

# Price Tests and Geographic Market Definition

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## Introduction

This article discusses five empirical price analyses (“price tests”) that commonly are used in the delineation of geographic markets in competition analysis. Such price tests typically are applied to prices series from different geographic regions to affirm or deny quantitatively the hypothesis that various regions are interrelated in an economic sense. If two or more regions are part of an integrated market, prices in these regions should follow a similar pattern, or be systematically related, over time. However, because there is debate over whether such price tests are able to properly identify relevant markets for antitrust purposes, some have questioned the utility of such techniques in antitrust analysis.<sup>1</sup> Despite this, price tests frequently do appear in competition matters and appear to be useful components of an overall antitrust study concerning market definition.

The price tests discussed are price correlations, Granger causality tests, cointegration and stationarity tests, and econometric models of price responses and co-movements across regions based on natural experiments. Such price tests are useful in geographic market definition exercises because they can help determine, for example, whether a putative price increase above a competitive level in a given geographic area – perhaps due to a proposed merger – will generate a sufficient supply response from other geographic areas to cause prices to return to competitive levels. If so, then this provides evidence of an broader geographic market as these “outside” areas ought to be included in the geographic market. However, if price tests find persistent price differences among the regions under study, this is evidence of separate, not integrated, markets.<sup>2</sup>

It is important to remember, however, that results of these price tests may be driven in part (or in full) by the effect of common factors or influences affecting all prices under study. If so, a finding that two (or more) prices from different regions are related might not necessarily show that these regions are part of the same geographic market, but might merely reflect parallel movements of common influences in each region over time. Unless the influence of common factors is explored, one cannot be sure whether an association found among prices by these price tests is spurious (i.e., due to common influences

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<sup>1</sup> While this paper touches upon some of these issues, the interested reader may consult the various references in this article concerning the use and potential misuse of price tests in defining markets for antitrust analysis.

<sup>2</sup> There is a relatively large (and growing) literature on using price tests to define markets. This may be because prices are the type of data frequently most easily obtained and analyzed. See, e.g., Audy, E. and Erutku, C. (2005) “Price Tests to Define Markets: An Application to Wholesale Gasoline in Canada,” *Journal of Industry, Competition and Trade*, 5, pp. 137-154. These authors review several of the price tests discussed in this article and apply them to Canadian wholesale gasoline to estimate the extent of geographic markets. Werden, G. and Froeb, L. (1993) “Correlation, Causality, and All that Jazz: The Inherent Shortcomings of Price Tests for Antitrust Market Delineation,” *Review of Industrial Organization*, 8, pp. 329-353 discuss in detail various price tests, and their limitations, used to delineate markets.

unaccounted for in the analysis) or valid. That is, the price data under study generally need to be “purged” of any common influences before valid conclusions about the extent of the geographic market can be drawn from price tests.<sup>3</sup>

## Key Time-Series Issues

Defining a few key concepts will aid in the understanding of the price tests discussed herein.<sup>4</sup> When analyzing time-series data such as prices in order to determine whether or not they are related, it is standard practice first to test each series for “stationarity.”<sup>5</sup> A complete discussion of stationarity, the related concept of “cointegration,” and the formal statistical tests used to diagnose such time-series phenomenon is not necessary for the purpose of this article. However, one insight from this literature is that several of the price tests discussed in this article (e.g., regression or correlation analysis) may produce spurious results if the prices under study are “nonstationary.” In particular, with time-series data, a spurious correlation exists when two (or more) variables are related only through their correlation with an omitted variable (e.g., some common input cost), especially if such data have increasing or decreasing trends. For example, finding a positive relationship between trending variables simply because each is growing over time is an example of spurious correlation. Data representing price series – which typically may trend one way or another over time without reversion to a long-run average – may exhibit nonstationary behavior. The concern, then, is that conclusions based upon statistical associations found between price series that individually are nonstationary may not be meaningful because such associations run the risk of being spurious. For this reason, it is recognized that in order to avoid this when using regression or correlation analysis to investigate relationships among prices, the price series under study, if not stationary to begin with, should be made so prior to analysis.<sup>6</sup>

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<sup>3</sup> For example, it might be the case that the various prices tests find a strong association between prices of retail gasoline in, say, Cleveland, OH and Washington, DC. However, this does not necessarily indicate that these two cities are in the same geographic market for retail gasoline. Rather, prices in both cities may respond at least in part to similar changes in cost (e.g., fluctuations in the price of crude oil).

<sup>4</sup> For a non-technical introduction to these topics, see Rubin, J.L. (2004) “Cointegration and Antitrust: A Primer.” Economics Committee Newsletter, distributed in the American Bar Association Antitrust Section Meetings, pp. 10-19. For a more detailed discussion, see, e.g., Dickey, D., Jansen, D., and Thornton, D. (1991) “A Primer on Cointegration With an Application to Money and Income,” Economic Review, Federal Reserve Bank of St. Louis, pp. 58-78; Enders, W. (2004) Applied Econometric Time Series. 2<sup>nd</sup> ed. (John Wiley & Sons, Inc.); Stock, J. and Watson, M. (2003) Introduction to Econometrics (Addison-Wesley); and Wooldridge, J. (2003) Introductory Econometrics: A Modern Approach. 2<sup>nd</sup> ed. (South-Western College Publishing).

<sup>5</sup> Generally, a time series is said to be “stationary” if basic statistical properties such as its mean and variance are constant over time. Time series that violate these conditions are called “nonstationary” and often exhibits an upward or downward trend without reversion to a constant mean.

<sup>6</sup> A standard technique to rid a time series of nonstationarity, should it be found to exist, is to take first differences and, if these are stationary, to use them the statistical analysis. The first difference of a price series is the difference (or change) in price between the current time period and the previous time period.

However, it may be the case that two or more nonstationary time-series (with the same order of integration) are “cointegrated.”<sup>7</sup> If so, then while each data series individually are nonstationary, they will tend not to move too far apart over time. As a result, regression analysis or correlation analysis containing such variables (*i.e.*, individually nonstationary but jointly cointegrated) likely is meaningful in that valid, and not spurious, associations among variables can be estimated. Also, if the price series to be analyzed from different geographic areas are found to be cointegrated, this is statistical evidence that there exists a systematic equilibrium (or long-run) relationship among them. This would support the notion that these products are part of the same geographic market. On the other hand, if the analysis determines that the prices are not cointegrated (*i.e.*, they tend to vary over time independently of each other), this is consistent with the products being in distinct markets.

### **Correlation Analysis**

Correlation analysis is a quantitative technique for measuring the degree to which two variables move together contemporaneously, and is a standard initial technique to analyze price movements across regions.<sup>8</sup> If it were argued that for a certain homogeneous product, two regions ought to be considered as part of the same geographic market, their prices ought to exhibit a high degree of correlation. A high and statistically significant correlation between prices in different regions provide short-term measures of parallel price movements, which is consistent with the regions being part of the same geographic market. Correlation analysis is statistically valid if the individual price series are stationary. If formal statistical tests show that this to be so, then more sophisticated analyses (e.g., cointegration tests) are unnecessary.

As noted above, correlations among prices may be driven by the effect of common factors or influences other than competitive interdependence. If so, it is possible that positive and significant price correlations do not necessarily show regions are linked in an integrated market, but might simply reflect parallel movements of common costs in each region over time. In order to minimize such spurious findings of correlation, one may statistically control for the common costs’ influence on prices, and then test if the remaining price movements are significantly correlated. Specifically, a regression equation for

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<sup>7</sup> More precisely, two (or more) non-stationary variables are cointegrated if there is a linear combination of them that is stationary. If the prices under study are found to be nonstationary, their “order of integration” needs to be the same for cointegration analysis to be used appropriately. The “order of integration” is the minimum number of times a data series needs to be “differenced” to yield a stationary series. For example, the first difference of a price series is created by calculating the difference in price between each period. If two variables are integrated of different orders, they cannot be cointegrated.

<sup>8</sup> A correlation coefficient ranges from a minimum of -1.0 (when variables move perfectly in opposite directions) to a maximum of +1.0 (when variables move together perfectly). Unrelated variables will yield a correlation coefficient that will be statistically indistinguishable from zero.

each of the price series of interest can be estimated to obtain the regression residuals.<sup>9</sup> Correlation analysis is then applied to these residuals so as to measure the degree to which prices in the three regions move together after adjusting for the effect of common influence. Controlling for common influences prior to analysis so as to minimize spurious results is not unique to correlation analysis; it also must be considered when doing other price tests such as Granger causality and cointegration.<sup>10</sup>

## **Granger Causality**

A Granger causality test indicates whether changes in prices in a region can be shown to statistically “cause” changes in prices in other regions, and so provides evidence that the regions are in the same geographic market. Specifically, this regression technique tests for whether past prices of one or more regions significantly explain the current prices of another region. The Granger causality test reveals such linkages, and has been used in the economics literature to test whether or not regions are economically linked to provide support for a common geographic market.<sup>11</sup>

A standard way to conduct this price test is to analyze first the extent to which past (“lagged”) prices for a given product for the region at issue (e.g., the U.S.) can explain current prices in that same region. Then the analysis investigates whether adding lagged prices from other regions that are potentially in the same geographic market (e.g., Europe, Asia) significantly improves the ability to explain current U.S. prices. In essence, the test determines how much of the variability in current U.S. prices can be explained by past U.S. prices, and then determines how much additional variation can be explained by controlling for past prices in other regions. If lagged or past values for the other regions significantly enhance the prediction of the current value of the region at issue, then prices for the other regions are said to “Granger cause” the prices in the region at issue. Finding that prices from regions other than the U.S. “Granger cause” U.S. prices (and vice versa) would provide statistical evidence of the regions being in the same geographic market. One advantage of Granger causality tests over price correlations is that the former can be used to make causal inferences whereas the latter cannot. Another is that Granger tests allow for dynamic interaction among price series (i.e., there can be “lagged” effects at work), and that more than two price series can be analyzed at once.

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<sup>9</sup> A regression “residual” is the difference between the *actual* value of the dependent variable (here, price) and its *estimated* value predicted by the regression equation.

<sup>10</sup> See e.g., Slade, M. (1986) “Exogeneity Tests of Market Boundaries Applied to Petroleum Products,” The Journal of Industrial Organization, XXXIV(3), pp. 291-303; and Audy and Erutku (2005), for examples of controlling for common influences when conducting correlation analysis and Granger causality. Werden and Froeb (1993) discuss how the presence of common influences may produce spurious cointegration results.

<sup>11</sup> Slade (1986) illustrates the use of this technique by applying it to petroleum prices from various U.S. regions. See, also, Cartwright, P. A., Kamerschen, D. R., and M. Huang (1989) “Price Correlation and Granger Causality Tests for Market Definition,” Review of Industrial Organization 4, pp. 79-98.

## Cointegration and Stationarity Tests

### *Cointegration Analysis*

If different regions are in the same geographic market, an equilibrium relationship should exist among these prices such that the prices do not move independently of each other in the longer term. Even though prices in the different regions may temporarily drift away from their equilibrium relationship, economic forces will restore the equilibrium relationship when the different regions are part of the same geographic market. Formal statistical tests of cointegration allow one to estimate whether prices in different regions systematically adjust back to an equilibrium relationship within a reasonable period of time, even in the presence of prices that trend upward or downward (i.e., they are nonstationary).<sup>12</sup> Cointegration analysis identifies both the short-run and long-run dynamic (or “lagged”) relationship among prices in different regions, and accounts for other influences among the prices such as the adjustment speed back toward a long run equilibrium.

If two or more regional price series are cointegrated, their relative values do not move too far apart from their longer-run equilibrium relationship and they systematically return to that relationship after temporary short-run disturbances. Accordingly, finding that regional prices are cointegrated provides evidence of regional linkages and integrated markets.<sup>13</sup> In contrast, if prices in different regions move independently in the short and longer term, their prices will not be cointegrated. This evidence would suggest that there is no tendency for the prices to come back together over time, and that the products may be in distinct geographic markets. Similar to price correlation analyses, it may be necessary to statistically control for the influence of common influences on the prices under study, and then test to see if the remaining price movements are cointegrated.

### *Stationarity Tests*

Forni (2004), in analyzing price data from the market for fresh milk in Italy, argues that if two products or geographic areas are part of the same antitrust market, their relative prices must be

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<sup>12</sup> There is a substantial and detailed literature pertaining to cointegration and how to test for it. Two widely used techniques are the Engle-Granger Augmented Dickey-Fuller (EG-ADF) method and the Johansen test. However, as recognized in this literature, although the EG-ADF test is relatively easy to implement, it does have several important defects which limit its overall utility in testing for cointegration among more than two variables. Since these shortcomings do not plague the Johansen cointegration test, Johansen’s methodology is viewed as the preferred test for cointegration.

<sup>13</sup> See, e.g., Engle, R. and Granger, W. (1987) “Co-Integration and Error Correction: Representation, Estimation, and Testing,” *Econometrics*, 55(2), pp. 251-276, who argue that if different geographic locations comprise a single market, then their prices from these different locations should be cointegrated. Forni, M. (2004) “Using Stationarity Tests in Antitrust Market Definition,” *American Law and Economics Review*, 6(2), pp. 441-464 presents an approach to delineate relevant markets for antitrust purposes using stationarity and cointegration techniques. Warell, L. (2005) “Defining Geographic Coal Markets Using Price Data and Shipments Data,” *Energy Policy* 33(17), pp. 2216-2230, uses a cointegration test to for a single international market for coal.

stationary.<sup>14</sup> Stationarity tests, like price correlations, measure the extent to which price levels move together over time. Specifically, Forni's stationarity test investigates whether the relative price tends to return to a stable value over time, and if it does, how quickly it does so. If two products are in the same geographic market, we would expect that their relative price would revert to a stable long-run value (i.e., their price ratio exhibits stationarity). However, if the two prices are stationary to begin with, then neither stationarity tests or cointegration analysis is appropriate; correlation (or regression) analysis will suffice.

Forni argues that since his stationarity test does not require that the two prices have the same "order of integration," (other price tests such as Granger causality and cointegration analysis require this), it is better able to handle real world price data that have this characteristic.<sup>15</sup> However, one limitation to his stationarity test is that it only handles pair-wise comparisons of prices whereas cointegration tests can analyze more than two prices (i.e., a "vector" of prices). That is, if the exercise is to test prices from three different geographic regions (i.e., Asia, Europe, and North America), cointegration tests remain useful whereas Forni's price ratio analysis does not.

While recognizing that price tests such as Forni's can be useful complements to more traditional approaches to market definition, Hosken and Taylor (2004) discuss several specific limitations to Forni's stationarity tests.<sup>16</sup> One is that stationarity tests often will fail to place differentiated (branded) consumer products in the same market. Another is that, like other price tests, unless prices are purged of the potential influence of common costs prior to analysis, findings of stationarity may be spurious.<sup>17</sup>

### **Natural Experiments**

The basic experimental design in, say, a pharmaceutical test is to have a treatment group (who receive the test drug) and a control group (who are not exposed to the test drug). Because the control group is the group that is otherwise highly similar to the treatment group except that they are not exposed to the drug, it is used as the benchmark to which the effects on the treatment group are measured. While economists generally cannot conduct such controlled experiments as these, they sometimes can observe "natural experiments" such as a natural disaster, an unexpected plant outage, the entry/exit by key competitors, or a change in the economic or regulatory environment. From such occurrences, one can

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<sup>14</sup> Specifically, he analyzes the log of the price ratio for stationarity. Forni (2004) notes that his stationarity tests are closely related to cointegration analysis: "Precisely, the relation is that, if prices are costationary in first differences of the logs, the stationarity of the log ratio is equivalent to cointegration of the log prices..."

<sup>15</sup> Forni (2004) also notes that since his stationarity test is based on the price ratio, the results are insensitive to the use of nominal versus real prices unlike other price tests.

<sup>16</sup> Hosken, D. and Taylor, C. (2004) "Discussion of 'Using Stationarity Tests in Antitrust Market Definition,'" American Law and Economics Review, 6(2), pp. 465-475. Other authors such as Werden and Froeb (1993) have raised similar points.

<sup>17</sup> Other limitations discussed by these authors deal with technical issues related to the exact statistical tests used by Forni.

statistically test for changes in the variable of interest, and significant differences in outcomes can then be attributed to the event.<sup>18</sup> As noted by the Antitrust agencies and with respect to merger analysis, “Evidence pointing directly toward competitive effects may arise from statistical analysis of price and quantity data related to, among other things, incumbent responses to prior events (sometimes called ‘natural experiments’) such as entry or exit by rivals.”<sup>19</sup>

With respect to geographic market delineation, suppose that a natural disaster reduces production capacity significantly for a given product in a certain region. As a result, prices for that product increase in the affected geographic area. An econometric analysis of the price responses across regions will allow for inferences about the geographic extent of the market. If the price effects are confined to the geographic area in which it occurred, this provides evidence of separate regional markets. However, if the price effects of the unexpected capacity reduction are shown to spread from one geographic area to other geographic areas, this provides evidence of an integrated geographic market.

### **Do Price Tests Define A Relevant Antitrust Market?**

There is a well recognized distinction between “economic markets” and “antitrust markets” particularly with respect to geographic boundaries. The latter is what concerns antitrust practitioners but the former may be what price tests actually are defining. Therefore, the issue that has arisen in the literature about price tests is whether or not they define a properly defined antitrust market in which competitive effects can be analyzed.

As discussed in Church and Ware (2000), the geographic extent of an economic market is determined by arbitrage and transportation costs, although it may be somewhat difficult to find a clear “gap” between firms that would indicate whether or not a particular firm is “in” or “out” of a contemplated geographic market.<sup>20</sup> The concept of an antitrust market involves the delineation of a range of product and geographic space within which market power by a hypothetical monopolist can be exercised. So, unlike economic markets where the emphasis is on finding the determinants of an equilibrium price (for a certain product or set of products), the goal of defining an antitrust market is to

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<sup>18</sup> See, e.g., Coleman, M. and Langenfeld, J. (2007) “Natural Experiments in Antitrust Analysis: The Use of Daubert Criteria to Evaluate Their Relevance and Reliability,” **[[FULL CITE – forthcoming in an ABA publication]]**

<sup>19</sup> Commentary on the Horizontal Merger Guidelines. (2006) Federal Trade Commission and U.S. Department of Justice, p. 10.

<sup>20</sup> As quoted in Church, J. and Ware R. (2000) Industrial Organization, A Strategic Approach. Irwin McGraw-Hill, at 601, Cournot’s definition of an economic market is still the one accepted today (An economic market is “the entire territory of which parts are so united by the relations of unrestricted commerce that the prices there take the same level throughout, with ease and rapidity.”) A similar definition of an economic markets was advanced by Alfred Marshall, who defined it as an area in which “prices of the same goods tend to equality with due allowance for transportation costs” (as quoted in Scheffman, D. and Spiller P. (1987) “Geographic Market Definition Under the U.S. Department of Merger Guidelines,” Journal of Law and Economics, vol. XXX ).

identify an area in which market power may be exercised. That is, the boundaries of an antitrust market are not so much determined by the “law of one price” (as used in defining an economic market) as by the “hypothetical monopolist test” as detailed in the U.S. Merger Guidelines. But, as noted by Scheffman and Spiller (1987), there may not be a clear correspondence between what the Merger Guidelines call antitrust markets and what economists usually understand economic markets to be. Relevant antitrust markets can be smaller or larger than the corresponding economic markets. For example, an antitrust market could be larger than the economic market where, due to an absence of entry barriers, firms from outside an industry would enter quickly in response to a significant and nontransitory price increase.

Audy and Erutku (2005) caution that while price tests are designed to determine whether certain areas are part of the same economic market, such an area may not constitute an antitrust market. Werden and Froeb (1993) warn that erroneous conclusion about competitive issues and effects may be made because of this. However, as noted by Hosken and Taylor (2004), “the price relationship tests of Forni and others can be useful complements to more traditional inputs to the market definition exercise.” And, Haldrup (2003) states, “We are aware that the concept of an anti-trust market as defined by the SSNIP-methodology is different from the concept of an economic market...Even though we realize that the market concepts are different, we will maintain that much useful information can be extracted from [price tests] based on the economic market concept, that is relevant for the anti-trust market and that cannot be extracted in any other way.”<sup>21</sup>

Therefore, price tests are best viewed as being most informative when accompanied by other analyses, based on a thorough investigation of the industry under study, that either confirms or refutes the appropriateness of the market defined by such tests for antitrust analysis. This sentiment seems to be consistent with the Agencies view on quantitative studies (at least as it pertains to merger analysis): “To be probative, of course, such data analyses must be based on accepted economic principles, valid statistical techniques, and reliable data. Moreover, the Agencies accord weight to such analyses only within the context of the full investigatory record, including information and testimony received from customers and other industry participants and from business documents.”<sup>22</sup>

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<sup>21</sup> Haldrup, N, (2003) “Empirical Analysis of Price Data in the Delineation of the Relevant Geographical Market in Competition Analysis.” University of Aarhus, Economics Working Paper No. 2003-09.

<sup>22</sup> Commentary on the Horizontal Merger Guidelines. (2006), p. 10.