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INTERNATIONAL TRADE PRICES AND PRICE PROXIES

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THE PRICE VARIABLE IN THE ANALYSIS OF TRADE FLOWS

Since Tinbergen's pioneering article on the measurement of elasticities of substitution in international trade of a quarter century ago,[1] there have been many studies designed to measure the relationship between changes in relative prices and changes in relative exports. It is in keeping with the spirit of these inquiries to observe that the increase in their quantity is attributable to changed supply and demand conditions. The demand for knowledge of price-quantity relationships in international trade has increased with the growing interdependence of nations, especially since governments often wish to influence trade flows for balance of payments or other reasons. The supply curve for such studies has also shifted outward, mainly as a result of the advent of the computer. A multiple correlation involving three or four independent variables required a substantial investment of man-hours when Tinbergen's article first appeared. Today, once the data are in hand, a computer can, in a few seconds, produce many equations, each involving different combination of the independent variables.

We are still, however, a long way from being able to assess in a quantitative fashion the influence of price and the other determinants of trade flows. The problems that confront us are, in part, a lack of understanding of the identity of all of these factors and of the relationships among the factors that we have been able to identify. There are also problems posed by the lack of appropriate data on prices and on other influences on trade.

Virtually all of the analytical work on international trade using prices as an explanatory variable has been based on unit value or wholesale price data, rather than on the actual international transactions prices which would be appropriate to the analysis of trade flows.

Both wholesale prices and the export unit-value indexes have at times given seriously misleading impressions of relative price movements in comparisons between U.S. and foreign price changes. Indexes of each type, as prepared by different countries, cover different commodities and are calculated by different methods. As a result, when either type of index for one country is compared with the corresponding index for another country, an apparent relative-price movement might be only a consequence of differences in the weighting of identical price movements. Furthermore, the unit-value indexes, including those published by the U.S. Department of Commerce, can change when the composition of exports or imports shifts, even though all prices remain the same. Wholesale prices avoid

[1] Jan Tinbergen, "Some Measurements of Elasticities of Substitution," *The Review of Economic Statistics* (August 1946).

this defect but include many list prices which may not reflect even domestic transactions prices and, being domestic prices, may not reflect fluctuations of prices in international markets. Changes in transportation costs, in the nature and extent of government intervention, and in other aspects of market imperfections, make it possible for the spreads between home and export prices to change.

In a recently published National Bureau of Economic Research study, the authors offered price indexes specifically designed for use in the analysis of international trade.[2] The new indexes are based on actual transactions prices or offers, not list prices or unit values, refer to international rather than domestic sales, and are combined using the same commodity weights in each country. Other innovations involve shifting the job of selecting commodities to be priced from the collecting agency to the reporter, the use of multiple regression methods to measure the prices of complex products such as aircraft engines and ships (many of which are usually omitted from price indexes), and the calculation of relative price levels as well as relative price changes.

The main purpose of the National Bureau study was to demonstrate that a wealth of data on actual international-trade price movements and price levels in private and government files could be collected by a sufficiently intensive effort, and to develop methods for tapping these sources and combining the data into overall measures for commodity groups and for the country as a whole.

The data were used to prepare "indexes of price competitiveness" which measured the changes in relative prices for each pair of countries, usually at the four-digit Standard International Trade Classification (SITC) level,[3] and these were aggregated, using world-trade weights.

Because our resources were limited and our objectives largely methodological, the resulting indexes are not very extensive in their coverage. They refer to five periods within the years 1953–1964 (1957/53, 1961/57, 1962/61, 1963/62, and 1964/63) and cover trade in machinery, transport equipment, metals, and metal products. Indexes were calculated for the United States, the United Kingdom, Germany, and to more limited degrees, for Japan and the Common Market as a whole. The range of products was determined both by their substantive importance in trade (about half the exports of the main industrial countries) and by the variety of competitive situations covered, from pig iron and its nonferrous equivalents to highly differentiated, technologically sophisticated products.

In addition to these indexes, it should be mentioned that Germany and Japan produce official export price indexes, which are more appropriate than wholesale prices and unit values for use in the analysis of international trade, although a close examination of the individual series in these indexes raises some puzzling questions—particularly with respect to the Japanese indexes.

[2] Irving B. Kravis and Robert E. Lipsey, *Price Competitiveness in World Trade*, New York, NBER, 1971.

[3] The index of price competitiveness is $[(P_t/P_{t-1})_F]/(P_t/P_{t-1})_U \times 100$ where P refers to prices, t to a time period, F to a foreign country and U to the U.S. It was usually formed by dividing the time-to-time price change for the foreign country by that of the U.S., but in some categories it was derived from the change in the place-to-place price comparison—i.e., $[(P_F/P_U)_t]/(P_F/P_U)_{t-1}$. The latter method was employed particularly for custom-made goods, for which place-to-place price comparisons could be obtained from bid data, while time-to-time data for any given country were difficult to obtain.

In the present paper we examine, more closely than we were able to do before, the relationship between changes in international prices on the one hand and changes in wholesale prices and export unit values on the other. Secondly, we compare the results of using international price indexes in the analysis of trade flows with those obtained from using indexes based purely on wholesale price data. For this purpose, we interpolated and extrapolated the National Bureau indexes for Germany and the U.S. covering five intervals within the 1953–1964 period, so as to convert them into annual data for the period 1953–1968.

The Relation of International Price Changes to Changes in Wholesale Prices and Export Unit Values

Because international price data have not been available for most countries, time periods, and commodities, studies of international trade in which prices are required have used various proxy variables, chiefly domestic wholesale prices and export and import unit values. Since we have now accumulated a body of data on international price movements, it is useful to compare our indexes to the widely used proxies in order to estimate the effects of discrepancies between them on the conclusions from past and future work in this area.

It is not obvious how such comparisons should be made. Wholesale price indexes are frequently published in groups which do not match trade classifications, even when they have the same or similar names. Thus, an analyst who uses published data directly is almost always, to some extent, comparing price changes for one group of commodities with quantity changes for another group. A comparison of one of these published domestic price indexes with international price indexes might then only reflect the degree of misclassification of commodities.

Even if classifications are made comparable, wholesale price indexes are aggregated with domestic production or consumption weights. Differences between domestic and international weights, and differences between one country's weights and another's, will enter comparisons with international prices. Differences in the list of specific commodities covered will also lead to discrepancies between the two indexes.

In the volume *Price Competitiveness in World Trade* (Chapter 8), we compared international prices, wholesale prices, and export unit values at the two-digit SITC level. In order to test the influence of differences in weighting, and to insure that we would not be basing our judgments on the effects of weighting differences, we calculated our own indexes for wholesale prices from data for individual commodities, aggregating them using both domestic weights and the same international-trade weights as in our international price indexes. To test the influence of coverage differences, we also calculated indexes for only those products covered in both international and wholesale price indexes.

In brief, the results were that there were substantial differences between domestic wholesale and international price indexes, particularly during periods of rapid price change. Moving from domestic to international weights for wholesale prices usually, but not always, improved the degree of agreement between the two series, but left fairly large differences. Adjusting further for differences in coverage produced some improvements, especially in the case of Germany, but no gain, or even a worsening of the degree of agreement in the case of the United States and of the United Kingdom. Not only were the wholesale price movements different, but in the United States, and especially in the United Kingdom, they were biased upward relative to international prices. The most probable explanation for the discrepancies remaining after these adjustments is that international price movements differed from domestic price movements even on the individual commodity level. Unit values were even worse than wholesale prices as approximations to international prices.

When we used our internationally weighted wholesale price indexes in equations explaining quantity movements at a fairly aggregative level (two-digit SITC), we found that only for the United Kingdom was there a substantial difference between the equations using wholesale prices and those using international prices. When we fitted equations at the more detailed commodity level, however, the international price data performed considerably better, in general, in terms of explanatory power and of the significance of the elasticity coefficients.

Here we explore further the relationship between the detailed wholesale price indexes and the corresponding indexes from international price data. The question is of interest because wholesale price data continue to be the main readily available basis for estimating relative international price movements, and because efforts to improve on the frequently poor price coefficients calculated up to now naturally tend to turn toward disaggregation. The international price indexes we use for this comparison are those published in Appendix C of the *Price Competitiveness* volume, the indexes from wholesale prices are those of Appendix F, and the unit values are those of Appendix G. The four-digit wholesale price indexes are unweighted aggregates of individual series and the three-digit indexes are aggregates of the four-digit indexes with international weights. For purposes of the regressions discussed here all the indexes were put in the form of time-to-time changes, i.e. 1957/53, 1961/57, 1962/61, 1963/62, and 1964/63.

In addition to the calculations based on NBER data, we have performed similar tests using some U.S. export price indexes recently published by the Bureau of Labor Statistics for the period 1964–1970.

Are International and Wholesale Price Changes Alike?

Some idea of the typical discrepancies between the changes in international prices and changes in wholesale prices can be derived from tabulations based on data from the *Price Competitiveness* book. In 30 percent of the possible comparisons between international price changes (P_i) and wholesale price changes (P_w)[4] the difference between the two was greater than $4\frac{1}{2}$ percentage points.

Absolute Value of Difference Between P_i and P_w (percentage points)	Number of Cases	Percent of Cases
$>4\frac{1}{2}$	255	30.8
$1\frac{1}{2}$ to $4\frac{1}{2}$	266	32.2
$<1\frac{1}{2}$	306	37.0
Total	827	100.0

[4] P_i is the percentage change in international prices from one year to the next, and P_w is the percentage change in wholesale prices.

On the whole, when the direction of the price movement was the same in the two sets of data, the wholesale price movement was larger than that of international prices as often as it was smaller. However, the distribution of these differences was strongly related to the direction of price change.

WHOLESALE PRICE CHANGE
[number of cases]

	Same Direction as P_i					
	Larger in Absolute Value	Equal	Smaller in Absolute Value	No Change	Opposite Direction from P_i	Total
P_i positive	166	68	115	69	42	460
P_i negative	26	25	60	39	72	222
Total	192	93	175	108	114	682

When international prices were rising, wholesale prices rose by as much or more in half the cases, but when international prices were falling, the wholesale price changes equaled or exceeded them less than a quarter of the time. There was also greater agreement on direction when international prices were rising. Wholesale prices fell in less than 10 percent of such cases, while they rose in almost a third of the instances in which international prices declined.

Looking at the same data in a different way, if we accept the international price indexes as correct measures of international trade prices, we find that wholesale price changes were biased upward when international prices were unchanged or declining. That is, on the average, wholesale prices rose, or declined by less than international prices. When international prices rose, wholesale prices were biased downward. The upward bias was dominant on the average, however, despite the fact that international price increases were twice as frequent as decreases.

WHOLESALE PRICE CHANGE
[number of cases]

	Biased Upward	Equal	Biased Downward	Total
P_i positive	166	68	226	460
P_i zero	64	50	31	145
P_i negative	137	25	60	222
Total	367	143	317	827

Another way of measuring the similarity between the two price measures is by the correlation between them. Of course, the correlation can be high even when the two price measures are different if there is a systematic relationship between them, but a low correlation is an indication of dissimilarity unless the variance in both measures is low, which is not the case for the prices we are studying.

The results in Table 1 indicate that the correspondence between the two price measures is not close. The $\bar{r}^2$ are almost all below 0.5, whether we compare the two measures for all commodities, years, and countries combined, or for various

TABLE 1
REGRESSION OF INTERNATIONAL PRICE CHANGES AGAINST WHOLESALE PRICE CHANGES
[all commodities, countries, and years; and by country; year; SITC division; and direction of price changes]

	b_{iw}[1]	t-Value	$\bar{r}^2$	Number of Observations
All commodities, countries, and years	.71	27.07	.47	827
By country				
United States	.69	24.69	.61	394
United Kingdom	.72	10.18	.48	114
Germany	.72	9.52	.30	206
Japan	.75	5.67	.22	113
By year				
1957/53	.55	9.30	.41	125
1961/57	.80	9.96	.42	138
1962/61	.73	8.95	.30	188
1963/62	.83	9.28	.31	188
1964/63	.75	8.92	.30	188
By SITC division (excluding Section 8)				
67 Iron and steel	.76	13.69	.54	162
68 Nonferrous metals	.85	8.22	.53	60
69 Other manufactures of metal	.59	8.03	.33	128
71 Nonelectrical machinery	.74	17.40	.64	170
72 Electrical machinery	.57	5.62	.21	113
73 Transport equipment	.69	7.52	.46	65
By direction of change in p_i				
p_i falling	.42	7.41	.18	254
p_i rising	.60	24.47	.51	573
By direction of change in p_w				
p_w falling	.95	10.18	.31	234
p_w rising	.66	19.96	.40	593

[1] From equation $P_i = a + b_{iw}P_w$, where P_i is the percentage change in international prices from one year to the next, and P_w the percentage change in wholesale prices.

subdivisions of the total—by country, commodity, year, or direction of price change. However, the wholesale price changes are related to international price changes, as we can see by the fact that the t-values for the b_{iw} coefficient are all statistically significant.

Among the comparisons for all commodity groups and periods combined, those for the United States show the strongest relationship; those for the United Kingdom also a fairly strong one; and those for Japan, a poor relationship. Taking all countries combined for individual periods, the $\bar{r}^2$ were all below 0.5.

A more detailed breakdown of the data in Table 2, separating them by country within each commodity division, shows a high correlation for the two U.S. price indexes in three divisions, and fair or poor results in the other three. For other countries, the relationship was much weaker. None of the $\bar{r}^2$ was as high as for some U.S. divisions, and many were quite low.

There is some ground here for saying that wholesale prices were somewhat more closely related to international prices in SITC 67 and SITC 71 than in SITC

TABLE 2
REGRESSION OF INTERNATIONAL PRICE CHANGES AGAINST WHOLESALE PRICE CHANGES
[commodity division by country][1]

SITC	Country	b_{iw}[2]	t-Value	$\bar{r}^2$	Number of Observations
67	United States	0.79	14.72	.79	59
	United Kingdom	0.75	7.60	.54	49
	Germany	0.45	0.99	0	20
	Japan	1.09	5.80	.50	34
68	United States	0.78	12.05	.83	30
	United Kingdom	0.53	1.94	.24	10
	Germany	1.31	4.28	.48	20
69	United States	0.52	6.54	.41	60
	United Kingdom	0.61	3.27	.25	30
	Germany	0.52	2.24	.15	23
	Japan	0.73	1.91	.16	15
71	United States	0.78	17.85	.75	105
	Germany	0.72	9.24	.63	51
	Japan	0.43	0.67	−.04	14
72	United States	0.54	4.64	.28	55
	Germany	0.82	2.54	.21	22
	Japan	0.49	1.67	.06	31
73	United States	0.23	1.35	.04	23
	Germany	0.49	5.11	.43	35

[1] Omitted countries are those with insufficient data.
[2] From equation $P_i = a + b_{iw}P_w$, where P_i is the percentage change in international prices from one year to the next, and P_w the percentage change in wholesale prices.

69 or SITC 72, a judgment similar to that one might derive from Table 1. The reasons for these differences probably vary from group to group. Nonelectrical machinery (SITC 71) showed few reductions in international prices—mostly fairly steady upward trends. Under relatively stable conditions or trends, the two kinds of prices may be expected to move more similarly. Some groups within electrical machinery (SITC 72), on the other hand, were subject to wide price fluctuations, severe international competition, and large discounts from list prices, and it is therefore not surprising that there were wide divergences between the two price measures.

It might be thought that these discrepancies between wholesale and international price measures are only short run in character, resulting from delays in announcing price changes, or in inserting them into the official or other price records. If that were true, they should average out over longer periods, and wholesale price changes should be similar to international price changes over periods of a few years, if not year by year.

This possibility is tested in the calculations shown in Table 3 where results for the three years, 1962/61, 1963/62, and 1964/63, are compared with those for 1964/61, taken as a whole. The results do not show much evidence that discrepancies are averaged out over time to a major degree. The levels of $\bar{r}^2$ increase more often than not as the periods are combined, but remain fairly low. The only really large

TABLE 3
REGRESSION OF INTERNATIONAL PRICE CHANGES AGAINST WHOLESALE PRICE CHANGES
[single years compared with three-year period]

	Single Years: 1962/61, 1963/62, 1964/63				Three-Year Period: 1964/61			
	b_{iw}	t-Value	$\bar{r}^2$	Number of Observations	b_{iw}	t-Value	$\bar{r}^2$	Number of Observations
All commodities, countries, and years	.80	16.30	.32	564	.82	11.67	.43	183
By country								
United States	.72	14.03	.44	253	.73	7.63	.41	83
United Kingdom	.38	1.81	.03	70	.46	1.87	.11	22
Germany	1.10	8.16	.33	136	.91	4.82	.34	45
Japan	.82	5.78	.24	105	.95	4.15	.34	33
By SITC division (excluding Section 8)								
67	.98	8.01	.36	112	.95	8.09	.65	36
68	.96	6.29	.52	36	.77	3.00	.42	12
69	.49	3.55	.12	84	.82	2.75	.20	27
71	.40	2.72	.05	116	.60	3.06	.18	38
72	.55	3.24	.10	85	.41	1.73	.07	28
73	.55	2.43	.10	44	.56	1.70	.13	14
By direction of change in P_i								
P_i falling	.70	9.22	.30	196	.71	5.95	.34	67
P_i rising	.53	9.52	.20	368	.42	5.28	.19	116
By direction of change in P_w								
P_w falling	.90	8.14	.25	196	.80	4.11	.21	60
P_w rising	.71	9.69	.20	368	.85	7.56	.32	123

improvement in the $\bar{r}^2$ is for SITC 67, in which the $\bar{r}^2$ for the period as a whole becomes 0.65, one of the highest in the whole set of regressions.

On the whole, the data do not support the idea that wholesale price changes are much more similar to international price changes for time spans longer than one year than they are for one-year periods.

Our international price data, and therefore the tests we report on them, are available only through 1964. However, the Bureau of Labor Statistics has begun to publish export price indexes for some types of machinery beginning with 1964, the last year of our data. These data can be used, in the same way as ours, to judge the relationship of wholesale prices to export prices.

These results are no more favorable to the proxy variable than the comparisons with the NBER indexes, as can be seen below. The $\bar{r}^2$ is very low, and the coefficient of b_{iw} is not statistically significant (partly because there are only twenty observations).

TABLE 4
REGRESSION OF U.S. EXPORT PRICE INDEXES (BLS) AGAINST U.S. WHOLESALE PRICE INDEXES[1]

b_{iw}	0.41
t-value	1.51
$\bar{r}^2$	0.06
Number of observations	20

[1] Four groups in SITC 71: 1965/64 through 1970/69.

This regression equation for 1964–1970 (Table 4) is almost identical to that for SITC 71 (the corresponding group) for the years 1961–1964, given in Table 3. The b_{iw} coefficient is 0.41 here, as compared to 0.40, and the $\bar{r}^2$ is 0.06, as compared with 0.05. These results suggest that there is no major discontinuity in the relationship to wholesale prices between the NBER international price indexes and the BLS export price indexes for the United States.

Are Changes in Unit Values and Changes in International Prices Alike?

A similar analysis can be made of data on U.S. export unit values. The results are even more unfavorable to the use of unit values as a proxy variable. As can be seen in Table 5, the $\bar{r}^2$ are all low, and hardly any of the coefficients are statistically significant. By this test, we would have to conclude that export unit-value changes are not only different from international price movements, but are almost totally unrelated to them.

Is the Measure of Price Competitiveness Sensitive to the Nature of the Prices Used?

The extent of errors in price competitiveness resulting from the use of proxy price measures cannot be inferred from the accuracy of a single country's price measures. For one thing, two incorrect price measures could yield a correct relative price measure if the errors in the two were identical in direction and magnitude. We therefore tested price competitiveness measures derived from wholesale price data in the same way that we examined the wholesale price series themselves.

TABLE 5

REGRESSION OF INTERNATIONAL PRICE INDEXES AGAINST INDEXES FROM U.S. EXPORT UNIT VALUES
[all commodities, countries, and years; and by year; SITC division; and direction of price change]

	b_{ie}[1]	*t-Value*	$\bar{r}^2$	Number of Observations
All commodities, countries, and years	.17	3.60	.06	192
By year				
1957/53	.19	1.56	.05	29*
1961/57	.12	0.69	−.02	34
1962/61	.004	0.03	−.02	43
1963/62	.01	0.09	−.02	43
1964/63	.04	0.65	−.01	43
By SITC division (excluding Section 8)				
67 Iron and steel	.26	3.44	.18	50
68 Nonferrous metals	.13	1.69	.09	20
69 Other manufactures of metal	.18	0.98	−.003	17
71 Nonelectrical machinery	.07	1.29	.02	41
72 Electrical machinery	.10	0.62	−.01	45
73 Transport equipment	.05	0.40	−.10	10
By direction of change in P_i				
P_i falling	.07	0.75	−.01	74
P_i unchanged or rising	.16	4.83	.16	118
By direction of change in P_e				
P_e falling	.02	0.09	−.01	85
P_e unchanged or rising	.16	2.65	.05	107

[1] From equation $P_i = a + b_{ie}P_e$, where P_i is the percentage change in international prices from one year to the next, and P_e the percentage change in export unit values.

Unfortunately we could not study unit-value measures in the same way, because we did not have the detailed data underlying foreign countries' unit-value indexes.

The results of these comparisons, for several groupings of the data, are given in Table 6. The $\bar{r}^2$ are all extremely low, none being above 0.08, but the coefficients relating the two price-competitiveness measures are all statistically significant. However, since the correlations are so low, it might be more sensible to treat the relation between the two competitiveness measures as almost random.

What conclusions can we draw from these comparisons about international trade demand or substitution elasticities estimated from wholesale prices or unit values? Errors in the measurement of prices affect not only the price variable, but also the quantity variable, because quantities are almost always estimated by deflating values by price indexes. Thus, errors in price measures cause equal and opposite errors in the quantity measures with which they are correlated. In the extreme case, where true price and quantity were not correlated at all with each other, or with the errors, the equation relating quantity to price change would essentially be reduced to a regression between the two sets of errors, producing an estimated elasticity of −1, even though the true price elasticity was 0. A corollary of this conclusion is that estimated elasticity coefficients close to −1 should not be taken very seriously, because they might easily represent only errors in the data.

TABLE 6
INTERNATIONAL PRICE COMPETITIVENESS CHANGES
[regression of measures derived from international prices against measures derived from wholesale prices; by country]

Coverage	Observations	b_{iw}[1]	t-Value	$\bar{r}^2$
All countries	419	0.29	4.71	.05
United Kingdom/United States	112	0.33	2.21	.03
Germany/United States	198	0.15	2.22	.02
Japan/United States	109	0.47	3.16	.08

[1] The coefficient b_{iw} is estimated from equations of the form $p_i = a + b_{iw}p_w$, where p_i is the percentage change in U.S. price competitiveness relative to a foreign country derived from international prices, and p_w is the corresponding index derived from wholesale prices.

Our comparisons here between proxy variables and international price measures certainly suggest that such errors are frequent.

Aside from random errors of this type, there are further effects of the systematic biases in wholesale price data. An important, and not unexpected, finding of the *Price Competitiveness* volume, in this connection, was that international price movements were more alike among countries than wholesale price changes. In other words, changes in international price competitiveness measures from international price data were smaller than those inferred from wholesale prices. This means that price and substitution elasticities derived from wholesale price data must be underestimated.

Similarly, the apparent upward bias of the wholesale price indexes described earlier must distort measures of elasticity. It presumably leads to exaggeration of the effect of price declines in some cases, and to incorrect signs in others when wholesale price measures move in the wrong direction, as they frequently do when international prices are falling.

ELASTICITIES OF SUBSTITUTION AS MEASURED FROM INTERNATIONAL AND WHOLESALE PRICE DATA

The NBER indexes, as already noted, covered only the years 1953, 1957, and 1961–1964. In order to increase the number of observations available for analysis, we have interpolated the various international price and price competitiveness indexes between 1953 and 1957, and between 1957 and 1961, and have extrapolated them from 1964 to 1968.

The interpolations between 1953 and 1961 produce hybrid indexes in which some part of the year-to-year price change is determined by the 1957/53 and 1961/57 movement of the indexes from international prices, as published in the *Price Competitiveness* book or derived from the same data. The indexes beyond 1964, however, are entirely dependent on the movements of the extrapolating series, and our contribution, aside from the selection of series to match earlier international price changes, is only the reweighting of each country's export or domestic price data by the same set of weights to make the indexes for different countries comparable.

In using the new annual NBER series to compare the utility of international price indexes in the analysis of trade flows with that of wholesale prices, it must be remembered that the comparison is not as sharp as we would like it to be, because the annual NBER international price series is an amalgam of true movements in international prices and of movements in wholesale prices. Also, it should be remembered that the wholesale price indexes that we use in this comparison are indexes that have been reworked in ways described in the *Price Competitiveness* volume[5] so as to make them more appropriate for the analysis of international trade; in this respect, they differ from the kinds of wholesale price data usually used for this purpose. It would be interesting to use our new annual indexes to compare the results they would yield with those obtained in some of the more widely cited studies of trade elasticities, but it is difficult for us to match the temporal and commodity coverage of these studies.

Our approach is to estimate the elasticity of substitution between U.S. and German exports in third-country markets. Our estimate of the elasticity is the coefficient b in an arithmetic relationship between the percentage change in relative quantities from one year to the next and the percentage change in relative prices. The relationship is:

$$(1) \qquad \left(\frac{Q_{G_t}/Q_{G_{t-1}}}{Q_{U_t}/Q_{U_{t-1}}} - 1\right) = a + b\left(\frac{P_{G_t}/P_{G_{t-1}}}{P_{U_t}/P_{U_{t-1}}} - 1\right),$$

where the Q's are export quantities to third countries; the P's are international prices; G, Germany; U, the United States; and t a particular time period. In what follows, we will write the bracketed quantity and price variables in (1) simply as q and p.

Export quantities were estimated by dividing trade values by country-weighted price indexes. Thus, there were two sets of German quantities, one corresponding to the German international price index and another to the German wholesale price index; and two sets of U.S. quantities, one corresponding to each of the U.S. indexes. The relative price variable was the index of price competitiveness (also described above), and there were also two versions of this, one based on the extrapolated and interpolated NBER indexes of international prices and the other on wholesale price indexes.

Each of the two sets of price and quantity data for each country could include as many as 90 observations for the 15 year-to-year changes between 1953 and 1968 for each of six SITC divisions included; in fact, the number was 88, since the 1954/53 price change for two of the divisions was missing.

First, we compare the results based on the original NBER international price series covering only five periods, equations (2) and (3), with those derived from the new annual series, equations (4) and (5). When this is done, we find, in Table 7, that the new data produce lower elasticities and somewhat lower $\bar{r}^2$s than the old, particularly a lower $\bar{r}^2$ than the old equation including a variable for time. That large difference in $\bar{r}^2$ is partly artificial, stemming from the fact that the use of some 4-year periods in addition to 1-year periods introduced wide variance in

[5] Kravis and Lipsey, *Price Competitiveness*, Chapter 8.

TABLE 7
EQUATIONS RELATING RELATIVE QUANTITY TO RELATIVE PRICE CHANGES
[6 SITC divisions pooled]

Equation Number (NBER data)	Coefficient of p[1]	Constant[1]	Time[2]	Number of Observations	$\bar{r}^2$	*S.E.*	$\bar{q}$
NBER data:							
Original data (5 periods)							
(2)	−9.75	28.15		29	.21	67.69	26.84
	(2.9)	(2.2)					
(3)	−4.55	−37.43	+28.51	29	.60	48.02	26.84
	(1.8)	(2.4)	(5.3)				
Annual series, 1953–64							
(4)	−2.67	7.54		64	.15	19.46	7.51
	(3.5)	(3.1)					
Annual series, 1953–68							
(5)	−2.46	6.07		88	.16	17.61	6.81
	(4.2)	(3.2)					
Wholesale price data (annual series) 1953–64							
(6)	−1.39	7.14		64	.07	19.83	7.40
	(2.3)	(2.9)					
1953–68							
(7)	−1.18	5.95		88	.05	17.80	6.48
	(2.5)	(3.1)					

[1] *t*-ratio in parentheses.
[2] Time variable set equal to 1 for 1-year periods, and to 4 for 4-year periods.

the quantity variable (as can be seen from the average q) which was then "explained" by the time variable.

While we have no means of choosing firmly among these and other explanations, a comparison between the results of equations (4) and (6), or between equations (5) and (7), using annual series for 1953–1964 and 1953–1968, respectively, seems to support the view that true international price indexes produce higher price elasticities and better explanations of quantity changes than do wholesale price data.

In the equations presented thus far, the explanatory power of the price variable taken alone is low, as we would expect both on theoretical grounds (since several important variables are omitted from the equation) and on the basis of our earlier finding that the substitution elasticity is not a constant but is affected by other variables.[6] Attention should be called also to the fact that while the first-difference forms of the variables in our equations produce much lower $\bar{r}^2$s than the more

[6] See Irving B. Kravis and Robert E. Lipsey, "The Elasticity of Substitution as a Variable in World Trade," in *International Comparisons of Prices and Real Incomes*, D. J. Daly, ed., Studies in Income and Wealth, Vol. 37, New York, NBER, 1972.

commonly used index-number forms, they avoid the severe problems of serial correlation that are often encountered.

Of course, the relative form in which the dependent and independent variables are cast (i.e., the percent change in Germany divided by the percent change in the United States for each variable) should obviate the need for some explanatory factors that would otherwise have to be taken into account. For one thing, if we have succeeded in comparing within each category identical or equivalent German and American goods, the income elasticity of demand confronting the exports of the two countries in any market should be identical. A variable reflecting growth of world income should not be significant except to the extent that Germany and the United States sell in markets which differ substantially with respect to the relation of their income growth to world income growth, or with respect to their income elasticity of demand for imports. Also, if the price changes in each country individually were substituted for the relative price change (i.e., Germany to United States), there should be no significant difference between the two individual-country price coefficients, although they should be opposite in sign, again except as differences in markets may affect the relationship.

In the light of these considerations, we have tried including individual-country price variables in our experiments as a check on the validity of our matching of price series. The results with respect to the 1953–1968 National Bureau series confirm our hypothesis about the equality of the coefficients for the individual-country time-to-time price indexes. For example,

$$q = \underset{(2.6)}{5.30} - \underset{(3.6)}{2.10}P_G + \underset{(4.0)}{2.18}P_U, \qquad \bar{R}^2 = 0.15 \tag{8}$$

where q is the relative change in export quantities, P stands for a country's time-to-time price index, and G and U represent Germany and the United States, respectively. The wholesale series do not meet this test as well. The corresponding equation is:

$$q = \underset{(2.1)}{4.51} - \underset{(2.3)}{1.01}P_G + \underset{(2.8)}{1.83}P_U \qquad \bar{R}^2 = 0.07 \tag{9}$$

The estimated elasticities are smaller and differ more from each other, and the $\bar{r}^2$ is lower.

Other Price Variables

We also experimented with other price variables and equation forms to allow for the possibility that the full response to a price change did not occur in the same year. Of these, equations using past changes in price did not produce good results and are not shown here.

Another approach to the possible lag in response is to compare price and quantity changes over a longer span than one year. The results, as can be seen from the following summary based on data for 1953–1968, suggest that longer than one year was needed for the full effects of price changes to work themselves out. However, a three-year span produced comparatively poor results. In each case, the equation based on NBER international price data suggested an elasticity more than twice that of the equations based on wholesale prices, and the $\bar{r}^2$, while not high, was also considerably better.

			Elasticity of Substitution		$\bar{r}^2$	
Equation	Length of Period (years)	Number of Observations	NBER	Wholesale Prices	NBER	Wholesale Prices
(10)	1	88	−2.5	−1.2	.16	.06
(11)	2	40	−4.4	−1.7	.20	.09
(12)	3	28	−1.7	−0.6	.09	.00

A very different way of getting at delayed reactions to price changes is to introduce into the equations price levels at the beginning of each period.

The price level variable, in a sense, incorporates all past price changes. If relative price changes always have their full impact upon relative trade flows within the year in which the price changes occur, there should be no relationship between the relative price level at the beginning of the period and trade changes during the period. In a world of perfect competition and instantaneous adjustment with no transfer costs, there could be no international differences in prices; indeed, there could be no international differences in price changes either. With transfer costs, there would be differences in f.a.s. export prices (which are what we measure), since competition would equalize c.i.f. prices at each destination. Even without these transfer costs, observed f.a.s. export prices could differ because of product differentiation—owing to real or reputed differences inherent in the appearance or performance of the product, or to nonprice factors, such as credit terms, speed of delivery, and presales and postsales service.[7] The net effect of all of these factors may be to establish an equilibrium position in which prices differ from one source of supply to another. Such price differences would have no relation to subsequent shifts in trade.

Sometimes, however, price-level differences represent disequilibrium situations in which purchasers, particularly of complex products, such as machinery, take a considerable time to respond to price differences. A number of factors work to cause such lags in response; among them are lack of knowledge, or the cost of obtaining it, uncertainty regarding the reliability of the supplier or the length of time he will remain in the market, reluctance to give up a satisfactory relationship with a supplier, a commitment to one type of machine because of previous purchases or stocks of spare parts, and official or private buy-domestic policies. When these factors are significant, we should be able to observe a shift in trade toward countries with relatively low price levels, quite apart from the impact of current changes in relative prices.

It turns out that when the price-level variable is added to an equation containing a variable for price change, its coefficient is almost always negative and

[7] See Kravis and Lipsey, *Price Competitiveness*, pp. 47–61.

often increases the proportion of the variation in quantity changes that is explained. An example is the equation based on 1953–1968 data shown below, first for the NBER series and then for the wholesale price series, with L representing the foreign price level relative to that of the United States.

$$(13) \qquad q = \underset{(0.9)}{3.17} - \underset{(4.3)}{2.48}p - \underset{(1.0)}{0.29}L \qquad \bar{R}^2 = 0.16 \qquad S.E. = 17.61$$

$$(14) \qquad q = \underset{(1.0)}{2.79} - \underset{(2.7)}{1.25}p - \underset{(1.5)}{0.31}L \qquad \bar{R}^2 = 0.07 \qquad S.E. = 17.67$$

The fact that L is not usually statistically significant suggests that it represents, as hypothesized above, a mixture of equilibrium and disequilibrium price-level differences. As in the earlier equations, both the elasticity coefficient and the $\bar{r}^2$ derived from international price data are twice as high as those from wholesale prices.

Conclusions

The conclusions that can be drawn from these comparisons of international price indexes and wholesale price indexes as alternative sources of the price variable in trade equations are:

1. International price movements are very different from movements in wholesale prices and unit values, and are not even related closely to those of these proxy variables. There is notably less association between unit values and international prices than between wholesale and international prices in the U.S. data which we have examined.

2. International price data produce higher elasticities of substitution than wholesale price data, at least in the case of German-U.S. exports to third countries for 1953–1968 for a limited, though important, range of products. The elasticities produced by the NBER annual data were roughly twice as high as those from the wholesale price data in a number of different formulations. Since the NBER data are themselves partly based on wholesale price data, the difference we find probably underestimates the downward bias in elasticity estimates from wholesale prices.