

The final column of table II shows the frequency with which the null hypothesis is rejected. For eighty three percent of the regressions involving two cities in SE, independent price determination is rejected. In contrast, price independence is rejected for only twenty five percent of the SE - NE pairs and for only four percent of the SE - WC pairs.

VI: SUMMARY AND CONCLUSIONS

The problem of market definition is faced by the courts in every monopolization and merger case. However, economists have provided the courts with almost no theory or testing procedure with which to delineate markets. It is therefore not surprising that, in practice, market definition relies on increasingly more complex legal distinctions. This paper introduces a statistical procedure that can be used in conjunction with an understanding of the industry and the institutions that govern it to restore economic rationality to market definition.

The common geographic-market test is based on the work on causality of Granger (1969) and Sims (1972). It makes use of the history of prices in various geographic regions to test for independence across regions. The test is developed to distinguish between geographic markets. However, with obvious modifications it could be used to distinguish between product markets.

The test is applied to the problem of determining geographic markets for wholesale gasoline. Based on the empirical results, one can conclude that the interior of the Southeastern part of the United States is a local geographic market that is only loosely connected to the Northeastern seaboard and is entirely separate from the West coast. If this conclusion is accepted, it has important antitrust implications. A merger between two oil companies that market heavily in the Southeast could have an anticompetitive impact on petroleum-product markets, even if its impact on the market for crude oil were negligible.

A statistical test can never establish conclusively that two regions are in different geographic markets. It is therefore useful to have several techniques to apply to the problem of market definition. It is hoped that the test proposed here will be used in conjunction with others, such as the one developed by Howell (1982), and that court procedure will become more rigorous as a consequence.

There are several possible extensions to the method. The technique could be extended to multivariate problems. Instead of performing pairwise tests, it would be possible to consider the hypothesis that several cities belong to the same market and to perform a joint test of this hypothesis. Another possible extension would be to embed the test in a complete dynamic simultaneous-equation model, which would include all of the endogenous and exogenous forces that determine prices. 23/ Because the question of market definition has important policy applications, it is hoped that this paper will generate further research in the area.

FOOTNOTES:

1 For example, the pertinent part of Section 7 states that "no corporation engaged in commerce shall acquire, directly or indirectly, the whole or any part of the stock or other share capital and no corporation subject to the jurisdiction of the Federal Trade Commission shall acquire the whole or any part of the assets of another corporation engaged also in commerce, where in any line of commerce, in any section of the country, the effects of such acquisition may be substantially to lessen competition, or to tend to create a monopoly."

2 For analyses of how the courts have treated the market-definition issue, see Elzinga and Hogarty (1973) and Horowitz (1981).

3 For example, in 1982 Stigler testified verbally before the Federal Trade Commission with respect to the merger between two flour milling companies. He used a test based on correlation coefficients to substantiate the claim that the flour-milling market is national.

4 The issue of seasonality in demand is complex. The fact that prices in two regions exhibit common seasonal patterns is not evidence that they are related. However, the fact that seasonal patterns are different could be evidence that the two regions are not related. For example, if prices are high in the summer and the regions are in the northern and southern hemispheres, respectively, the fact that north-south trade flows do not iron out north-south price differences could be evidence that the markets are separate.

5 For an excellent survey of causality in econometrics, see Geweke (1980).

6 An alternative possibility is that price is determined in region 1, whereas region 2 acts as a price taker. In this case, P^1 would cause P^2 but P^2 would not cause P^1.

7 These functions are linear in parameters, not variables, and can include a constant term.

8 If P^1 and P^2 are contemporaneously correlated, equations 3 and 4 must be interpreted as reduced-form equations.

9 If the functions, $g^i(Z_t)$, $i = 1,2$, contain infinite lags, these lags must also be truncated.

10 A problem with the method is that if step 1 fails, there is no general technique for proceeding. Several special cases are discussed in Geweke (1978).

11 n_1 and n_2 are chosen similarly.

12 Residuals must be serially uncorrelated for the seemingly unrelated regressions estimation technique to be applied and for the F-test to be valid.

13 Much of the information contained in this section came from verbal interviews with petroleum refiners.

14 Product from local refineries is of comparable cost because typically crude oil has to be transported by pipeline to these refineries.

15 For example, Shell coordinates crude flows into and product flows out of its West-coast refineries. It also coordinates operations in the East and Midwest, but does not coordinate between East and West.

16 OPIS reports are published weekly except for the last weeks in June and December. For the missing weeks, an average of the previous and following weeks prices was used.

17 Deregulation was complete in January of 1981.

18 It might be possible to capture this effect by including crude-oil prices in Z_t. However, the cost of crude is very different, depending on its source. It was therefore thought preferable to model exogenous effects on product prices as functions of time.

19 The coefficients shown were not obtained by regressing prices on time. They are estimates of the deterministic part of equations 1' for each city.

20 Results of hypothesis tests were not very sensitive to the choice of n_i.

21 When Z_t are the same in each equation and the lags are all of the same length, the seemingly unrelated regression technique reduces to ordinary least squares.

22 The length of the filter must be shorter than the lag lengths in the equations.

23 Embedding the test in a more complicated model would be interesting from the point of view of research into the market-definition issue. However, one of the advantages of the test shown here is its simplicity. When a proposed merger is challenged and a preliminary injunction is sought, the government has only three weeks to prepare its court case. Therefore, if a simple test is useful, it has obvious advantages over one that is much more time consuming.

APPENDIX

Table A1 shows results of all pairwise tests (not just those involving cities in SE). Regressions were run with variables in levels and contain a constant term and a quadratic trend.

The most striking feature of the table is that when tests involve city pairs where one is on the West coast and the other is in the East, independent price determination is never rejected.

Table A2 shows estimates of equation 3' for the city pairs included in table II. The coefficients c_0, c_t, and c_t2 correspond to the quadratic trend, $g^{3*}(Z_t)$. t-statistics are shown in parentheses under the corresponding estimated coefficients.

TABLE A1

F-Statistics for Exogeneity Tests

City Pair [a]	F [b]	City Pair [a]	F [b]
Gr → Sp	2.5 *	LA → Sp	.82
Sp → Gr	4.5 **	Sp → SF	2.1
Gr → Ba	2.6 *	SF → Sp	.53
Ba → Gr	.89	Ba → Bo	2.3
Gr → Bo	1.0	Bo → Ba	4.8 **
Bo → Gr	2.5 *	Ba → LA	.83
Gr → LA	.83	LA → Ba	1.3
LA → Gr	.73	Ba → SF	.39
Gr → SF	1.4	SF → Ba	.79
SF → Gr	.96	Bo → LA	.87
Sp → Ba	5.1 **	LA → Bo	1.5
Ba → Sp	.40	Bo → SF	1.9
Sp → Bo	1.3	SF → Bo	1.1
Bo → Sp	1.2	LA → SF	1.0
Sp → LA	.76	SF → LA	.89

a For a list of the city abbreviations, see page 20.

b * denotes significance at the 95% level of confidence.
** denotes significance at the 99% level of confidence.

TABLE A2

Econometric Estimates of Equation 3'

City Pair[a]	c_1	c_2	c_3	c_4	c_5	d_1	d_2	d_3	d_4	d_5	c_0	c_t	c_t^2	R^2	DW
Gr → Sp	.780 (4.4)	.488 (2.4)	-.132 (-.62)	-.335 (-1.3)	.251 (1.1)	-.250 (-1.4)	-.284 (-1.4)	.387 (2.0)	.293 (1.4)	-.305 (-1.8)	10.1 (1.4)	.107 (2.4)	-.002 (-2.9)	.99	1.9
Sp → Gr	.352 (1.9)	.007 (.04)	.177 (.88)	-.026 (-.12)	-.112 (-.65)	.536 (3.0)	-.022 (-.10)	.161 (.74)	-.190 (-.71)	.121 (.50)	-1.15 (-2.0)	.074 (1.6)	-.002 (-2.0)	.99	2.0
Ba → Gr	.706 (3.6)	.033 (.15)	.071 (.31)	-.028 (-.12)	-.050 (-.19)	.237 (.85)	-.005 (-.02)	.177 (.70)	-.070 (.26)	-.315 (-1.2)	10.7 (.61)	.042 (.73)	-.001 (-1.6)	.98	1.9
Gr → Ba	.335 (1.5)	.156 (.80)	.101 (.51)	-.224 (-1.0)	-.203 (-.98)	.150 (.97)	-.056 (-.31)	-.072 (-.40)	.444 (2.4)	.190 (.93)	19.0 (1.4)	.038 (.84)	-.001 (1.6)	.98	2.0
Ba → Sp	.812 (4.2)	.100 (.43)	-.088 (-.36)	.055 (.21)	.061 (.25)	-.144 (-.61)	.286 (1.2)	-.158 (-.63)	-.131 (-.53)	.113 (.52)	8.87 (.71)	.096 (2.0)	-.002 (-2.9)	.98	2.0
Sp → Ba	.240 (1.3)	.260 (1.4)	.012 (.06)	.118 (.63)	-.116 (-.70)	.452 (3.1)	-.354 (-2.0)	.042 (.23)	-.121 (-.59)	.508 (2.8)	-5.87 (-.62)	.125 (3.4)	-.002 (-3.9)	.99	2.1
Bo → Gr	.752 (4.5)	.023 (.10)	-.091 (-.42)	.088 (.40)	-.016 (-.01)	.202 (2.1)	.114 (.98)	-.257 (-2.2)	.018 (.15)	.142 (1.5)	2.31 (.30)	.021 (.59)	-.001 (-1.1)	.99	1.9
Gr → Bo	.518 (3.1)	.103 (.52)	.066 (.33)	-.099 (-.47)	-.138 (-.85)	.579 (2.0)	-.429 (-1.1)	.037 (.10)	.025 (.07)	.058 (.21)	28.1 (2.1)	.190 (3.1)	-.004 (-3.6)	.95	1.9

TABLE A2 Cont.

City Pair[a]	c_1	c_2	c_3	c_4	c_5	d_1	d_2	d_3	d_4	d_5	c_0	c_t	c_t^2	R^2	DW
Bo → Sp	.714	.099	-.137	-.046	.122	.195	.028	-.136	.004	.085	6.91	.041	-.001	.98	1.9
	(4.2)	(.43)	(-.36)	(.21)	(.25)	(-.61)	(1.2)	(-.63)	(-.53)	(.52)	(.71)	(2.0)	(-2.9)		
Sp → Bo	.405	.158	.069	-.183	-.171	.411	.068	-.185	.126	.114	14.3	.249	-.005	.96	1.9
	(2.3)	(.82)	(.35)	(-.95)	(-1.1)	(1.1)	(.18)	(-.50)	(.29)	(.35)	(1.3)	(3.2)	(-3.7)		
LA → Gr	.829	.063	.052	.132	.104	.038	.214	-.295	.335	-.193	3.13	-.009	.0003	.98	1.9
	(4.7)	(.28)	(-2.1)	(.53)	(-.59)	(.24)	(1.1)	(-1.3)	(1.5)	(-1.0)	(.20)	(-.05)	(.01)		
Gr → LA	.628	-.101	.102	-.075	-.191	.052	-.014	.163	.147	-.267	56.1	.430	-.010	.99	2.1
	(3.6)	(-.48)	(.43)	(-.30)	(-.92)	(.28)	(-.06)	(.63)	(.55)	(-1.4)	(3.3)	(2.4)	(-2.8)		
LA → Sp	.716	.122	.015	-.114	.100	.213	.018	-.119	-.030	.152	-.737	-.079	.002	.98	1.9
	(4.2)	(.59)	(.07)	(-.46)	(.55)	(1.4)	(.18)	(.18)	(.16)	(13.)	(.15)	(.003)			
Sp → LA	.775	-.132	.073	-.111	-.126	.286	-.471	.187	.069	-.018	47.2	.357	-.008	.99	2.0
	(4.2)	(-.59)	(.34)	(-.50)	(-.64)	(1.4)	(-1.9)	(.70)	(.23)	(-.08)	(2.8)	(2.0)	(-2.3)		
SF → Gr	.843	.086	.042	-.146	.103	-.154	.221	.225	-.386	.060	10.2	.101	-.002	.98	2.0
	(4.9)	(.38)	(.19)	(-.63)	(.61)	(-.86)	(1.1)	(1.1)	(-1.8)	(.33)	(.57)	(.71)	(-.07)		
Gr → SF	.718	.058	-.205	.038	.029	.222	-.214	-.259	.445	-.172	35.0	.222	-.006	.99	1.9
	(4.3)	(.30)	(-1.0)	(.19)	(.17)	(1.4)	(-1.0)	(-1.2)	(2.1)	(-1.1)	(2.1)	(1.7)	(-2.1)		
SF → Sp	.738	.207	-.176	-.024	.159	-.042	.258	-.099	-.198	.131	3.73	.071	-.001	.98	1.9
	(4.4)	(.94)	(-.76)	(-.09)	(.76)	(-.24)	(1.3)	(-.47)	(.98)	(.83)	(.22)	(.55)	(-.55)		
Sp → SF	.669	.150	-.229	.101	-.031	.459	-.407	-.318	.398	-.111	33.2	.187	-.005	.99	2.0
	(3.9)	(.76)	(-1.1)	(.52)	(-.21)	(2.8)	(-1.9)	(-1.4)	(1.5)	(-.55)	(2.1)	(1.5)	(-1.9)		

a For a list of the city abbreviations, see page 20.

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