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Robert E. Baldwin

R. Spence Hilton

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ABSTRACT

This paper estimates relative differences in factor prices (and thus industry comparative cost differences) between the United States and each of eight country groups by relating differences in factor-use requirements and actual bilateral export/import ratios across industries. Predictions concerning changes in industry export/import ratios are also made (and tested against actual subsequent changes) by comparing these trade ratios with those expected on the basis of the estimated average differences in factor costs and assuming that adjustment lags are the major reason for the differences between these ratios.

Robert E. Baldwin
Department of Economics
University of Wisconsin
Madison, WI 53706

R. Spence Hilton
Federal Reserve Bank
33 Liberty Street
Room 922
New York, NY 10045

A TECHNIQUE FOR INDICATING COMPARATIVE COSTS AND PREDICTING CHANGES IN TRADE RATIOS

Robert E. Baldwin and R. Spence Hilton*

I. Introduction

In determining industries of unusual strength or weakness in international competitive terms, past practice has been to look at actual trade performance. However, in a world characterized by market imperfections, this approach can be misleading, especially in the short run. The method suggested here tries to improve upon the standard revealed-comparative-cost approach by using estimated relative factor price differences between two countries to calculate relative cost differences between the countries for the products of each industry. A country is revealed to be highly competitive in its trade with another country for the products of a particular industry if its estimated production costs are significantly below those of the other country.

Future "winners" and "losers" can also be predicted in the sense that an industry's future export growth rate is expected to be either higher or lower than the growth rate of its imports. The procedure for this purpose is to compare an industry's ratio of exports to imports that is predicted on the basis of the estimated unit cost difference for a particular year with the actual export/import ratio for the industry in that year. Sectors where the actual ratio is much lower than the predicted trade ratio should, if adjustment lags are an important cause of such differences, exhibit a rise in this ratio over time. The opposite should occur when the actual ratio is above the predicted one.

II. An Outline of the Technique

A. Production Costs, Factor Prices and Trade Flows

Although variations among countries in relative factor endowments, states of technology and tastes shape the direction and composition of international trade, the immediate cause of commodity flows across national borders is differences among countries in the costs of producing tradable goods. In a two-country world, if one country can produce a particular standardized item more cheaply than the other and the transportation cost is less than the production cost difference, the first country will export the item to the second country.

Considerations that make the framework more realistic complicate the relationships but the basic point about cost differences remains. For example, in most manufacturing industries each firm produces goods that are similar but not identical to those provided by other domestic or foreign firms in the sector. One consequence of this is that two-way trade may take place in the same industry between countries. However, differences in production costs would still play an important part in determining the size of the ratio of exports to imports in each commodity category.

The existence of more than two countries also complicates the situation. The ability of (say) country A to produce and ship an item to country B at a cost below that at which B can produce the good is only a necessary (and not sufficient) condition for trade. This is because some third country (C) may be able to deliver the product in country B at an even lower cost than country A can. However, given the existence of differentiated products, one would still expect some net exports of the item from country A to B and the difference in production costs to be an important determinant of the size of exports compared to imports.

If countries share a common linearly homogeneous technology, differences in their unit costs of producing various goods depend solely upon the differences among the countries in the prices of the factor inputs. For n commodities, m factors and two countries, A and B, the relationship between the unit costs of producing the same good with the same technology in A and B and the differences between A and B in factor prices can be expressed as follows:

$$(1) \qquad \hat{UC}_j = \sum_{i=1}^{m} \theta_{ij} \cdot \hat{w}_i \ , \ j=1,2,\ldots n,$$

where $\hat{UC}_j$ stands for the relative difference for the unit cost of the j^{th} good, θ_{ij} is the i^{th} factor's share of unit costs of the j^{th} good, and $\hat{w}_i$ is the relative difference in the return to the i^{th} factor between A and B.[1] Let $\hat{UC}_j$ be positive if the unit cost is greater in B than in A and let $\hat{w}_i$ be positive if the return to the i^{th} factor is greater in B than in A.

B. Estimating Factor Price Differences

Since factor shares can be obtained from published data fairly readily, it is possible to determine relative unit cost differences between two countries, provided factor prices (or their differences) can be ascertained for the two countries. While the determination of factor price differences by direct observation might seem to be a relatively simple exercise, obtaining data that accurately represent the cost of a particular factor is, in fact, a difficult task. For example, only the advanced industrial countries systematically collect earnings data for various types of labor. Even when earnings data are available, intercountry differences in classification systems and in fringe benefits received by factors that are often unknown to the investigator cause serious measurement problems. Ascertaining differences in capital costs and rental returns to land and natural resources also is very difficult.[2]

Another quite different approach developed by Hilton (1981) is to estimate bilateral differences in factor prices on the basis of observable trade patterns. If country A exports a particular product to country B, this implies that the relative difference in unit costs between B and A, $\hat{UC}_j$, is positive. If A imports the item, $\hat{UC}_j$ is negative.

In a world of identical goods and production functions together with perfect knowledge, the relationships between the direction of trade, relative unit cost differences, and the weighted average of factor shares (where the weights are relative differences in factor prices) are completely deterministic and therefore not suitable for estimation. Furthermore, all commodity trade would be unidirectional. However, aggregation of product data within a particular industry as well as differentiated products will lead to two-way trade in most of the sectors identified under standard classification systems. Furthermore, imperfect factor and product markets, adjustment lags, relative differences in the state of technology between two countries, etc. can cause the weighted average of factor shares only to approximate relative differences in unit costs and can affect net trade flows. If one assumes that the various conditions preventing an exact relationship between factor prices and unit costs on the one hand and unit costs and net trade flows on the other are randomly distributed, an estimable model can be derived.[3]

Assuming the greater the relative cost advantage of one country over another in any product group the higher the ratio of exports of these products from the first country to imports from the second country, the following relationships are posited:

$$(2) \qquad \ln(X_j/M_j) = \beta_1 + \beta_2 \cdot \hat{UC}_j + e_j$$

$$(3) \qquad \ln(X_j/M_j) = \beta_1 + \beta_2 \cdot \sum_{i=1}^{m} \theta_{ij} \cdot \hat{w}_i + e_j ,$$

where X_j is the value of exports from country A to B in the j^{th} product class, M_j is the value of imports into A from B in this product class, β_1 and β_2 are constant terms, and e_j is a normally distributed random component. From a knowledge of factor shares, that is, the θs, and actual trade flows between two countries in every industry, one can obtain estimates of the rank order of relative factor price differences between the two countries.[4]

III. Analyzing U.S. Bilateral Trade Flows

In implementing the model empirically the industry breakdown used is that of the 367 sectors of the 1972 U.S. input/output table published by the Department of Commerce. Excluding nontraded-goods industries and aggregating industries in agriculture and mining to a 2-digit (rather than 4-digit) basis yields 296 separate industries. Trade between the United States and each of eight countries or regional groups (as well as an "all country" group) was analyzed for each of these industries. The countries or regions are: (1) Canada; (2) the United Kingdom; (3) France; (4) Germany; (5) Italy; (6) South Asia (India, Pakistan, Sri Lanka, Nepal and Bangladesh); (7) East Asia (South Korea, Taiwan and Hong Kong); and (8) Japan. The value of each U.S. industry's output was divided into the following five factor shares: (1) unskilled labor; (2) skilled labor; (3) physical capital; (4) land; and (5) natural resources.[5]

The return to U.S. unskilled labor is measured as the 1972 average annual income of a full-time worker with less than eight years of education. Multiplying this return by the total number of employees in each industry and dividing by the total value of industry output yields the share of output representing compensation to unskilled labor. The factor shares for skilled labor were calculated as the difference between the published industry factor shares for all labor and the calculated shares for unskilled labor. The output shares received by capital, land, and natural resources were estimated by subdividing the property income share, as reported in the input-output table, according to capital-stock, land, and natural resource information based on various reports from the Commerce, Agriculture and Interior Departments. Finally, trade data for each industry and country group was obtained by reclassifying exports and imports as reported by the Commerce Department first to a 4-digit SIC basis and then into the 4-digit I/O industrial breakdown.

The estimated coefficients reported in Table 1 for the two labor groups, physical capital, land and natural resources indicate the comparative magnitudes of differences in relative factor prices between the United States and each of the eight country groups.[6] Thus, for example, in trading with Western European countries and Japan the United States has the greatest comparative factor price advantage in either land or natural resources. The relative size of the coefficients for physical capital and skilled labor also indicates that the former is the relatively cheaper factor when comparing the United States with other developed countries (France is the exception), whereas skilled labor is the cheaper when the comparison is with less developed countries. Except for Southeast Asia where the coefficient on land is unexpectedly low, unskilled labor is the relatively most expensive factor in U.S. trade with Europe, Japan, and the developing countries. U.S.-Canadian trade reveals that the factor price difference most favorable for the United States is the one that exists for physical capital and the least, the one for natural resources.[7]

By multiplying the factor shares of each industry by the appropriate coefficients in Table 1, it is possible to calculate the bilateral export/import ratio for each industry that is predicted for each region on the basis of relative differences in factor prices (up to a uniform factor of proportionality) and a common constant term. The higher (lower) an industry's predicted trade ratio the more (less) competitive in comparative factor cost terms the U.S. industry is revealed to be in its trade with the appropriate region.

The results of these calculations reveal, as expected, that the U.S. is particularly strong in comparative factor cost terms _vis à vis_ most countries or regions in agricultural products, manufactured foodstuffs, tobacco, lumber and wood products, chemicals, plastic and synthetic materials, drugs, and computing equipment. A somewhat surprising result is the narrowness of the U.S. relative factor cost strength in the machinery and equipment categories. Though the U.S. export surplus in these sectors is still significant, it is only with developing countries where the United States has a strong cost advantage. (The same holds for the various metal products.) Moreover, the United States is now at a significant factor cost disadvantage in its trade with Japan in many of the machinery and equipment categories.

Other than the revealed strength of the Japanese over a very wide range of products there are few surprises on the least-competitive list. The breadth of the U.S. comparative disadvantage in apparel, miscellaneous fabricated textile products, and footwear and leather products is well known. Although the fabric and textile goods sectors are often lumped with the apparel industry, the textile sectors are not nearly as weak as apparel. Another point that emerges from the analysis is that other than in the apparel and footwear fields, the United States is not as yet at a significant factor cost disadvantage in its trade with developing nations.

IV. A Test of the Model's Ability to Predict Changes in Export/Import Ratios

If comparative cost conditions and other determinants of trade flows are reasonably stable between two periods and there are lags of adjustment in export/import ratios, the model can be used for the purpose of predicting changes in trade ratios across countries. A test on how well this technique works was undertaken by regressing changes in the export/import ratio from 1972 to 1979 on the residuals of the estimated equation (3), which are measures of the deviation of the actual 1972 export/import ratio from its predicted level. Specifically, the regression equation is:

$$(4)\qquad [\ln(X_j/M_j)_{1979} - \ln(X_j/M_j)_{1972}] = \alpha_1 + \alpha_2\tilde{e}_j + u_j \qquad j=1,2,\ldots n,$$

where the $\tilde{e}_j$'s are the residuals from the estimated equation (3), u_j is a normally distributed random term, and α_1 and α_2 are unknown constants. A positive and significant result for α_2 will suggest the technique is useful for predictive purposes. Table 2 indicates the results of this test. As the t statistics in this table indicate, actual and predicted changes are significantly related in the expected direction. On average, the actual change between 1972 and 1979 in the log of the trade ratio equalled a constant term plus between one-third and one-half of the amount by which the predicted 1972 ratio differed from the actual 1972 ratio.

Another test undertaken was to examine changes in actual trade ratios between 1972 and 1979 for only those bilateral industry relations where the difference between the log of the 1972 predicted trade ratio and the log of the 1972 actual trade ratio was absolutely "large", specifically, either greater than +2 or less than -2. In both sample sets, about 75 percent of the bilateral industry trade relationships moved in the expected direction.[8] The country distribution of these predicted shifts in trade ratios is indicated in the first two columns of Table 3.

There are several other interesting features of this analysis. One is the wide range of industries covered in both sample sets. The two-digit industries within which the number of predicted increases in bilateral trade ratios at the four-digit level not only exceeds the number of predicted declines but where this excess amounts to at least 20 percent of all the bilateral four-digit relationships in the industry are as follows: (1) livestock and livestock products; (2) forestry and fishery products; (3) stone and clay mining and quarrying; (4) wooden containers; (5) household furniture; (6) other furniture and fixtures; (7) chemicals and selected chemical products; (8) rubber and miscellaneous plastic products; (9) primary iron and steel manufacturing; (10) electric lighting and wiring equipment; and (11) optical, opthalmic and photographic equipment and supplies.

Included in this list of predicted "winners" are not just competitively strong industries such as livestock and livestock products, chemicals, selective lighting and wiring equipment, and optical, opthalmic and photographic equipment, but also industries that are comparatively weak in relative cost terms, e.g., household furniture, and other furniture and fixtures. Either recent (and not as yet fully exploited) technological developments had brought a narrowing in the cost-disadvantage position of these latter sectors or they had been burdened by policies that reduced their trade ratios below their equilibrium levels. But for whatever reason, their inclusion on the list emphasizes the point that industries with sizable trade deficits can also have the potential for significant improvements in their trade ratios.

Shifting to the "losers'" side, at the four-digit level the net number of predicted declines in bilateral trade ratios exceeds 20 percent of the pairwise trading relationships in the following two-digit sectors: (1) paper and allied products except containers and boxes; (2) paperboard containers and boxes; (3) paints and allied products; (4) heating, plumbing and fabricated structural metal products; (5) construction, mining and oil field machinery and equipment; (6) metalworking machinery and equipment; (7) service industry machinery; (8) electronic components and accessories; and (9) aircraft and parts. This list also brings out the point that an industry's current status in terms of its relative cost strength is not a good predictor of the sector's future prospects. For example, the paint and aircraft industries both are among our most competitive industries in terms of comparative costs. However, their strong positions seem to be eroding and lower export/import ratios are predicted. The predicted widespread decline in the trade position of the various machinery and equipment sectors is also worthy of special note. As mentioned previously, Japan is now more competitive in cost terms in these industries. However, predicted declines in this sector cover not only trade with Japan but with both other developed and developing nations.

The last two columns in Table 3 show for each country or region the percent of trade ratios predicted to increase or decrease that changed between 1972 and 1979 in the predicted direction. The variations among the percentages could indicate differences in the degree to which trade is restricted between the United States and the specified countries.[9] For example, the comparatively low percentage of correctly predicted increases for South Asia, East Asia and Italy may reflect higher barriers against U.S. exports in these areas. Similarly, the lower shares of correctly predicted declines in trade ratios in the cases of the United Kingdom, Japan, Italy and Germany may indicate that the United States restricts the importation of goods from these nations relatively more than for the other countries listed.

V. Conclusions

On the basis of an analysis of changes in industry-by-country export/import ratios for the United States between 1972 and 1979, the technique set forth in this paper seems to be useful as a means of predicting changes in a country's bilateral trade ratios. However, one would want to examine other time periods and other sets of bilateral trade ratios before making any strong statement along these lines. There are, moreover, several improvements that should and can be made in any further studies based on the technique. One is to introduce explicit differences in tariffs and transportation costs as sources (besides factor-price differences) of differences in unit costs.[10] Future investigations should also deal more directly with the problem of interpreting the estimated coefficients that arises because of the existence of imported intermediate products. Hilton (1981) outlines some ways of handling this problem and also indicates the data requirements and methodology for estimating a truly multicountry model. Even more difficult problems to deal with in the future concern taking into account the differences in technology, in the extent of scale economies, and in levels of nontariff distortions that exist between countries and industries.

Table 1

ESTIMATED ORDER OF RELATIVE FACTOR PRICE DIFFERENCES BETWEEN THE UNITED STATES AND SELECTED REGIONS[a]

Productive Factor	Canada	East Asia	France	Germany	Italy	Japan	South Asia	United Kingdom	Total Trade
Unskilled Labor	-.54 (.63)	-15.03 (7.16)***	-6.71 (4.37)***	-5.43 (3.84)***	-10.37 (6.07)***	-9.23 (5.57)***	-15.64 (5.51)***	-3.86 (2.93)***	-4.86 (5.44)***
Physical Capital	4.70 (3.23)***	11.62 (4.01)***	3.47 (1.64)	3.47 (1.79)*	7.82 (3.34)***	9.39 (4.13)***	13.25 (3.41)***	3.99 (2.21)**	2.44 (1.98)**
Skilled Labor	-.48 (.33)	14.51 (4.91)**	6.76 (3.13)***	2.51 (1.28)	6.61 (2.81)***	.29 (.13)	26.03 (6.54)***	.14 (.08)	6.31 (5.14)***
Land	-1.47 (.19)	16.80 (1.11)	11.33 (1.00)	23.47 (2.28)**	5.28 (.42)	21.67 (1.81)*	-50.63 (2.43)**	28.94 (3.04)**	6.85 (1.06)
Natural Resources	-58.34 (4.77)***	61.90 (2.21)**	50.80 (2.87)**	37.72 (2.02)**	29.45 (1.50)	36.14 (1.89)*	10.52 (.33)	11.78 (.77)	-39.61 (3.82)***
R^2	.093	.237	.132	.122	.161	.223	.191	.139	.151
Number of Observations	289	281	280	285	285	286	271	288	289
F ratio	7.28	21.43	10.46	9.73	13.43	20.16	15.70	11.42	12.63

[a]The comparative magnitudes of the coefficients indicate the order of the relative factor-price differences for a particular country-group.

***, **, * indicates that the coefficients are significant at the 1, 5 and 10% levels, respectively.

Table 2

RELATION BETWEEN ACTUAL CHANGES IN TRADE RATIOS FROM 1972 TO 1979 AND PREDICTED CHANGES[a,b]

Independent Variables	Canada	East Asia	France	Germany	Italy	Japan	South Asia	United Kingdom	Total Trade
Constant	.11 (1.60)	-.63 (-.47)	.13 (1.27)	.31 (3.26)***	.11 (.94)	.46 (4.05)***	-.28 (-1.44)	.50 (4.90)***	.23 (4.13)***
Predicted Trade-Ratio Change[b]	.43 (12.74)***	.48 (16.13)***	.53 (14.78)***	.42 (11.81)***	.35 (10.75)***	.42 (11.73)***	.32 (19.47)***	.54 (12.39)***	.34 (11.11)***
R-Squared	.37	.51	.45	.34	.31	.34	.64	.36	.30
Number of Observations	289	257	266	271	259	270	215	274	286

[a]Number in parenthesis below regression coefficient is the t statistic; ***indicates significance at the 1% or less level.

[b]The predicted change is the difference between the 1972 trade ratio predicted on the basis of the revealed 1972 order of relative factor price differences and the 1972 actual trade ratio. The dependent variable in the regression equations is the difference between the actual 1979 trade ratio and the actual 1972 ratio.

Table 3

COUNTRY DISTRIBUTION OF TOTAL PREDICTED SHIFTS
IN BILATERAL TRADE RATIOS AND
PERCENT OF CORRECT PREDICTIONS BY COUNTRY

	Percent of Predicted Increases[a]	Percent of Predicted decreases[b]	Percent of Correctly Predicted Industry Increases	Percent of Correctly Predicted Industry Decreases
Canada	9	10	83	89
East Asia	17	16	67	75
France	11	14	80	76
Germany	9	12	89	71
Italy	14	16	72	67
Japan	13	13	89	69
South Asia	18	8	48	90
United Kingdom	9	11	90	63
	100%	100%		

[a,b]The set of bilateral industry relationships for which increases or decreases in trade ratios are predicted covers only those cases where $\tilde{e}_j$ either exceeds +2 or is less than -2, respectively.

FOOTNOTES

*University of Wisconsin and Federal Reserve Bank of New York, respectively. The views expressed in the paper do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System. We are especially grateful for the comments of one of the referees. Financial support from the National Science Foundation and the U.S. Department of Labor is acknowledged.

[1]For a derivation of this equation see Jones (1965). It is approximately true given relatively small factor price differences.

[2]A study using this direct approach yielding reasonably good results is Somersan (1969).

[3]Influences for which this assumption is clearly not appropriate and which can be directly determined on an industry basis, e.g., tariffs or subsidies, can be explicitly introduced into the relationships between unit cost differences, factor share and factor price differences, and net trade flows.

[4]Because of the imposition of linear homogeneity, the set of factor shares sums to unity for all product classes. Therefore, a separate constant term was not included in estimation. The regression coefficients represent estimates of $\beta_2(\hat{w}_i + (\beta_1/\beta_2)$ instead of $\beta_2\hat{w}_i$, where both β_1 and β_2 are unknown constants. This means that one cannot be sure of the estimated sign of any given $\hat{w}$. However, the comparative magnitudes of the coefficients still indicate the rank ordering of the relative differences

in factor prices. Furthermore, the inability to determine the sign of any $\hat{w}_i$ does not affect the use of the coefficients to predict bilateral industry trade ratios, which is the main purpose of this paper. As Hilton (1981, pp. 167-8) points out, one possible method of obtaining a direct reading on the sign of relative factor price difference would be to use the existing overall trade imbalance between two countries as the basis for estimating β_1.

[5]The breakdown includes the value added directly by each factor as well as the indirect contribution of each factor in the form of the intermediate purchases by each industry.

[6]If β_1 in equation (3) is relatively small, a positive coefficient indicates that the factor price is lower in the United States than in the country listed at the top, while a negative sign indicates the reverse.

[7]The low R^2 for the regressions covering U.S. trade with Canada and the European countries compared to the R^2 for the developing countries and Japan suggests that--as might be expected--comparative cost differences based on such factors as non-uniform differences in technology and economies of scale rather than on relative factor price differences may play a relatively larger role in accounting for variations in trade ratios with the first group of countries.

[8]Between 1972 and 1979 53 percent of the 2,260 industry-by-country trade ratios in the sample sets increased while 47 percent declined.

[9]However, other factors such as differences among rates of technological progress could also account for these variations.

[10]In preliminary work along these lines, Hilton (1981) found that the inclusion of these costs had little effect on the signs and significance levels of the estimated differences in factor prices.

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