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QUANTIFYING COMPARABILITY FOR APPLICATIONS IN ECONOMIC ANALYSIS: THE WEIGHTED DISTANCE METHOD[39]

Brian C. Becker
Economic Consulting Services Inc., Washington, D.C.

Kenneth R. Button
Economic Consulting Services Inc., Washington, D.C.

Abstract

Several areas of economic analysis require the comparison of the price of a product of concern with the price of a benchmark product; therefore, the selection of the appropriate comparable product as the benchmark is important to the validity and accuracy of the analysis. This paper specifically examines how the comparability of products is determined in the context of an import dumping analysis and in the analysis of intercompany transfer pricing. The "weighted distance" method is suggested as a procedure that incorporates greater information into the matching calculations used in these applications, as well as other applications. Instead of merely rank ordering the characteristics used for comparison, the weighted distance method statistically weights each characteristic to reflect its relative importance in determining product price. Using these weights in conjunction with the mathematical definition of distance between two points, the weighted distance algorithm can determine the

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weighted "distance" between every potential comparable product and the subject product.

Introduction

In regulatory economics, several areas of economic analysis require the comparison of the price of a product of concern with the price of a benchmark product. The goal frequently is to determine whether a particular company's price for the product is consistent with the price charged by the company for the identical, or nearly identical, product in a different market or with the prices charged by other producers. This task arises prominently in international trade matters both in the analysis of price discrimination between markets known as "dumping" and in analyzing international transfer prices among related companies. Both types of analysis commonly compare a company's transaction price in a particular market with the prices for comparable products in other circumstances.

The identification of the "comparable product" is an important part of these analyses. Comparability has some inherent subjectivity, and there is no single method that is universally accepted for determining product comparability. While different methods are used in different applications, the goals of any method should be: (1) to properly reflect the similarities/differences between the subject product and the potential comparables, and (2) to be objective in its application.

When the U.S. Internal Revenue Service ("IRS") performs a transfer pricing analysis on a product sold between related parties, it seeks to identify transactions between unrelated parties involving a comparable product, but the IRS does not rigidly apply a single mechanical procedure in determining what constitutes a comparable product. In contrast, when the U.S. Department of Commerce ("DOC") conducts a dumping analysis, it identifies the foreign producer's home-market product that is "comparable" to the product exported to the United States by use of a specific product matching procedure.

This paper examines the DOC's matching algorithm, considers

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its limitations, and proposes an alternative, less subjective matching algorithm for all types of comparability applications. The proposed comparability algorithm classifies each product according to a set of characteristics and assigns statistical weights to these characteristics denoting importance. This weighted distance method finds the "comparable" product that is the shortest "distance" away from the subject product.

Literature Review of Comparability

Although this paper considers comparability issues in the context of international trade and tax analysis, the most common application of the study of comparability has been the residential real estate market. Realtors will typically find "comparables" for their potential buyers and sellers to infer a reasonable market price for the house that is being bought or sold. In making their comparable selections, realtors usually consider a number of attributes of the potential comparables, including number of bedrooms, number of bathrooms, square footage, lot size, and neighborhood. Houses that are similar in these attributes to the house in question will be chosen to be comparables.

Significant research has not been performed regarding "how similar" a potential comparable needs to be to be classified as an appropriate comparable. Similarly, the question of which attributes should be considered more important than others has not been thoroughly addressed. The concept of "closeness" between a subject and potential comparables was addressed by Isakson (1986), who advocated a distance criterion to select those potential comparables closest to the subject.[40] Tchira (1979) found that a simple distance method, which ignores the relative importance of amenities, can lead to a biased set of comparables.

There have been, however, a number of articles regarding

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[40] The use of the Mahalanobis distance criterion incorporates the variance/covariance of the attributes.

determination of the optimal number of comparables and their weights. Based upon a minimizing variance criteria, Vandell (1991) showed that it was always optimal to add more comparables.[41] Gau, et. al. (1992) advanced Vandell's model to minimize variance per dollar of value (similar to a "coefficient of variation"). This distinction increased the robustness of their results and furthered the cause for making comparability analysis more of a "science" than its current state of being an "art." Further, Vandell proposed a methodology for determining the optimal weights of comparables. Such weights applied to the various comparables, and not to the specific characteristics of the products (residential housing) under consideration. Gau, et. al. extended the Vandell model which had a number of restrictions, including an imposed non-negativity constraint.

In the intercompany transfer pricing area, Witte and Chipty (1990) proposed analyzing comparability using an hedonic approach. Under this approach, the implicit prices of the attributes are derived from a regression of the comparables' prices on these attributes.

The DOC's Comparability Algorithm

Fundamentally, dumping involves price discrimination between markets. Generally, dumping arises when a product is sold for export at a lower price than it is sold in the home market.[42] The difference

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[41] In Vandell's model, each comparable was given a weight. The estimated sale price would be set to equal a weighted average of the comparables. Thus, Vandell showed that comparables could continue to be added so long as they had positive weights.

[42] Dumping may also occur if the product's export price is below the sum of its cost of production, general expenses, and a profit factor (its "constructed value"). In this paper, it is assumed to be appropriate to compare the export price and home market price to determine the existence of dumping. For an antidumping order to be issued by the DOC, the U.S. International Trade Commission must also make a determination that the U.S. industry producing the product is being materially injured, or is threatened with material injury by reason of the product exported to the United States. Tariff Act (1930). The international agreement governing the use of antidumping measures by the United States and most other countries is GATT (1994). GATT (1994) Article VI provides the basic antidumping framework. During the Uruguay Round of Multilateral Trade Negotiations, which concluded in 1994, a detailed accord on how GATT Article VI (1994) should be implemented was concluded. The "Agreement on Implementation of Article VI of GATT

between these prices, as a percent of the export price, is referred to as the dumping margin.[43] If the product, as exported, has an identical matching product sold in the home market, the ex-factory price of this product as exported and as sold in the home market are compared to determine the dumping margin. However, if the product as exported has no exact match with respect to the physical characteristics of the product sold in the home market, an effort is made to find the domestically-sold product which is the closest match to the exported product. The matched home-market product that is most like the exported product is termed the "like product."[44] The price of the like product, after certain adjustments, is termed the "normal value", and is the benchmark against which the export price is compared in order to determine whether dumping is occurring.

When the exported product has no identical match sold in the home market, the DOC applies its procedure for finding the closest match, which typically has the following steps:

1. Identification of the most salient characteristics of the product exported to the United States and sold in the home market (e.g., size, power level, and features).

2. Rank ordering of these characteristics in a strict hierarchical listing according to their importance.

3. Selection of appropriate measures or categories within each characteristic reflecting the relevant subgroups of attributes

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(1994)" is generally referred to as the Antidumping Code.

[43] The dumping margin in an initial investigation is also the estimated dumping liability, and is the amount of money which must be posted as a bond or deposit with the authorities of the importing country.

[44] The Antidumping Code provides that a product is considered as being dumped "if the export price of the product, exported from one country to another is less than the comparable price, in the ordinary course of trade, for the like product when destined for consumption in the exporting country." (Article 2.1, Emphasis added.)

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being measured (e.g., continuous cardinal measures; high, medium, and low segments; and discrete models, such as Models A, B, C, and D).

4. Classification of the exported product and each home market product according to all of the hierarchical matching characteristics.

5. Identification and selection of the home market product that most closely matches the exported product according to this procedure, and rejection of all other home market products.

Once the product exported to the United States (the U.S. product) and the products sold in the home market have been classified according to the matching characteristics, the DOC's comparability algorithm can be employed. As the first step, the comparability algorithm merely finds the product in the home market (the "like product") with the closest match to the U.S. product for the first-ranked characteristic. Home-market products that are not the closest match to the U.S. product on this characteristic are simply removed from further consideration as possible matches. If more than one product in the home market match the U.S. product on the first characteristic, they are assessed with respect to their closeness in matching on the second most important characteristic. This tie-breaking procedure continues until only one home market product remains or until no characteristics remain.

The DOC's product comparability algorithm is heavily influenced by the rank ordering assigned to the characteristics. For example, assume a U.S. product and two home market products have the values on the three highest-ranked characteristics as shown in the table below:

Product	Characteristic #1	Characteristic #2	Characteristic #3
U.S. Product	Type 1	100	100
Home Product A	Type 1	20	20
Home Product B	Type 2	100	100

These values show that, for characteristic #1, home market product A is similar to the U.S. product, but the two products are very different with respect to characteristics #2 and #3. In contrast, home market product B does not match the U.S. product for characteristic #1, but it is identical to the U.S. Product with respect to characteristics #2 and #3. Given these facts, the DOC procedure would select home market product A as the best match. However, it is quite conceivable that characteristics #1 and #2 could both be very important and that placing them in that order was a "close call".

Weighted Distance Comparability Method

The weighted distance method for establishing product comparability incorporates some of the features of the DOC's method, but also incorporates the mathematical definition of distance between two points. The weighted distance method specifies the relative level of importance by assigning corresponding weights to each characteristic.

After determining the appropriate characteristic values for the products in question, one way to determine which product is comparable" to the subject product is to use the mathematical definition of distance between two points, each of which are defined in "n"

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dimensions. As such, the distance between the point $(A_1, A_2, A_3,..., A_n)$ and the point $(B_1, B_2, B_3,..., B_n)$ is equal to:

$$\sqrt{\sum_{1}^{n}(A_i - B_i)^2}$$

In the context of economic analysis, such "distance" would refer to the square root of the sum of the squares of the differences of each of the characteristics between two products. Unlike n-dimensional mathematical space, where the distance from 0 to 3 on the x-axis is always the same as the distance from 4 to 1 on the y-axis, the simple difference of X units in one matching characteristic may be very different from a difference of X units in another matching characteristic because:

-- one product characteristic is likely to have a more significant effect than other characteristics on product price, and differences within that first characteristic should reflect its significance; or

-- one characteristic may be valued over a much broader (or narrower) range of numbers than other characteristics.

Therefore, a means must be found to determine a weight for each characteristic which will reflect both its relative importance and its range of values. A technique for determining such a weight is hedonic analysis. Hedonic analysis begins by estimating the price (or cost) of a product as a function of its attributes through the use of a regression. The regression is run across the prices of all potentially comparable products to determine the specific coefficients of the characteristics that define the price of that product. These coefficients would provide the weights for the matching characteristics.[45]

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[45] The hedonic analysis will result in coefficients for each of the product's characteristics, as well as a constant. For instance, assume that an hedonic analysis performed on pickup truck prices yields the following coefficients for wheel base, drive type, engine size, and transmission: 2,000; 3,000; 2,500; and -1,000. In addition, assume that the analysis yields a constant of 5,000. This implies that the price for a pickup truck

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Making use of the weights through hedonic analysis, <u>weighted distance</u> may be defined as the square root of the sum of the differences in characteristics' values multiplied by the characteristics' respective weights. Thus, when assigning weights of "W" to each of the "n" attributes, the weighted distance between two products would be equal to:

$$\sqrt{\sum_{1}^{n} W_i * (A_i - B_i)^2}$$

As an example, suppose that a product has 3 characteristics with weights equal to 2, 4, and 10 and that the subject product's characteristics are valued at 1, 2, and 10, and the first potential comparable's (Comparable #1) characteristics are valued at 5, 2, and 10. (See the following table.) The weighted average distance between these two products would be equal to:

$$\sqrt{2*(1-5)^2 + 4*(2-2)^2 + 10*(10-10)^2} = 5.7$$

If the same subject product is compared to another product (Comparable #2) with characteristics 2, 2, and 9, the weighted average distance between these two products would be equal to:

with wheel base of 3, drive type of 1, engine size of 2, and transmission of 4; should be $15,000, as follows:

5,000 + 2,000*(3) + 3,000*(1) + 2,500*(2) - 1,000*(4) = 15,000

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$$\sqrt{2*(1-2)^2+4*(2-2)^2+10*(10-9)^2} = 3.5$$

Thus Comparable #2, with a distance of 3.5, would be more similar (a "closer comparable") to the subject product, than would be Comparable #1.

Product	Character-istic A	Character-istic B	Character-istic C	Weighted Distance
Subject Product	1	2	10	N/A
Comparable #1	5	2	10	5.7
Comparable #2	2	2	9	3.5
Weights	2	4	10	

This type of application could be used directly in an antidumping analysis in this manner or, with slight modifications, in a transfer pricing context (see below.)

Intercompany Transfer Pricing Analysis

Intercompany transactions are analyzed by tax authorities to determine if multinational companies are attempting to shift profits into tax haven jurisdictions (or shift profits out of high-tax jurisdictions) through the manipulations of intercompany prices. The governing principle (known as the "arm's length" principle) among international tax agencies and tax authorities is that the terms of intercompany transactions (for tangible property, intangible property, and the provision of services) should be set as if the two parties to the intercompany transaction were independent companies. To determine what an arm's length price (or service fee, royalty rate, commission, etc.) would be, it is most useful to find data that show the prices of similar property in independent transactions.

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Section 482 of the Treasury Regulations ("482 regulations"), which governs the intercompany pricing of tangible property, services, and intangible property into and out of the United States, allows a taxpayer to set its transfer prices using different ranges of the comparables that it uses as benchmarks (arm's length ranges). If the comparables being used are so reliable that all adjustments that would reflect differences between them and the intercompany transaction have been made ("strict comparables"), the 482 regulations (1994) allow the taxpayer to use the full range of the comparables as an arm's length range for its transfer pricing. That is, the intercompany price may fall anywhere between the minimum and maximum adjusted prices of the comparables. In cases where all of these adjustments cannot be made or quantified ("unadjusted comparables"), the 482 regulations only allow the taxpayer to use the interquartile range (middle 50 percent) of the comparables' results.

Applying the weighted distance method of comparability to intercompany transfer pricing would suggest that two levels of comparability ("strict" and "unadjusted") would need to be defined. Under this method, a potential comparable could only be considered strictly comparable if it was within a small weighted distance ("strict distance") from the intercompany transaction. Similarly, unadjusted comparability would be reached for potential comparables that were within a slightly larger weighted distance ("unadjusted distance") from the intercompany transaction.[46]

In order to make these determinations, it is first necessary to define the values for strict and unadjusted distance. Thus, if strict distance were determined to be 4 and unadjusted distance were determined to be 6, (a) a potential comparable that was a weighted distance of 3 away from the intercompany transaction would be considered a strict comparable, (b) a potential comparable that was a

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[46] A potential comparable would be specifically defined as an unadjusted comparable only if it: (1) was within the unadjusted distance from the intercompany transaction, and (2) it was outside of the strict distance from the intercompany transaction.

weighted distance of 5 away from the intercompany transaction would be considered an unadjusted comparable, and (c) a potential comparable that was a weighted distance of 9 away from the intercompany transaction would not be considered an acceptable comparable.

Mathematically, if strict distance were defined as "S", and if unadjusted distance were defined as "U"(>S), a potential comparable "P" (with characteristics P_1, P_2, P_3, ... , P_n) would be strictly comparable to the intercompany transaction "I" (with characteristics I_1, I_2, I_3, ... , I_n) if:

$$\sqrt{\sum_{1}^{n} W_i * \left(P_i - I_i \right)^2} \leq S$$

Similarly, the same potential comparable would be considered an unadjusted comparable if:

$$S < \sqrt{\sum_{1}^{n} W_i * \left(P_i - I_i \right)^2} \leq U$$

Conclusion, Applications, and Topics for Further Research

As several areas of economic analysis require the comparison of the price of a product of concern with the price of a benchmark product, the selection of the appropriate comparable product as the benchmark is important to the validity, objectivity, and accuracy of the analysis. However, the analysis of comparability among products has some inherent subjectivity, and there is no universally-accepted single method for determining comparability. Therefore, research as to a

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method which minimizes subjectivity, and which may have broad applicability may be valuable.

The weighted distance method is suggested as a procedure that incorporates greater information into the matching calculations than current methodologies employed in dumping and transfer pricing analyses. The weights may be determined through an hedonic analysis which has the advantage of providing weights, for the characteristics of comparison, which simultaneously reflect the relative importance of the characteristic and account for differences in the range of values over which the different characteristics are measured. Using these weights in conjunction with the mathematical definition of distance, the weighted distance algorithm can determine the weighted distance between every potential comparable product and the subject product.

Furthermore, the measurement procedures used for classifying products within a product characteristic deserve additional research. It is unclear to what extent different segmentation patterns and the alternative treatments for nominal values can lead to different outcomes in the hedonic analysis and the product matching. An hedonic analysis will determine coefficients that maximize the percentage of the product prices that are explainable (adjusted R-square statistic) for a given set of classification numbering. By varying the classification numbering, one can also change the results of the hedonic analysis, and increase the adjusted R-square.

The weighted distance method has been shown as an effective tool when comparing products in the applications of antidumping and intercompany pricing analyses. Further research and extension of this work can be performed in the intercompany pricing area, as this area involves the comparison not only of products, but also of companies and agreements. In comparing potentially comparable companies, the characteristics might include main line of business, R&D as a percent of sales, and ratio of manufacturing to distribution. Similarly, the choice of comparable companies is often an important element in business valuation, where use of the weighted distance method could be considered. Thus, the weighted distance method could be applied in many different contexts.

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