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PART THREE

ASSESSING THE ROLE OF PRICES IN TRADE

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QUANTITY-PRICE RELATIONSHIPS

The Utility of the New Indexes

Indexes of the type we have developed should be superior to previously available measures as the price variable in trade models which incorporate other important influences such as incomes in exporting and importing countries, tariffs and other restrictive or preferential arrangements, and transport costs. We would have liked to test the indexes in this role, but such an undertaking would have required the extension of our work far beyond our original purpose into virtually a new study of its own. One reason is that the assessment of the role of price and of the success of our indexes in measuring that role requires knowledge of the underlying supply and demand functions, and some way of taking account of the influences of the prices of import-competing goods and of income changes and other nonprice factors. Another and practical reason is that to test our indexes we would need an extensive body of matching trade data, much of it not readily available.

For both reasons, therefore, we attempt a more modest goal. We assume, first, that we have a group of countries producing exports that are more or less competitive. What we would like to measure in our quantity-price studies is the impact of a change in relative prices, attributable to a change in supply conditions in one or both of a pair of these countries, upon their relative export quantities, all other influences held constant. If the exports from the two countries were perfect substitutes in all uses and locations, the quantity response of buyers to a small change in relative prices would be infinite. In fact, substitutability is limited by transport costs and market preference for the goods from one source of supply over another as a result of custom or of real or fancied differences in product quality or design. It is because these limitations upon substitutability exist that the extent of substitution is measurable and worth measuring.

To estimate properly the extent to which the exports of different countries are substitutable we would have to be able to isolate the effects of demand and supply in our data. In the price indexes, as we argued earlier (Chapter 3), our use of a common set of weights reduces, but does not eliminate, the possibility that our indexes will show relative price changes induced by changes in demand for a product. If the demand effects had been eliminated, the effects of relative supply changes could be gauged from the price shifts, and the response produced from existing (and unchanging) demand conditions could be measured from the quantity shifts.

Unfortunately, this identification of the effects of demand and supply would be valid only if it could be assumed that the elasticity of supply of each of the pair of countries being compared was the same. If this is not the case, then a rise or fall in demand will bring a larger quantity response from one country than the other, even though neither country's supply curve has shifted, and we can no longer be sure to what extent the correlation between relative prices and relative quantities reflects changes originating from supply or changes traceable to demand factors. As we suggested earlier (see Chapter 2), there is reason to believe that U.S. supply elasticities are higher than those of Europe and Japan. Thus the relative quantity changes that we observe are the results not only of changes in supply conditions in one or both trading countries, which are what we would like to observe, but also, to some extent, in shifts of sources of supply (without a change in the country's supply curve) in response to changes in total market demand. The upshot is that even though we would like to estimate the basic parameters of the international economy, all we can be sure we are measuring falls in the category of historical description.

An additional deficiency of our calculations is that we cannot allow for the possibility of lagged reactions of quantity to price, because the period we cover is too short and because we have gaps in both time and commodity coverage of the price series for the early years.

With further work it should be possible to deal with some of these problems more adequately than we have done here. It would be useful, for example, to experiment with measures of determinants of export supply, possibly including the relationship between export and domestic prices and data on the movement of domestic costs. This would, however, require trade data we do not now possess, a fact which leads up to the second major limitation on our ability to use our new indexes to explain trade flows.

We would like to compare our new price series with trade data that include information on each covered country's exports over the whole period of the study, 1953–64, subdivided by destination and commodity class, with the commodity division comparable among all countries and aligned to the classification used for the price indexes. Some of the obstacles to the fulfillment of this goal cannot be surmounted completely. Particularly important in this regard are the difficulties arising from the change in the Standard International Trade Classification in 1961, which makes the assembly of comparable time series on a detailed commodity level difficult. Another problem is that data for even ostensibly identical SITC classes have had to be drawn from differing national statistical systems. Unfortunately, the set of products included in a given international trade classification may vary from country to country. The U.S. data are particularly troublesome in this respect for three reasons. One is the presence of "special-category" export classes which conceal destinations of shipments and, often, the exact commodity description as well. The second is that the U.S. trade classification before the 1960s was not based on the Brussels Tariff Nomenclature (BTN), the basis for the SITC. The third, partly a result of the second, is that the published attempts to fit U.S. trade data into the SITC contained many serious classification errors, and official corrections to the data have been made only for 1962 and later years. There may, of course, be similar defects in the figures for other countries that we are not aware of because we are not as familiar with the data.

At present, we have two-digit data for 1953 and 1957, and more detailed data only for 1961–64, except for a small number of commodity groups. Unfortunately, 1961–64 are analytically unsatisfactory because they were years of comparatively small price changes for most commodity groups. Furthermore, our present data collection gives destinations of exports only for 1963, the year shown in the trade data of Appendix A.

Given the lack of detailed trade data for 1953 and 1957, we have had to restrict our examination of the relation between price changes and trade flows for the whole period to highly aggregated totals (all commodities and two-digit categories), and to confine our examination of three- and four-digit data to 1961–64. We are able, in addition, to use some cross-sectional data comparing relative exports and relative price levels for 1963.

Our inability at this stage to distinguish each country's exports according to destination may be a serious defect because Germany's exports were concentrated in the Common Market countries, and therefore most strongly influenced by developments there, while the United States had a particularly large stake in Canada and Latin America; and Japan, in the United States.

We hope, in subsequent work, to fill some of the gaps described in the preceding paragraphs. For a first step in this direction, see "The Elasticity of Substitution as a Variable in World Trade," to be published in a forthcoming volume of Studies in Income and Wealth.

The Price-Quantity Equations

The basic form we used in estimating quantity-price relationships relates the percentage change in relative exports (foreign to United States) during a period to the percentage change in relative prices (foreign to United States), i.e., to the percentage change in U.S. price competitiveness, including a constant term. That is,

$$V_{F/S} - 1 = a + b(P_{F/S} - 1) \tag{1}$$

or

$$Q_{F/S} - 1 = a' + b'(P_{F/S} - 1) \tag{2}$$

where F represents a foreign country; S, the United States; V, the index of relative export values;[1] $P_{F/S}$, the index of U.S. price competitiveness,[2] that is, the ratio of foreign to U.S. prices; and Q, the index of relative export quantities.[3]

[1] $V_{F/S} = V_F/V_S$, where $V_F = V_{F(t)}/V_{F(t-1)}$ and $V_S = V_{S(t)}/V_{S(t-1)}$. V_F represents foreign and V_S, U.S. exports in dollars; t represents a reference year and $t-1$, a preceding reference year.

[2] $P_{F/S} = P_F/P_S$, where $P_S = \Sigma[(P_1/P_0)_S w_{63}]/\Sigma w_{63}$ and P_F is the corresponding index for the foreign country. See Chapter 1 for discussion of these measures.

[3] $Q_{F/S} = V_{F/S} \div P_{F/S}$.

The coefficient of the price variable in equation (2), the quantity-price regression, is the familiar elasticity of substitution.[4] In the double log form, this coefficient is equal to the coefficient in equation (1), the export value–price regression, minus one.[5] In the arithmetic form which we employed, the substitution elasticity in terms of quantity cannot be inferred exactly from the elasticity in terms of value. Whatever the mathematical form used, a higher coefficient of correlation was obtained when the dependent variable was relative export quantities rather than relative export values.

Elasticities of substitution derived from the regression of relative quantities on relative prices are subject to several types of measurement problems. If the relative prices and quantities reflect demand as well as supply changes, the elasticities will typically be biased toward zero. If quantity change is derived from value and price changes, as is almost universally the case, errors in value measurement bias the elasticity toward zero, and errors in price measurement, probably more frequent and larger, bias it toward one.[6]

The elasticity measure is also affected by the choice of index number and base period. A fixed base-price index, such as we use, implies a quantity index with given-year weights. A base year near the end of the period produces results different from those of an early-year base (see footnote fourteen, below).

Another foreign trade parameter used frequently in analytical work, the price elasticity of demand for a country's exports of a product, can be derived as a weighted average of the elasticities of substitution with respect to each rival exporter. Harberger[7] gives this relationship as $E_x = \Sigma_i s_i b'_{xi}$ where E_x is the elasticity of demand for exports of country x; i, one of the countries for which elasticities of substitution with

[4] It is really only an approximation to the true point elasticity, since the price changes are finite. Arc elasticity measures yield similar results and are therefore not shown separately.

[5] $Q = aP^b$ or $\log Q = \log a + b \log P$
$PQ = aP^{b+1}$ or $\log V = \log a + (b + 1) \log P$.

[6] Cf. Guy H. Orcutt, "Measurement of Elasticities in International Trade," *Review of Economics and Statistics,* May 1950; G. D. A. MacDougall, "British and American Exports: A Study Suggested by the Theory of Comparative Costs, Part II," *Economic Journal,* September 1952; and Raymond E. Zelder, "Estimates of Elasticities of Demand for Exports of the United Kingdom and the United States, 1921–1938," *Manchester School of Economic and Social Studies,* January 1958, p. 34.

[7] Arnold C. Harberger, "Some Evidence on the International Price Mechanism," *Journal of Political Economy,* December 1957. The formula underestimates E_x if some of the commodities exported by x can be substituted for commodities not covered by the b'_{xi}.

respect to x are available; and s_i, the share of country i in the total exports of x and the other included countries.

All Goods Treated as a Single Aggregate

We begin with the price-quantity relationship for the total of machinery, transport equipment, metals, and metal products. We have a total of ten observations, consisting of five time-to-time comparisons (1957/1953, 1961/1957, 1962/1961, 1963/1962, and 1964/1963) for the United Kingdom/United States and five for Germany/United States. Given the small number of observations, an obvious approach is to pool all of the observations, regardless of country and period.[8] The changes first in the value and secondly in the quantity of relative exports associated with changes in relative prices are as follows, with the subscript KG/S representing pooled data for the U.K.-U.S. and Germany-U.S. comparisons: [9]

$$V_{KG/S} - 1 = .14 - \underset{(1.12)}{6.34}(P_{KG/S} - 1) \qquad \bar{r}^2 = .03 \qquad (3)$$

$$Q_{KG/S} - 1 = .14 - \underset{(1.33)}{7.56}(P_{KG/S} - 1) \qquad \bar{r}^2 = .08 \qquad (4)$$

The price elasticity for the value of trade is around $-6\frac{1}{3}$ and the price elasticity of substitution around $-7\frac{1}{2}$. The positive constant term may be interpreted as a rising trend in foreign exports relative to those of the United States that is attributable to factors other than relative prices. These nonprice factors include changes in commercial policies, buyer preferences, supply availabilities (at fixed prices), and different rates of growth in various geographical markets, all of which may favor one country or another. They also include any effects on relative exports of the covered countries that are attributable to price changes in excluded countries or for excluded products.

If the constant term is interpreted as a trend, it must be trend per period. Since some of the periods were four years long and others only one year, we tried inserting a specific time variable to take account of

[8] As will be seen later, there is evidence against the propriety of both types of pooling.

[9] The figures in parentheses under the coefficients are t-ratios.

this difference. The time variable, a 4 or a 1, in combination with the constant term, can produce any combination of trends per year before and after 1961 that will best fit the data. Of course, the effects of any change in trend over time still cannot be distinguished from the effects of differences between one-year and four-year periods in general, since the two four-year periods make up the period before 1961. However, even if the cause of the differences cannot be fully explained, it is clearly preferable to take account of them rather than to ignore them as in equations comparable to (3) and (4).

When the time variable (T) is added, the equations corresponding to (3) and (4) are as follows:

$$V_{KG/S} - 1 = -.12 + \underset{(2.63)}{0.11T} - \underset{(0.45)}{2.07}(P_{KG/S} - 1) \qquad \bar{R}^2 = .44 \qquad (5)$$

$$Q_{KG/S} - 1 = -.12 + \underset{(2.61)}{0.11T} - \underset{(0.72)}{3.32}(P_{KG/S} - 1) \qquad \bar{R}^2 = .47 \qquad (6)$$

The time coefficient is significant but the elasticities and the t-ratios are smaller than those of equations 1 and 2, and not statistically significant. This implies that the elasticities in the earlier equations were biased upward because they included part of the effects of nonprice trends against the exports of the United States, a country which also had adverse (relatively rising) price movements, particularly in the two four-year periods before 1961. The combination of the constant and the T coefficient in equations 5 and 6 tells us that the trade and quantity ratios of the United Kingdom and Germany to the United States tended to rise, owing to nonprice factors, by 8 per cent per annum $\{[-0.12 + (.11 \times 4)] \div 4\}$ before 1961 and to fall by 1 per cent per annum $[-0.12 + (.11 \times 1)]$ after 1961.

Alternatively, it may be that the elasticities differed before and after 1961. There is, indeed, some evidence that the elasticity was higher before 1961. However, when a slope dummy was added for the two four-year periods, the coefficient, with or without the time variable, was not significant. For example,

$$Q_{KG/S} - 1 = -.13 + \underset{(2.35)}{0.11T} - \underset{(0.27)}{2.10}(P_{KG/S} - 1) - \underset{(0.20)}{2.03D_4} \qquad \bar{R}^2 = .38 \qquad (7)$$

where D_4 is the slope dummy for the two four-year periods.

Two-digit Categories

The use of the total of covered commodities involves a very small number of observations, and the relationships should be tested with large numbers. This can be done by relating relative exports and price competitiveness for two-digit SITC divisions. If all countries and commodities are pooled, under the implied assumption that elasticity is not correlated with commodity or country characteristics, 68 observations are obtained: 29 for the U.K.-U.S. comparison (5 time periods and six two-digit categories) [10] plus 29 for Germany/United States, plus 10 for Japan/United States. The resulting equations are:

$$V_{F/S} - 1 = -.14 + \underset{(4.06)}{0.13T} - \underset{(3.34)}{4.58}(P_{F/S} - 1) \qquad \bar{R}^2 = .37 \qquad (8)$$

$$Q_{F/S} - 1 = -.15 + \underset{(4.03)}{0.14T} - \underset{(4.18)}{6.22}(P_{F/S} - 1) \qquad \bar{R}^2 = .42 \qquad (9)$$

A comparison with the previous set of equations shows that disaggregation into commodity groups reduces the $\bar{R}^2$'s and raises the elasticities. However, if we had confined these calculations to the United Kingdom and Germany, as in the equations for the aggregate, the price elasticities would have risen only to -2.34 and -3.67.

The larger number of observations provides an opportunity to determine whether the elasticities differ systematically from one country to another, from one time period to another, by product category, or by size of the change in the index of price competitiveness. For brevity, we present only the equations in which relative quantity is the dependent variable and time and relative price are independent.

The equations for the individual binary comparisons are as follows:

$$Q_{K/S} - 1 = -.10 + \underset{(2.14)}{0.04T} - \underset{(3.04)}{2.66}(P_{K/S} - 1) \qquad \bar{R}^2 = .41 \qquad (10)$$

$$Q_{G/S} - 1 = -.35 + \underset{(5.04)}{0.26T} - \underset{(2.49)}{4.73}(P_{G/S} - 1) \qquad \bar{R}^2 = .59 \qquad (11)$$

$$Q_{J/S} - 1 = -.77 + \underset{(15.88)}{0.89T} - \underset{(3.12)}{3.24}(P_{J/S} - 1) \qquad \bar{R}^2 = .99 \qquad (12)$$

[10] SITC 67, 68, 69, 71, 72, and 73. For SITC 67 comparisons were made for 1961/1953 rather than 1957/1953 and 1961/1957 to avoid the distorting effects of the Suez Crisis upon 1957 data.

where K stands for the United Kingdom; S, the United States; G, Germany; and J, Japan. The German elasticity is higher than that of the United Kingdom and also Japan, which is based on a subset of years and commodity divisions. The increasingly favored position of Germany vis-à-vis the other countries in the rapidly expanding markets of its EEC partners may have increased the size of its T coefficient. When the U.K. and German comparisons are based solely on the subset of ten observations available for the Japanese-U.S. comparison, they produce elasticities of -1.26 for the United Kingdom vs. the United States and -1.79 for Germany vs. the United States.[11]

The combination of the constants and time coefficients in equations 10–12 implies the following percentage changes per annum in the relative quantity ratios attributable to nonprice factors: [12]

Country	*1953–61*	*1961–64*
U.K.-U.S.	+1.71	−6
German-U.S.	+18.0	−9
Japan-U.S.	NA	+12

The substantial difference in the elasticities for the U.K.-U.S. and German-U.S. comparisons between those based on ten and those based on twenty-nine observations suggests that the elasticities may vary according to time period or product category. This possibility can best be explored by examining the two comparisons for which we have virtually complete coverage for each of the five periods and each of the six commodity groups. To avoid erratic results attributable to small numbers, we pooled the U.K-U.S. and German-U.S. data and consolidated the periods and groups.

For the time periods, we compare 1957/1953 and 1961/1957 on the one hand with 1964/1963, 1963/1962, and 1962/1961 ratios on the other:

$$(Q_{KG/S} - 1)_4 = .32 - \underset{(3.18)}{8.03}(P_{KG/S} - 1)_4 \qquad \bar{r}^2 = .20 \qquad (13)$$

$$(Q_{KG/S} - 1)_1 = -.03 - \underset{(2.66)}{1.23}(P_{KG/S} - 1)_1 \qquad \bar{r}^2 = .15 \qquad (14)$$

11 The Japanese comparison is omitted for 1957/1953, when the other two countries had large price changes and high elasticity coefficients. However, it may be the size of the price changes rather than the time period that is relevant here. Japanese prices for 1957–64 have as wide a range of changes as European prices for 1953–64.

12 The Japanese coefficient is not shown for 1953–61, because the number of observations is too small.

where the numerical subscripts refer to the early four- and the later one-year periods, respectively.[13] The difference between −8.03 and −1.23 can be regarded either as a difference between one-year and four-year elasticities of substitution or as a decline in the elasticity between earlier and later periods. Since a high elasticity does not characterize 1961–64 as a whole, the latter view is supported. Indeed no correlation was found between changes in relative quantities and relative prices between 1961 and 1964; the elasticity for the pooled U.K.-U.S. and German-U.S. data was virtually zero.

Somewhat different results are obtained when the Japanese-U.S. observations are included; the elasticity coefficient for the three-year period (−5) is significant and lies between the high coefficient for the four-year periods (−11) and the lower one for the one-year periods (−2). This result suggests that the length of the period may explain part, but not all of the difference between the elasticity coefficients for the earlier and later periods.

Our method of computing the elasticities tends to increase the difference between two periods over the result that might be obtained from other procedures. The reason is that the elasticities are computed not from individual prices but from price indexes with end-of-period weights. Such indexes probably tended to produce larger elasticities, particularly for the early periods when there were relatively large price changes, than those that would have been obtained from indexes with beginning-of-period weights.[14] It seems unlikely, however, that the large difference

[13] In equation 13, SITC 67 is taken for the 1961/1953 ratio. Japan is omitted because the observations were concentrated in the one-year periods.

[14] The difference between an index with end-of-period weights (P_e) and one with beginning-of-period weights (P_b) depends on the covariance of price and quantity changes for individual commodities, as follows:

$$\frac{P_e}{P_b} = \frac{V}{V - \text{cov}_W}$$

where V is the value index, and cov_W is the weighted (by value) covariance of price and quantity relatives (cf. Robert E. Lipsey, *Price and Quantity Trends in the Foreign Trade of the United States,* Princeton University Press for NBER, 1963, pp. 88–89). If the covariance is negative, as we expect, and large, then P_e will be substantially smaller than P_b, and the price index based on end-of-period weights will imply larger quantity changes, and therefore a higher price elasticity, than an index with beginning-of-period weights. How different the index will be depends on the covariance. The covariance, in turn, is related to the price elasticities and the extent of price changes for individual commodities; if both are high the covariance will be high. Thus, if individual commodities have high elasticities, an end-weighted price index will usually yield a higher group elasticity than a beginning-weighted one. Furthermore, large price changes will also contribute to such a difference.

Therefore, some of the higher elasticities in 1953–61 relative to 1961–64 may be attributable to the use of end-of-period weights, since price changes were comparain the elasticities for the two periods can be explained entirely on these grounds.

The equations described thus far involve the assumption that the substitution elasticities and constant terms could, and obviously did, differ among countries and perhaps from period to period, but not among commodity groups, or that if they did, such differences were not correlated with country, time periods, or price changes. Since the commodities range from standardized metals to complex machinery, with probably different price behavior and different degrees of response to price change, the assumption that elasticities do not vary for different commodities is hazardous. However, it is not clear how the substitution elasticities of various groups should differ. One would expect that where there is product differentiation along national lines, as is at least partially true, for example, of U.S. and German automobiles, the elasticities will not be as high as, say, in metal products, which are more standardized. It is conceivable, however, that the true elasticities may be unobservable for highly standardized products because similar export price changes are imposed in all the countries by market forces. We have some evidence (see Chapter 8) that export price movements are more alike than domestic ones, and trade shifts for standardized goods could come about principally through the operation of domestic supply elasticities in countries with declining competitiveness.[15]

The number of observations of two-digit commodity groups is small. However, we divided the commodities into "metals" (M) and "equipment" (E). The former includes iron and steel (SITC 67) and nonferrous metals (SITC 68); the latter, metal manufactures (SITC 69), nonelectrical machinery (SITC 71), electrical machinery (SITC 72), and transport equipment (SITC 73). The results, based on eighteen and forty observations, respectively, are:

$$(Q_{KG/S} - 1)_M = -.35 + \underset{(1.98)}{0.19T} - \underset{(.77)}{3.30}(P_{KG/S} - 1)_M \qquad \bar{R}^2 = .40 \tag{15}$$

$$(Q_{KG/S} - 1)_E = -.13 + \underset{(3.97)}{0.11T} - \underset{(1.70)}{2.34}(P_{KG/S} - 1)_E \qquad \bar{R}^2 = .29 \tag{16}$$

tively large in the early years. Similarly, the weighting may account for some of the high Japanese elasticity estimates, since Japanese price changes were, for the most part, larger than those of other countries.

[15] See Robert M. Stern and Elliot Zupnick, "The Theory and Measurement of Elasticity of Substitution in International Trade," *Kyklos*, 1962, Fasc. 3.

The metals elasticity is higher, but the difference is not statistically significant.

Another possibility is that relative export changes (value or quantities) may not be a continuous function of relative price changes but may be different for large price changes and small ones or different for relative price changes of opposite directions. Accordingly, we estimated the coefficients for relative declines in foreign prices of 2 per cent or more, for changes in either direction of less than 2 per cent, and for relative increases in foreign prices of 2 per cent or more:

Change in $P_{F/S}$	*No. of Obser-vations*	$\bar{R}^2$	*Constant*	*Coefficient of* *Time*	*Coefficient of* $P_{F/S}$ *(elasticity)*
Decline ≧ 2%	15	.43	−.71	0.18 (1.50)	−14.17 (1.66)
Change < 2%	36	.07	−.02	0.03 (0.94)	−10.18 (1.96)
Increase ≧ 2%	17	.63	−.03	0.10 (5.30)	−3.56 (2.72)

This set of figures indicates that relative declines in foreign prices were associated with substantial increases in foreign export quantities relative to the United States, while relative increases in foreign prices were associated with smaller gains in U.S. exports. The evidence is, however, too slight to accept without further investigation.

In general, then, we found that price competitiveness was a significant but far from exclusive factor in accounting for shifts in trade shares. The data suggest that trade shares were more sensitive to price changes before 1961 than afterward. The trend in trade shares, which presumably reflects the effects of factors other than price, also ran against the United States during the years from 1953 to 1961. After 1961 only Japan still gained at the expense of the United States, aside from the effect of price changes.

Some of the further exploration suggested by these results requires larger numbers of observations. We cannot add to the time or country coverage for this purpose but can raise the number of observations by splitting the large and heterogeneous two-digit divisions into smaller and more homogeneous groups and subgroups.

Three- and Four-digit Groups

As already noted, the detailed trade data necessary to match our three- and four-digit price indexes are available at present only from 1961 on. Taking relative quantities as the dependent variable, the results for the completely pooled data for 1964/1963, 1963/1962, and 1962/1961 for all countries (161 observations) and for the United Kingdom and Germany combined (147 observations) are as follows:

$$Q_{F/S} - 1 = -.017 - \underset{(3.98)}{1.47}(P_{F/S} - 1) \qquad \bar{r}^2 = .06 \qquad (17)$$

$$Q_{KG/S} - 1 = -.008 - \underset{(2.71)}{1.04}(P_{KG/S} - 1) \qquad \bar{r}^2 = .03 \qquad (18)$$

The elasticity in (18) is very similar to that in (14), which is for two-digit groups over the same periods. The results for individual-country comparisons are:

Country Compared with U.S.	*Constant*	*Elasticity Coefficient*	$\bar{r}^2$	*Number of Observations*
U.K.	−0.006	−1.55 (2.60)	.06	91
Germany	−0.010	−0.54 (1.11)	.002	99
Japan	−0.17	−2.81 (2.84)	.20	29

Only the price coefficients for the United Kingdom and Japan are significant, while that for Germany, which showed the highest coefficient in the two-digit data, almost vanishes.

Although we experimented with several ways of classifying the data, we were unable to improve substantially upon these results. For metals (SITC 67 and 68) all the $\bar{r}^2$'s were slightly higher, and the equations pointed to higher (though not significantly higher) elasticities except for Japan. When elasticities for different ranges of price change were examined, the results for all countries for all three periods (1964/1963, 1963/1962, 1962/1961) pooled were as follows:

Change in $P_{F/\$}$	*Elasticity*
Decline $\geqq$ 2%	−4.04
	(2.58)
Change < 2%	−1.37
	(0.56)
Increase $\geqq$ 2%	−0.97
	(1.43)

The results are somewhat surprising, for we would have expected the disaggregated data to produce higher elasticities of substitution than the two-digit data for the same countries and periods on the hypothesis that the substitutability of U.S. and foreign goods would be greater within three- and four-digit SITC categories than within two-digit ones. Indeed, the implicit assumption underlying these calculations is that substitution occurs only within the four-digit subgroups and that there are no cross elasticities operating beyond these boundaries, or at least that if there are significant cross elasticities between products, they affect the two countries equally. As we compare quantities and prices at ever higher levels of aggregation, the results become more subject to the operation of price-induced substitutions in relative exports across detailed SITC classifications. For example, suppose a rise in the German-U.S. price ratio for copper leads to a decrease not in that ratio but in the German-U.S. export ratio for aluminum. Quantities and prices in the two-digit data, in which copper and aluminum are combined in the nonferrous metals division (SITC 68), would move in opposite directions. However, the three-digit data, in which copper and aluminum are in separate categories, would not reveal such a negative association in either category. We do not in fact consider it likely that such cross elasticities are very important, and their impact would be offset or more than offset by reductions in the measured substitution elasticities resulting from the combination into two-digit categories of goods having low cross elasticities.

Grunfeld and Griliches's "synchronization" or "grouping" effect of aggregation may explain the higher coefficients of correlation of the one- and two-digit data compared to the three- and four-digit grouping.[16] In our data, we find an intercorrelation for our main independent vari-

[16] Y. Grunfeld, and Zvi Griliches, "Is Aggregation Necessarily Bad?" *Review of Economics and Statistics,* February 1960.

able (the index of price competitiveness) for the detailed categories we combine into more aggregative ones.[17] In addition, we may expect that the residuals arising out of the use of only one (price competitiveness) or two (prices and length of period) independent variables in the estimating equation will be offsetting for the detailed categories that are consolidated into more aggregative groups. As long as the intercorrelation of the independent variable is larger than that of the residuals, the correlation coefficient based on more aggregative data will be higher.

The very tentative conclusions that emerge from this preliminary use of our new indexes, if we ignore the possible biases arising from aggregation and omission of important variables, is that the historical elasticity of substitution between U.S. exports and those of its main foreign competitors was around −8 for the period 1953–61 and about −1 to −1.5 for the period 1961–64. The many questions raised by these findings can be investigated only after the additional data, noted at the beginning of this chapter, have been assembled. The low correlation coefficients between relative quantities and relative prices make it clear that factors omitted in our analysis, including income, capacity utilization, and nonprice elements of competitiveness, had significant influences on export shares. A possibility that is difficult to check on is that the elasticities for the early period are exaggerated because prices were not permitted to reflect tight European and Japanese supply conditions. If that were the case, the easing of supply would not result in large price declines, as in a free market. It would instead appear as a large increase in exports with little change in price and, therefore, a high price elasticity.

Earlier Estimates of Elasticities

These estimates add to a long series of calculations of foreign trade elasticities beginning with Tinbergen's pioneering article in 1946.[18] All except a few of the previous estimates were derived from aggregative export and price data. Among the small number of studies that were based on quantity and price data for individual commodities or groups of commodities, those of Zelder and of Ginsburg and Stern may be

[17] That is, changes in the index of price competitiveness tend to be similar for categories in the same two-digit group.

[18] Jan Tinbergen, "Some Measurements of Elasticities of Substitution," *Review of Economic Statistics,* August 1946.

cited.[19] Both studies used unit values for prices and both derived elasticities of substitution between the United Kingdom and the United States, the former for 1921–38 and the latter for 1922–38 and 1948–59. Zelder computed elasticities for 27 commodity groups and 12 subgroups through a regression of relative quantities against relative prices based (usually) on one observation relating to each of the eighteen years he covered.[20] Elasticities of −1 to −3 characterized 17 of the 27 groups; the others were about evenly divided on either side of this spectrum.[21] Elasticities for the subcategories were higher; 7 out of the 12 were over −3. The distribution of elasticities for the 16 groups and 8 subcategories that fell in the metal and machinery classifications covered by our study was not substantially different.

Ginsburg and Stern worked with 60 to 70 commodities, and in each of the two periods they pooled the data for all years and all commodities using dummy variables to distinguish the intercept terms for different years. In one formulation they assumed that the elasticity of substitution was the same for all commodities; the coefficient was −1.59 for 1922–38 and −1.49 for 1948–59. However, a statistical test led them to reject the hypothesis that all commodities had the same elasticity of substitution, and in a second formulation they permitted each commodity to have its own elasticity (retaining the same intercept dummies as before). The resulting elasticities were somewhat more dispersed than Zelder's, with about one-fifth positive in each period and 21 out of 50 negative

[19] Zelder, *op. cit.*, and Alan L. Ginsburg and Robert M. Stern, "The Determination of the Factors Affecting American and British Exports in the Inter-War and Post-War Periods," *Oxford Economic Papers*, July 1965. Mention may be made also of Z. Kubinski, "The Elasticity of Substitution between Sources of British Imports, 1921–38," *Yorkshire Bulletin of Economic and Social Research*, January 1950. Kubinski calculated 289 elasticities of substitution between various pairs of countries, modifying the basic regression of relative quantities against relative prices in over half the cases by inserting a time lag, distinguishing different subperiods, eliminating trend, or transforming the variables into deviations from moving averages. Ignoring the 24 cases in which a positive coefficient was obtained for relative prices, the averages of his coefficients were as follows:

	Mean	*Median*	*No. of Cases*
Food, drink, and tobacco	−6.3	−3.4	63
Raw materials and articles mainly unmanufactured	−2.4	−2.2	52
Articles wholly or mainly manufactured	−4.5	−2.2	150
All	−4.5	−2.4	265

[20] Zelder also presents the elasticities derived by regressing prices against quantities and elasticities based on the division of the coefficient of variation of the quantity ratios by the coefficient of variation of the price ratios. The elasticities obtained from the coefficients of variation represent geometric means of those derived from the two regression forms (*op. cit.*, pp. 35–36).

[21] Two were positive, four were between zero and −1, and four were above −3.

ones in the −1 to −3 range in 1922–38 and 24 out of 53 in 1948–59. (The other negative coefficients were divided about evenly on either side of this range in both periods.) In general, Ginsburg and Stern worked with more narrowly defined categories than Zelder, and only about a fifth of them fell within the scope of the present study.[22] For those categories which appear both in the Zelder and in the Ginsburg and Stern study (1922–38 data),[23] the elasticities compare as follows:

	Zelder	*Ginsburg and Stern*
Ammonium sulphate	−3.11	−3.10
Sodium hydroxide	−1.22	−2.52
Pig iron	−3.10	−4.36
Iron and steel sheets, galvanized	−1.85	−1.90
Motorcycles	−5.52	−4.02
Copper wire, uninsulated	−3.83	−1.59
Cement	−2.61	−1.42
Glass, plate and sheet	+2.10	+2.48
Cotton cloth	−1.45	−3.72

While the differences between the two sets of estimates are not inconsequential there are important elements of agreement also; the extreme estimates apply to the same products in the two lists, the range and medians are very similar, and for several of the items the elasticities are very close. If this small sample of overlapping subsets can be relied upon, the more sophisticated methods used by Ginsburg and Stern do not produce results that differ, for similar sets of data, in their general contours from the results of Zelder's simpler approach.

It is difficult to assess the significance of the apparent agreement between the U.K.-U.S. substitution elasticity of −1.55 for 1953–64 produced by our disaggregated data and the elasticity of −1.49 for 1948–59 calculated by Ginsburg and Stern. Only one of our time periods falls in their time span, we cover more complicated types of

22 They used data originally selected by MacDougall with the idea of avoiding categories for which a wide product mix would make changes in unit values a poor proxy for price changes. A number of Zelder's categories such as, for example, "automobiles and chassis," "pipes, tubes, and fittings," and "electricity generators," are quite suspect from this standpoint.

23 Aluminum sulphate has been omitted since the large difference between Zelder's −2.02 and Ginsburg and Stern's +1.96 may have been due to Zelder's exclusion of data for 1921–24.

goods, and we base our analysis on categories of goods that are somewhat broader than those for which they used unit values.

Product Elasticities (1963 Cross-sectional Data)

Another approach to the measurement of elasticities of substitution was offered by MacDougall in his famous study dealing with British and American exports.[24] He calculated what he called "product" elasticities of substitution from cross-sectional data; the product elasticity of substitution is the percentage variation in two countries' relative exports from one category of goods to another, associated, at a moment in time, with a 1 per cent difference in relative prices as between the categories. It is calculated from a regression, across commodity groups, of export ratios against price ratios. This formula—$\log (Q_F/Q_S)_t = a + b \log (P_F/P_S)_t + e_t$—assumes that quantity-price relationships are determined by common factors operating across commodities. The more usual time series formulations assume that there are differences in the factors affecting different commodities but that these differences remain constant over time and are eliminated in equations like those discussed in the previous section.

Opinion is divided on the economic significance of product elasticities. MacDougall argued that, with suitable corrections for errors in the price and quantity data and with adjustments to take account of differences in the trade patterns of the two areas introduced by an aggregation bias that makes the actual or "total" elasticity of substitution smaller than the product elasticity, the latter provides a useful basis for order-of-magnitude estimates of the true elasticity of substitution. MacDougall estimated that his product elasticity of −3.6 for U.S.-U.K. exports of manufactures for 1934–38 should be adjusted to −4 or −4.5 on the first account and then downward to −2.5 to −2.8 on the second account, and finally perhaps raised to −3 to allow for the impact of price changes on the quantity of both countries' exports.[25]

Others, including Nicholson [26] and Bhagwati,[27] have questioned the

[24] MacDougall, *op. cit.*, Part I, December 1951, Part II, September 1952.
[25] *Ibid.*, December 1951, p. 720 and September 1952, p. 495.
[26] R. J. Nicholson, " 'Product-Elasticities of Substitution' in International Trade," *Economic Journal*, September 1955. See also MacDougall's rejoinder in the same issue.
[27] J. Bhagwati, "The Pure Theory of International Trade," *Economic Journal*, March 1964, p. 11.

Table 6.1
MacDougall's Estimates of Product Elasticities of Substitution, Selected Years, 1913–59

	Number of Commodities	r	Product Elasticity
U.S./U.K.			
1913	32	-0.54	-3.2
1922–38[a]	86 to 109	-0.40 to 0.68	-1.8 to -3.2
1934–38[b]	109	-0.73	-3.6
1948–59[a]	90 to 95	-0.36 to 0.62	-1.9 to -3.0
1929	109	-0.57	-2.6
U.S./Germany, 1929	51	-0.60	-2.4
U.S./France, 1929	56	-0.54	-2.4
U.S./Japan, 1929	41	-0.62	-2.8
U.K./Germany, 1929	77	-0.43	-1.6
U.K./France, 1929	58	-0.48	-2.2
U.K./Japan, 1929	44	-0.61	-1.6

Source: G. D. A. MacDougall, "British and American Exports: A Study Suggested by the Theory of Comparative Costs, Part I," *Economic Journal,* December 1951; and D. MacDougall, M. Dowley, P. Fox, and S. Pugh, "British and American Productivity, Prices and Exports: An Addendum," *Oxford Economic Papers,* October 1962.

[a]Ranges of data for individual years given in source.

[b]Based on quantities and average values for the period as a whole.

relevance of a measure based on instantaneous price and quantity comparisons for various categories of goods to a concept such as the elasticity of substitution which is designed to gauge *changes over time* in the quantity ratios associated with changes in the price ratios.

It requires, as MacDougall himself observes, a bold step to draw conclusions about the elasticity of substitution from the product elasticities. On the other hand, the strength and persistence of the inverse association between relative exports and relative prices found by MacDougall calls for some explanation.[28] It can be seen from Table 6.1 that MacDougall found product elasticities mainly in the −1.5 to −3.5 range for the U.S.-U.K. comparisons at dates spread over nearly fifty years and for half a dozen other pairs of countries in 1929.

For 1963, the year selected for weighting purposes in this study, we

[28] Bhagwati is "astonished" at the results (*op. cit.,* p. 12n). The relative "prices" used by MacDougall were unit values. Relative exports were relative quantities exported to third countries.

collected trade data showing the origin of exports for the classifications for which we produced price indexes—almost all three-digit and many four-digit categories.[29] With these data and our 1963 price level comparisons, we can estimate product elasticities. When, for example, we pool the U.K.-U.S., German-U.S., and Japanese-U.S. comparisons for 1963, we obtain a product elasticity of substitution, i.e., a coefficient of relative price levels, of −3.6. The equation, based on 96 observations covering 59 different product categories, is:

$$\log \frac{Q_F}{Q_S} = -0.46 - \underset{(7.23)}{3.59} \log \frac{P_F}{P_S} \qquad \bar{r}^2 = .35 \tag{19}$$

Our own results confirm and even strengthen the earlier findings. For individual binary comparisons we obtain:

Country	*Number of Categories*	$\bar{r}^2$	*Constant*	*Product Elasticity*
U.K.-U.S.	43	0.39	−0.64	−3.75 (5.28)
Germany-U.S.	37	0.48	−0.07	−3.63 (5.91)
Japan-U.S.	16	0.31	−1.28	−4.83 (2.78)

Our U.K.-U.S. elasticity is higher than those obtained by MacDougall and well above his results for 1953–59 (the period which overlaps our study) which varied between −1.9 and −2.6. An upward shift in the elasticity between the 1950s and 1963 may cause the difference, but it may be due also to the smaller bias in our coefficient if, as we think, the errors in our price comparisons are smaller and less systematically correlated (inversely) with the errors in the quantity comparisons than was true of MacDougall's "prices" based on unit values.[30]

Also, less clearly, our estimate may be higher because of the difference in commodity coverage. When manufactured foods were omitted from

[29] However, we restrict analysis of the data in this section to the categories for which we give price indexes in the appendixes. The proportion of total exports of metal, metal products, and machinery covered by these categories is less than one-half for Japan, two-thirds for the United Kingdom, three-quarters for Germany, and four-fifths for the United States.

[30] For a discussion of the bias imparted by errors of observation in the price and quantity ratios, see MacDougall, *op. cit.*, Part I, pp. 721 f.

MacDougall's regressions, the elasticities were changed by amounts ranging from -0.1 to -0.4 in the years 1953–59. These changes suggest that his results are sensitive to the nature of the categories included.

Our own data are not very helpful in determining whether elasticities tend to be associated in any systematic way with the degree of processing.[31] The following figures compare the product elasticities of our three- and four-digit categories within two-digit SITC divisions, with U.K.-U.S., Germany-U.S. and Japanese-U.S. comparisons being pooled to build up the number of observations:

SITC		*Number of Observations*	$\bar{r}^2$	*Constant*	*Product Elasticity*
67	Iron and steel	18	.00	0.47	−1.34 (1.00)
68	Nonferrous metals	2	Not calculated		
69	Metal manufactures, n.e.s.	14	.14	−0.41	−2.75 (1.77)
71	Machinery, nonelectric	32	.19	−0.60	−3.53 (2.87)
72	Electrical machinery	17	−.02	−0.18	−1.30 (0.82)
73	Transport equipment	8	.76	−0.68	−5.39 (4.84)

Our findings offer independent confirmation that there tends to be a significant inverse correlation between relative quantities and relative prices in the exports of pairs of industrial countries. Perhaps the best interpretation of this finding is to regard it as the outcome of the comparative advantages of each of the pair of countries as manifested in an imperfectly competitive world.[32] Under perfect competition and with

[31] Ginsburg and Stern found wide variations in elasticities among the products they examined. For 1948–59, for example, the largest negative coefficients were for barbed wire (−9.19), fertilizers (−7.92), and ferromolybdenum (−6.51). Positive coefficients included those for finished cotton thread, railway spikes, and box cameras. Their results suggest higher elasticities for more standardized products, as might be expected.

[32] Cf. Nicholson, *op. cit.*, and MacDougall, *op. cit.* Note that the existence of transport costs also tends to produce inverse quantity-price relationships.

no transport costs, P_F/P_S would always equal unity and the quantity ratios would deviate much farther from unity than they actually do.

Export Specialization and Price Trends

The quantity-price relationships may also be examined in terms of the changes in relative quantities for goods characterized by different types of price movement. It may be interesting to know, for example, whether some countries have tended to gain relative to others in exports of types of goods marked by rising prices.

Some evidence on this question was offered earlier (Chapter 2) when the detailed international price indexes were aggregated with the export weights of each country in turn. To investigate the matter more directly, we calculated "average" international price indexes for 1964/1953 for each three- or four-digit level, weighting each country's price change for a category over the whole period from 1953 to 1964 by that country's exports of the category in 1963. The value of each country's 1963 exports of each three- or four-digit category was then taken as the dependent variable in a regression in which the average international price index was the independent variable. The regression coefficients[33] and their t-values (in parentheses) are:

U.S.	2.07	(1.44)
U.K.	0.02	(0.02)
Germany	−0.14	(0.08)
Japan	−1.62	(2.81)

The positive U.S. coefficient indicates that U.S. exports were larger in groups with relatively rising prices, and the negative Japanese coefficient indicates that exports were larger in groups with declining world prices. A U.S. export product mix weighted in the direction of relatively rising prices, and the opposite for Japan, conform with the earlier finding based on the reweighting of international price indexes by various country weights (Table 2.5).

One possible explanation of this finding is that the impetus to the relative price increases comes from the demand side and that the U.S.

[33] The regression coefficients were the b's in each country equation, in the form $E_j = a + bP_j$, where E_j is the value of exports by the country of commodity j in 1963, and P_j is the average price change for that commodity in all countries from 1953 to 1964.

economy has more elastic supply conditions. The United States, on this hypothesis, is more flexible than others in shifting production into lines of growing demand; the lack of adequate supply response in other countries causes prices to rise, and the United States enjoys large market shares for these products. If in fact rising quantities were correlated with rising prices, an explanation along these lines would be plausible, but our lack of detailed trade and quantity data prior to 1961 prevents us from ascertaining this.

An alternative is to seek explanations based on the assumption that the impetus to the price change comes from the supply side. A country such as Japan may be catching up technologically with cost-reducing methods developed elsewhere, or rapid growth at home may provide it with economies of scale that can be extended to exports. The leader in price reduction would also gain in export shares, and world prices of the commodities in which that country specialized would decline. The facts fit this hypothesis, but further investigation would be required to eliminate alternative hypotheses that might also be consistent with the observed behavior of trade and prices, such as the role of technological leadership in producing the observed changes.

It would be useful to have a measure of technological progress in the various commodity groups with which to compare the export performance of the different countries. We do not have such a measure, but insofar as technological progress takes the form of cost reduction in the production of a particular commodity (rather than the development of new product variants) it should result in a fall in price relative to the prices of commodities enjoying slower technological gains. If we use, as a proxy for cost-reducing technological development, the average price change for that commodity,[34] described above, the conclusion would be that Japan leads in the technological race and the United States is last.

A more likely reading of the technological implications of the U.S. concentration on products with relatively rising prices takes account of the introduction of new product variants and of their subsequent diffusion and price behavior. The United States might be specializing in the earliest stage of innovations in product type—the introduction of new,

[34] The average price change seems preferable to the largest price decline in any country as a measure, because the latter would include some cases that represent only a catching-up by a backward country, rather than a characteristic of the commodity in general. Countries in the early stages of production of a commodity, when the catching-up process produces very steep price declines, will be given little or no weight in the average.

more sophisticated products, perhaps products still in the experimental stage. The possibly low price elasticity for the new product at this stage, might account for the price behavior of U.S. exports. Following this may be a second stage of rapidly rising production of a now more standardized product with falling cost and prices.[35] Production may then shift to overseas plants of U.S. companies, or to countries such as Japan, specializing in low-cost production rather than innovation. As noted in Chapter 12, we observed industries in which something like this may occur systematically; U.S. parent firms in these industries typically develop and introduce new models in the United States and begin production in their plants abroad only at a later stage of product acceptance.[36]

Finally, we may not have been uniformly successful in removing the effect of quality improvement in different groups, and U.S. exports, concentrated in high-technology or rapidly changing products, may be more affected by this upward bias than those of other countries. The large predominance of price rises over declines in the nonelectrical machinery division suggests that this explanation cannot be entirely dismissed.

35 See Raymond Vernon, "International Investment and International Trade in the Product Cycle," *Quarterly Journal of Economics*, May 1966.

36 For some recent discussions of the role of technology in international trade see the papers by Gary C. Hufbauer and Seev Hirsch in *The Technology Factor in International Trade*, New York, Universities–National Bureau Conference Series 22, 1970.