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The Elasticity of Substitution as a Variable in World Trade

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PRICE changes, as well as income changes, play the major role in theoretical explanations of shifts in trade from one country to another. It has been natural, therefore, that economists have made many attempts to estimate the response of trade to price changes by calculating demand and substitution elasticities for individual countries' exports and imports. Our new estimates of international price levels and price changes, prepared as part of a recently published National Bureau study of price competitiveness in international trade,[1] provide an opportunity to carry forward this work on the basis of data which are in important respects more appropriate for the purpose than those previously available.

NOTE: The authors take pleasure in acknowledging helpful suggestions by Lawrence R. Klein. The computations were performed by Sultan Ahmad, Lorenzo Perez, and Jane Samuelson. The research reported on here is part of a National Bureau study of the role of prices in international trade, which is an outgrowth of the earlier work on international price measurement.

[1] Irving B. Kravis and Robert E. Lipsey, *Price Competitiveness in World Trade*, New York, NBER, 1971. See Chapter 6 for some earlier experimental calculations of elasticities on the basis of these data.

The main purpose of that study was to seek ways of improving the basic data on international prices for an important segment of trade in manufactured goods; machinery, transport equipment, and metal products.[2] The choice of this range of products was determined not only by their substantive importance in trade (about half of the exports of the main industrial countries) but also by the variety of competitive situations covered. They embrace all the stages of metal fabrication beginning with pig iron and its nonferrous equivalents and including differentiated products and custom-built goods as well as homogeneous products. Indexes were computed for 1953, 1957, and 1961 through 1964, for the United States, the United Kingdom, Germany, and, wherever possible, Japan. These indexes are distinguished from those used in other studies of international trade by several characteristics: (1) actual prices or price offers were used rather than unit values derived from trade statistics or domestic wholesale prices; (2) a uniform set of world trade weights (actually 1963 exports of member countries of the Organization for Economic Cooperation and Development) was employed in the aggregation of price indexes for each country, rather than the trade weights of the country itself; (3) country-to-country price relations for different points in time were used to aid in the establishment of intertemporal movements in price competitiveness; (4) price collection in terms of detailed preselected specifications was abandoned in favor of the collection of pairs of prices for specifications of the respondents' own choosing, each pair providing either a time-to-time or country-to-country price relative; and (5) regression techniques were employed to make international price comparisons for some commodity groups.

These 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 SITC level.[3] In the present paper, how-

[2] SITC divisions 67 (iron and steel), 68 (nonferrous metals), 69 (manufactures of metals, n.e.s.), 71 (machinery other than electric), 72 (electrical machinery), and 73 (transport equipment).

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

ever, we confine ourselves to aggregations of the price competitiveness indexes for two-digit categories. The potential number of observations on this level of aggregation for each pair of countries is 30 (5 periods times 6 categories) but in fact we have only 29 for the U.K.-U.S. and for German-U.S. comparisons,[4] and only 10 for the Japanese-U.S. comparisons owing to the paucity of data, particularly for 1953–57 and 1957–61.

A disadvantage of our data is that the observations cover only five periods, and that estimates of substitution elasticities cannot be made from time series in the usual way. While all five time periods have been employed, data for the six different commodity divisions and three different pairs of countries have been pooled in most of the calculations.

The basic form we have used in estimating price-quantity 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) including a constant term. That is,

$$(1)\quad [(Q_t/Q_{t-1})_F/(Q_t/Q_{t-1})_S] - 1 = a + b\{[(P_t/P_{t-1})_F/(P_t/P_{t-1})_S] - 1\}$$

where F represents the foreign country; S, the United States; Q, the quantities exported; P, the international prices (export prices in the large majority of cases, but domestic prices where exports of a particular category were nil or negligible); t, a reference year; and $t-1$, a preceding year.

The usual method of calculating demand or substitution elasticities is to use as a price variable the ratio of one country's export price index to another country's export or domestic price index or the ratio of an index of import prices to an index of domestic prices. Since the indexes used are usually not constructed specifically for these comparisons, the results do not represent the demand or substitution elasticities they purport to. The indexes being compared may represent completely different collections of goods, or the same goods with different weights, and the elasticities are then not own-price elasticities, as they are intended to be, but rather a mixture of own-price and cross elasticities. For example, more than one study has produced a low estimate of the U.S. price elasticity of demand for

[4] For SITC 67, comparisons were made for 1961/1953 rather than 1957/1953 to avoid the distorting effects of the Suez Crisis upon 1957 data.

raw material imports by comparing the movements of prices of imported raw materials with the price movements of domestically available raw materials—the former with large weights for crude rubber and raw silk, and the latter with small weights for these items and large weights for cotton and coal. Furthermore, since one or both of the collections of goods may be changing over time, there is little reason to expect the elasticities to be stable.

As already indicated, the prices used here for the estimation of elasticities of substitution have been collected specifically for the purpose of measuring changes in price competitiveness. Two assumptions, each related to the fact that we are dealing with four great industrial countries capable of producing a wide range of products, govern the way in which the prices have been used to form the relative price variable in equation (1):

1. The potential market of each country is represented by the aggregate of machinery and metal manufactures entering world markets. This means that the same set of weights, based on world trade, is used for aggregation for each country.
2. Price-induced substitutions favoring one of the countries as against another take place between products found within the same four-digit SITC code. It is German machine tools versus American machine tools, British trucks against American trucks, etc., that characterizes international competition. Of course, competition across four-digit categories such as British copper against American aluminum or British steam locomotives against American diesel locomotives can also be found, but an examination of the list of four-digit SITC categories led us to the judgment that such cases are much less important than those involving within-category competition.

In the results reported here we have confined our calculations to two-digit SITC divisions, and have ignored competition across the lines of four-digit SITC subgroups. However, it would be perfectly possible, using the data collected in the study, to use price indexes for one group in the explanation of exports in another group. For example, at a finer level of detail than we are presently reporting on, the change in U.S. exports of aluminum could be a function not only of income and relative prices of aluminum, but also of the ratio of U.S. aluminum prices to U.S. and foreign copper prices.

The relative change in export quantities, taken as the dependent variable in our equations, was derived by dividing the relative change in export values, $(X_t/X_{t-1})_F/(X_t/X_{t-1})_S$, where $X =$ export values, by the relative change in prices, $(P_t/P_{t-1})_F/(P_t/P_{t-1})_S$. The use of relative quantities rather than export values produces a higher coefficient of correlation and a higher elasticity of substitution. However, it should be kept in mind in interpreting these results that the elasticities of substitution derived by regressing relative quantities against relative prices are biased toward zero under certain circumstances.[5]

We begin by pooling all our data covering six two-digit groups, five time periods, and three pairs of countries. Using q's and p's to denote the measures of relative quantity and price change in (1),[6] we obtain

$$(2) \qquad q = \underset{(2.5)}{0.16} - \underset{(5.3)}{8.23}p \qquad \bar{r}^2 = 0.29 \quad S.E. = 0.53$$

The price elasticity of substitution is $-8\frac{1}{4}$. The positive value for the constant term may be interpreted as a trend toward a rise in foreign exports relative to those of the United States that is attributable to factors other than relative prices. These "nonprice" factors include the effects of 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 countries compared that are attributable to price changes in excluded countries.

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, the idea of inserting a specific time variable to take account

[5] Cf. Guy H. Orcutt, "Measurement of Price 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.

[6] q is the entire expression on the left side of equation (1), and p is the expression for which b is the coefficient.

of this difference suggested itself. The time variable, entered as "4" or "1,"[7] can, in combination with the constant term, produce any combination of trends per year before and after 1961 that will best fit the data. Of course, it still is not possible to distinguish the effects of any change in trend over time 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 we cannot fully explain the cause of the differences, it is clearly preferable to take account of them rather than to ignore them as in equation 2.

When the time variable is added, the equation becomes:

$$(3) \qquad q = -0.14 + \underset{(4.0)}{0.14T} - \underset{(4.03)}{6.22p} \quad \bar{R}^2 = .42$$

(4.0) (4.03) (4.1) $S.E. = .48$

The time coefficient is significant and the elasticity is smaller. The implication is that the elasticity in the earlier equation was biased upward because it included part of the effect of a nonprice trend against the exports of the United States, a country which tended also to have adverse (relatively rising) price movements in the two four-year periods before 1961. The combination of the constant and the T coefficient in the present set of equations tells us that the foreign-to-U.S. quantity ratio tended to rise, owing to nonprice factors, by 10½ per cent per annum $\{[-.14 + (.14 \times 4)] \div 4)\}$ before 1961 and to have no trend after that date $[-.14 + (.14 \times 1)]$.

An alternative possibility might be that the elasticities differed before and after 1961 simply because four-year periods provide more time for adjustments to changes in relative prices than do one-year periods. This can be tested by comparing the results for the two kinds of periods with each other and with those for the three-year period, 1964–61, within which the one-year periods all fall. Using the subscript "4" to refer to the 23 observations for 1957–53 and 1961–57, "3" to refer to the 15 observations for 1964–61, and "1" to refer to the

[7] In a few cases "8" was the length of the period. The effects of the formation of the European Economic Community, which began reducing internal tariffs in January 1959, and of the European Free Trade Association, which began cutting internal tariffs in July 1960, are among the many influences we have not tried to take specifically into account.

45 observations for 1962–61, 1963–62, and 1964–63, the equations are:

(4) $$q_4 = 0.37 - 11.11p_4 \quad \bar{r}^2 = .34 \quad S.E. = .81$$
$$(2.2) \quad (3.5)$$

(5) $$q_3 = 0.07 - 5.03p_3 \quad \bar{r}^2 = .38 \quad S.E. = .24$$
$$(1.1) \quad (3.1)$$

(6) $$q_1 = 0.01 - 2.22p_1 \quad \bar{r}^2 = .29 \quad S.E. = .11$$
$$(0.5) \quad (4.3)$$

The higher coefficient for p in equation 5 relative to equation 6 suggests that longer duration produces a higher observed elasticity of substitution. However, it seems unlikely that the one-year difference between the length of the two periods before 1961 and the three-year period after 1961 can account for the whole of the difference between an elasticity of substitution of −11 and one of −5.[8]

This raises the question as to why the elasticity of substitution should have been so high before 1961 and so low afterward. Alternatively, the issue may be the difference in nonprice trends before and after 1961. In either case, the implication is that estimates of elasticity of substitution have to be evaluated in terms of the historical context from which the data for their estimation are drawn.

As a background for discussing this matter, it is useful to set out the average percentage (unweighted) changes in the relative prices and quantities for the four- and one-year periods (the former include eight-year periods for SITC 67):

	p	q
Four-year periods	−1.3	+48.9
One-year periods	+0.5	−0.3
All periods	−0.1	+16.4

The small average decline in U.S. price competitiveness during the four-year periods and the still smaller average increase during the one-year periods cannot be regarded as the net results of widely dif-

[8] These coefficients differ from those reported in *Price Competitiveness in World Trade* mainly because data for Japan are included here. The data excluding Japan yielded a very low elasticity for the three-year period.

fering changes in relative prices for different two-digit categories and periods. The changes in relative prices were generally small, only three out of the 68 having been greater than 10 per cent and only seven others greater than 5 per cent. The changes in relative quantities showed much greater dispersion, nearly half being in excess of 10 per cent.

We turn now to some possible explanations for the apparent differences in the elasticity of substitution before and after 1961. This search for explanations for the particular differences we have found will serve also to call attention to some of the various kinds of influences that, in general, affect observed elasticities of substitution.

1 *The Recapture-of-Shares Explanation*

It is conceivable that the large quantity changes at a time of small relative decreases in foreign relative prices may have represented the final stages of the restoration of trading relationships that were disturbed by the war. Indeed, immediately after the war, West European countries were relying so heavily upon the United States as a source of supply that one of the important aims of the Marshall Plan was to increase intra-European trade. We selected 1953 as the starting date for our study because the recovery of Europe could be regarded as substantially completed by that date, but it is not unlikely that the process of recapturing lost market positions continued into the 1953–61 period, particularly for Germany and Japan.

If this were the explanation, it would be interesting to know more about the mechanism through which the recapture of former markets worked. Perhaps small declines in relative prices were associated with large increases in relative quantities simply because of the re-establishment of old customer loyalties or the reassertion of the advantages of location or of banking and distribution skills. It is more likely that this awaited or was facilitated by the recovery of supply capacities in the war-devastated countries.

Explanations along these lines have underlying implications concerning domestic and export price policies during the periods of scarcity. In perfectly free markets, optimizing firms would have charged high export prices during the period in which their exports were limited by supply scarcities. If, however, they were limited in their freedom to raise export prices by price levels set by the United States, and they preferred to supply the home market even at lower prices or were pressed to do so by their governments, improving supply conditions might have produced the observed results.

Further light could be thrown upon the recapture-of-shares hypothesis by a study of pre- and postwar shares for particular product groups in particular markets.

2 *Supply Elasticity Explanations*

The recapture-of-shares explanations may be regarded as a subgroup under a more general category of the effects of supply elasticity differences. The calculated substitution elasticities may reflect not only measurements derived from shifts in supply along the demand curve but also differences in supply responses to the same change in demand (i.e., differences in the slopes of supply curves) even when there are no shifts in supply curves.

It is, of course, difficult to estimate supply elasticities for exports, and recent work has fallen back on the use of activity variables (growth of GNP, extent of idle capacity, etc.). It is reasonable to suppose that supply elasticities are related to domestic economic activity, but it is not easy to say what the relationship can be expected to be. In the short run, growth in production to near-capacity levels should result in low observed supply elasticities. In the longer run, however, growth in production and capacity reflect high observed supply elasticities. Capacity is increasing, the economies of long production runs become attainable for more and more product variants, and productivity is rising on other accounts. In addition, expansion may bring new product variants which were not available for export before. These favorable consequences depend, however, on a situation in which the growth of demand is not outstripping the growth of aggregate supply. If aggregate demand is excessive it will lead to shipment delays, diversion of potential exports to domestic purchasers, and, depending on economic conditions abroad, possibly to relative inflation and thus to price disadvantages for exports.

It is not easy to sort out these matters, but for the products and times covered in our study the periods of rapid expansion in foreign exports relative to those of the United States were marked by relatively rapid foreign growth, as shown by the table below, which gives annual rates of growth in real product: [9]

	1953–61	1961–64
U.S. (GNP)	2.4	3.9
U.K. (GDP)	2.9	3.7
Germany (GDP)	7.0	3.5
Japan (GNP)	11.5	9.8

The data are thus consistent with the hypothesis that rapid growth gives a significant export advantage as long as it is not accompanied by a relative increase in prices, but they do not, of course, prove it.

3 Absolute Differences in Prices

It is possible that relative price levels (P_F/P_S) as well as changes in relative prices (p) affected the changes in relative quantities. If the exchange rates that were established at the end of the war caused foreign price levels to be lower than U.S. price levels, some relative rise in foreign exports could have been expected even without a further relative decline in foreign prices; the response to a decline in foreign relative prices might therefore appear to be very great.

When a variable L is added to measure the effects on q of the percentage difference in the foreign and U.S. price levels,[10] we obtain:

$$(7) \qquad q = 0.17 - \underset{(1.6)}{} \; 8.22p + .05L \qquad \bar{R}^2 = .28$$
$$\qquad (1.6) \quad (5.2) \quad (.06) \qquad S.E. = .53$$

$$(8) \qquad q = -0.20 - 6.25p - 0.43L + 0.15T \qquad \bar{R}^2 = .41$$
$$\qquad (1.2) \quad (4.1) \quad (0.6) \quad (4.06) \qquad S.E. = .48$$

$$(9) \qquad q_4 = -0.03 - 12.56p - 4.88L \qquad \bar{R}^2 = .36$$
$$\qquad (0.09) \quad (3.8) \quad (1.34) \qquad S.E. = .79$$

$$(10) \qquad q_1 = -0.03 - 2.17p - 0.29L \qquad \bar{R}^2 = .32$$
$$\qquad (1.1) \quad (4.3) \quad (1.7) \qquad S.E. = .11$$

A small or insignificant coefficient for L may mean that the difference in price levels at the beginning of a period, if any exists, repre-

[9] Based on data in the United Nations *Yearbook of National Accounts Statistics, 1966 and 1968.*

[10] $L = (P_F/P_S)_{t-1} - 1$.

sents an equilibrium situation. Such differences did exist in each of the five periods, and for the average of all included goods, changed very little, the U.K.-U.S. ratio varying within the 91–94 range and the German-U.S. ratio varying between 90 and 93. The coefficients for *L* suggest that, while there was probably a tendency for foreign relative quantities to rise more when foreign price levels were low, this influence was not a powerful factor. The failure of *L* to exert a greater influence and the persistence over eleven years of a situation in which U.S. prices were 6 to 10 per cent above those of its main competitors may, incidentally, have some adverse implications for the contention that the dollar was overvalued during this period.[11]

In any case, the difference in the calculated elasticity of substitution before and after 1961 does not appear to be explicable in terms of a rapid or gradual adjustment of relative exports to differences in beginning-of-period price levels.

4 Higher Price Elasticities of Demand for Foreign Goods

The fact that foreign relative prices were decreasing in 1953–61 and slightly increasing in 1961–64 might yield different estimates of elasticities of substitution for the two periods if the exports of the foreign countries had higher price elasticities of demand than U.S. exports. There are indeed a priori reasons for believing that this difference in price elasticities exists: More than for other large industrial countries, U.S. exports depend on technological sophistication, special-purpose uses, and speed of delivery.[12] However, if this were an important explanatory factor the behavior of foreign and U.S. prices over time, each taken separately, rather than the movement of foreign prices in relation to U.S. prices would be the appropriate independent variables. Equations using the time-to-time movement

[11] Of course, the difference in price levels we have found may have been offset by opposite differences in the types of goods not covered in our study. Also, while the overall U.S. trade surplus did not show a downward trend during the period, it may be claimed that U.S. needs for foreign exchange for purposes other than commodity imports required a larger or expanding trade surplus. However, if attention is confined to the trade account and if there were not offsetting differences in prices for other goods, the evidence would weigh against the claim that the dollar was overvalued. See Kravis and Lipsey, *Competitiveness*, Chap. 2, for a brief discussion of the factors that might have made the price level difference referred to in the text sustainable.

[12] Cf. *ibid.*

of foreign (P_F) and U.S. (P_S) prices are as follows:

$$(11) \qquad q_4 = \underset{(1.3)}{4.05} - \underset{(3.6)}{16.70}P_{4F} + \underset{(3.5)}{13.22}P_{4S} \qquad \bar{R}^2 = .35 \quad S.E. = .80$$

$$(12) \qquad q_1 = \underset{(0.8)}{1.51} - \underset{(.5)}{.01}P_{1F} - \underset{(0.8)}{1.50}P_{1S} \qquad \bar{R}^2 = .04 \quad S.E. = .13$$

Neither equation can be regarded as an improvement over equations (4) and (6) in which changes in *relative* prices were used as the independent variable. The coefficients for the four-year periods [equation (11)] conform to expectations with respect to signs and a higher impact for changes in foreign prices than for changes in U.S. prices. For the one-year periods the results are much worse; the sign of P_{1S} is wrong and the relationship is not statistically significant ($F_{2,42} = 1.93$). In neither equation is the difference between the two coefficients statistically significant.

Different coefficients for P_F and P_S would imply lack of complete success in our effort to compare foreign and U.S. price changes for directly competitive goods. Also, were these two coefficients not equal, one of the underlying theoretical requirements for the valid measurement of the elasticity of substitution would not be met. The required condition is that $\alpha_F + \beta_F = \alpha_S + \beta_S$, where $\alpha =$ the price elasticity of demand and $\beta =$ the cross elasticity with respect to the good of the other country.[13]

5 *Differences in Income Elasticities of Demand*

World incomes rose more in the four-year periods than in the one-year periods. If the varieties of goods exported by the foreign countries were marked by greater income elasticities than the varieties exported by the United States, the omission of an income term from equations (4) and (6) would bias the estimate of price elasticity in (4) upward relative to that in (6).

When the relative change in export quantities is related to changes in world income as measured by the U.N. series on world gross

[13] Cf. E. E. Leamer and Robert M. Stern, *Quantitative International Economics*, Boston, Allyn and Bacon, 1970, Chap. 3; and Zelder, "Estimates."

domestic production,[14] the results are as follows:

$$(13)\qquad q = -0.19 + 0.04G - 6.11p \qquad \bar{R}^2 = .44$$
$$(1.9)\quad (3.4)\quad (4.2) \qquad S.E. = .47$$

$$(14)\qquad q_4 = -0.57 + 0.05G_4 - 8.00p_4 \qquad \bar{R}^2 = .38$$
$$(0.9)\quad (1.5)\quad (2.2) \qquad S.E. = .79$$

$$(15)\qquad q_1 = 0.13 - 0.02G_1 - 2.03p_1 \qquad \bar{R}^2 = .29$$
$$(1.2)\quad (1.2)\quad (3.8) \qquad S.E. = .11$$

where G stands for the percentage change in real-world GDP and the other symbols have the same meanings as in the earlier equations.

It can be seen that equation (13), which includes all observations, is not substantially different from equation (3), in which a time variable was used in lieu of G. The reason is that the annual percentage rates of growth in world gross domestic product did not vary much from one period to another and were almost equivalent to a scaled version of the time variable: [15]

	Time	Per Cent Increase in World GDP
1957–53	4	16
1961–57	4	17
1962–61	1	5
1963–62	1	4
1964–63	1	6

If growth in real world income really were the true explanation, rather than some other unspecified factors subsumed under T in equation (3), we should obtain significant coefficients for G within the two four-year periods and within the three one-year periods. In fact, the G coefficient is significant for neither set of periods [equations

[14] *Yearbook of National Accounts Statistics, 1968,* Vol. II, p. 119.

[15] We experimented with both industrial production and world manufactures export volume as alternatives to gross domestic product. The export series was more variable from one period to another, but its explanatory power was smaller than that of GDP, the $\bar{R}^2$ for the equation analagous to (12) being 0.37. Industrial production did better ($\bar{R}^2 = .40$), but neither industrial production nor exports has a superior theoretical claim to priority over GDP for this purpose. In any case, all three yield elasticities of substitution in the range from -6.4 (industrial production) to -6.9 (exports).

(14) and (15)], and in one of the cases [equation (15)] the sign points to higher income elasticity for U.S. exports.

The test may be unfair in view of the small variation in income changes between the two four-year periods and among the three one-year periods. On the other hand, the growth rates are hardly atypical of what we may expect in the future; it would take great economic success to raise the one-year rates a few percentage points above 6 per cent and great economic calamity to drive them down a few points below 4 per cent. The fact that the coefficients of G are not larger or statistically significant is therefore ground for rejecting the hypothesis that differences in the response of foreign and U.S. exports to income growth accounted for the differences in the elasticities of substitution before and after 1961.

As in the case of the price elasticities of demand, the finding of a substantial impact of income growth upon relative exports would reduce our confidence in our success in having compared prices for identical or at least directly substitutable products. Theoretically, a zero coefficient for G is another of the conditions for the validity of elasticity-of-substitution measures.[16]

6 *The Effect of Market Shares upon the Elasticities*

The difference in response of relative quantities to price changes before and after 1961 may be related to another finding from the price competitiveness study, namely, that there was an asymmetry in the response to relative price changes between cases of increases and decreases in U.S. price competitiveness. The response to the latter was much greater than to the former. The two time periods can be distinguished by the fact that declines in U.S. price competitiveness predominated in the early period, while improvements were more frequent in the later years.

One explanation for these asymmetries might be that the response of quantity changes to price changes is not uniform under all circumstances and that it may be sensitive, in particular, to the market share of each country included in the comparison.

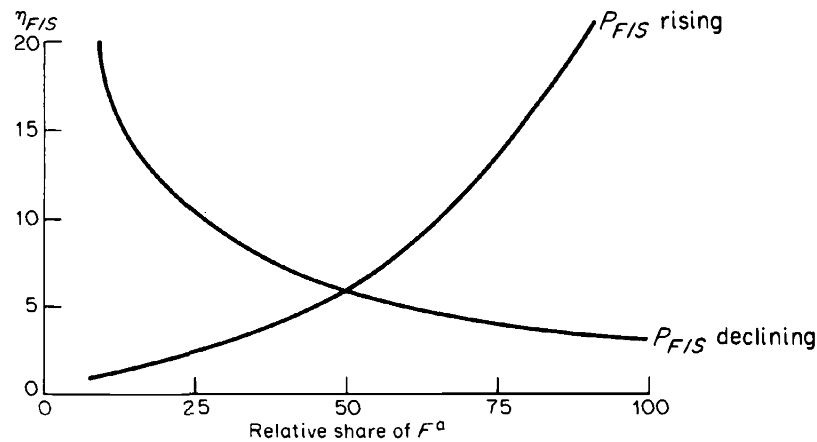
The smaller the share of the market a country has, the larger the

[16] Leamer and Stern, *Economics.* In our equations q plays the same role as q_1/q_2 in theirs.

potential benefit it can reap from a decline in its relative prices. If its share is large, the export expansion it can expect from a price decline may be small in relative terms, because it cannot gain much at the expense of other sellers and finds its expansion limited by the market price elasticity (see curve labeled "$P_{F/S}$ declining" in Figure 1). When prices are rising (price competitiveness declining), a country with a high share is vulnerable to losses and therefore has a high elasticity of substitution. The relation of elasticity to market share is less easy to predict when prices are rising for a country with a low market share. It is possible that it is already relying only on those markets in which it is entrenched, and thus has a low elasticity. That is the relation suggested by "$P_{F/S}$ rising" in the figure. But it could also be argued that large percentage reactions can most easily take place where exports (and export shares) are small; this would, for example, be the case if a country with a small share were knocked out of the market completely by a rise in its relative prices.

In any case, the elasticity of substitution may be asymmetrically related to market shares, changing differently for falling and rising relative prices. [Were the U.S. relative share plotted on the horizontal axis, the diagram would be similar except that the identity of the

FIGURE 1



[a] Actual numbers on axes are used solely to make the diagram more tangible, and are not meant to convey the quantitative relationships.

curves for rising and falling relative prices ($P_{F/S}$) would be reversed.]

Average (unweighted) market shares for the six two-digit SITC categories were as follows:

	U.S.	U.K.	Germany	Japan	OECD
1953	30	20	14	2	100
1957	29	23	18	6	100
1961	21	16	21	6	100
1962	22	15	22	6	100
1963	21	14	20	7	100
1964	21	13	19	7	100

It can be seen that the United States did in fact have high shares at the earlier dates and that by 1961 the U.S. shares were lower and not much different from those of Germany.

The range of export shares among two-digit groups, the relevant consideration for this discussion, is considerably wider. Japan accounts for most of the very low export shares, particularly in the early years; and the United States, the highest proportion of the large export shares, again concentrated in the beginning of the period.

In seeking to test the expectations of asymmetries associated with shares, we make the coefficient b in equation (3) dependent on relative shares and the direction of price movement:

$$b = f(S_S, S_F, S'_S, S'_F)$$

where subscripts have the same meanings as before and S stands for the share of each country in OECD exports, the primed figures for the cases in which foreign prices were rising relative to those of the United States, and the unprimed figures for the cases in which foreign relative prices were falling.[17] The estimating equation for q may then be taken as

$$q = \alpha + \beta p + \gamma S_F p + \delta S_S p + \epsilon p' + \theta S_F p' + \lambda S_S p' \quad (16)$$

where the p' represent the product of p and a dummy variable which takes the value of 1 for observations in which p is positive (i.e., foreign prices are rising relative to U.S. ones), and 0 for observations in which p is negative. The results, first for all periods and then separately for

[17] That is, p or $\{[(P_t/P_{t-1})_F/(P_t/P_{t-1})_S] - 1\}$ was positive for the S' figures and negative for the S ones.

the four- and one-year periods are as follows:

$$(17)\quad q = -.05 - \underset{(2.2)}{15.23p} + \underset{(3.0)}{1.37S_Fp} - \underset{(3.7)}{0.83S_Sp}$$
$$(.6)$$
$$+ \underset{(1.2)}{11.34p'} - \underset{(2.3)}{1.49S_Fp'} + \underset{(3.3)}{1.11S_Sp'}$$

$$\bar{R}^2 = .53 \qquad S.E. = .43$$

$$(18)\quad q_4 = \underset{(.5)}{.11} - \underset{(2.2)}{36.46p_4} + \underset{(2.5)}{2.64S_Fp_4} - \underset{(1.4)}{0.68S_Sp_4} - \underset{(0.7)}{79.15p'_4}$$
$$+ \underset{(0.4)}{1.99S_Fp'_4} + \underset{(1.3)}{1.25S_Sp'_4}$$

$$\bar{R}^2 = .53 \qquad S.E. = .68$$

$$(19)\quad q_1 = \underset{(.5)}{.01} - \underset{(5.2)}{11.52p_1} + \underset{(3.0)}{0.42S_Fp_1} + \underset{(2.3)}{0.26S_Sp_1} + \underset{(3.4)}{9.50p'_1}$$
$$- \underset{(3.3)}{0.59S_Fp'_1} - \underset{(.8)}{.12S_Sp'_1}$$

$$\bar{R}^2 = .49 \qquad S.E. = .09$$

In these equations, the coefficients of the unprimed variables refer to the cases in which foreign prices are falling relative to U.S. prices. The coefficients for the primed variables in the equation show the amounts by which the coefficients for rising foreign prices differ from those for falling foreign prices. The t ratios for the p' terms refer to the significance of the difference, and not to the significance of the relationship between quantity change and price change when foreign prices are rising. Essentially the same analysis may be performed by estimating separate equations for the cases of falling and rising prices. For example, such equations corresponding to equation (17) are:

Foreign prices falling ($p < 0$)

$$(17a)\quad q = \underset{(.4)}{-.05} - \underset{(1.6)}{15.24p} + \underset{(2.1)}{1.37S_Fp} - \underset{(2.8)}{0.83S_Sp}$$

$$\bar{R}^2 = .50 \qquad S.E. = .60$$

Foreign prices rising ($p > 0$)

$$q = -0.04 - 4.01p - .11S_Fp + 0.28S_Sp \quad (17b)$$
$$(1.0) \quad (1.7) \quad (.7) \quad (3.1)$$
$$\bar{R}^2 = .22 \qquad S.E. = .16$$

In general, the coefficients conform well to the model set out in the diagram. When foreign prices are falling relative to U.S. prices [equation (17a), "$P_{F/S}$ declining" in Figure 1, and unprimed p in equations (17) to (19)], the coefficient for the product of the foreign share (S_F) and negative p should have a positive sign if a high foreign share acts as a deterrent to the relative expansion of foreign export quantities, and the coefficient for S_Sp should have a negative sign if a high U.S. share facilitates the expansion of relative foreign exports. The first expectation (positive coefficient for S_Fp) is satisfied in all three equations and the second in the first two. When foreign relative prices are rising [equation (17b), "$P_{F/S}$ rising" in the diagram, and p' in the equations], the sum of the coefficients for S_Fp and S_Fp' in equations (17)–(19) should be negative and the sum of the coefficients for S_Sp and S_Sp' should be positive. The corresponding two conditions for equation (17b) are that the coefficient of S_Fp should be negative and that for S_Sp positive. The first of these conditions is found in equations (17), (17b), and (19), and the latter in all the equations. Although equations (17), (17a), and (17b), which cover all periods, pass all tests, the equation for the four-year periods has the wrong sign for S_Fp' and the equation for the one-year periods has the wrong sign for S_Sp. In each of the two latter instances the variance of the shares was low relative to the variances for the situations in which the same coefficients conformed to the model.

These equations make the elasticity of substitution a variable, the size of which depends upon the shares in trade and the direction of the price change. Taking some illustrative shares on the basis of the unweighted observed averages given in an earlier text table, the elasticities of substitution derived from equation (17)[18] are as follows:

[18] In terms of equation (16) the elasticities for $P_{F/S}$ falling (η_p) and rising ($\eta_{p'}$) are:

$$\eta_p = \beta + \gamma S_F + \delta S_S$$

and

$$\eta_{p'} = \beta + \epsilon + (\gamma + \theta)S_F + (\delta + \lambda)S_S$$

	$P_{F/S}$ Declining	$P_{F/S}$ Rising
$S_F = 15,\ S_S = 30$	−19.58	+2.71
$S_F = 15,\ S_S = 20$	−11.88	−0.09
$S_F = 20,\ S_S = 20$	−4.43	−0.69

Even though the coefficients are significant and have the correct signs, the equation produces elasticities for rising $P_{F/S}$ that have to be rejected. We are unable to explain this result other than to point to the imperfections in the market share and quantity data, particularly the improper inclusion of domestic markets, mentioned below. Perhaps more data will improve the result or a different specification of the relationship, particularly that involving the shares, may be needed.

When other variables discussed above such as T, T and L, or L and G are added to the variables in equation (17), they do not greatly alter the coefficients of the p and Sp variables; the coefficients of the added variables usually have t values between 1 and 2 and do not affect the $\bar{R}^2$ very much either. This can be seen in the following equation in which T and L have been added:

$$
(20)\quad \underset{(2.4)}{q = -0.27} + \underset{(2.6)}{0.10T} - \underset{(2.2)}{14.78p} + \underset{(3.5)}{1.54S_Fp} - \underset{(3.5)}{0.79S_Sp}
$$

$$
+ \underset{(1.3)}{12.80p'} - \underset{(2.8)}{1.76S_Fp'} + \underset{(2.9)}{1.00S_Sp'} - \underset{(1.2)}{0.81L}
$$

$$
\bar{R}^2 = .58 \qquad S.E. = .41
$$

The equations described thus far involve the assumption that changes in relative quantities depend not only on changes in relative prices, but also on certain other variables, particularly shares. The pooling of the data for different commodity groups and for different countries implicitly assumes that the relationships are not affected by differences in commodity or country. 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 relationships do not differ among commodities is a hazardous one. However, it is not clear how one should expect the quantity-price relationships of various groups to differ.

One would expect that where there is product differentiation along national lines, as is at least partially true, for example, between U.S. and German automobiles, quantity responses will not be as great as, say, in metal products, where there is a greater degree of standardization. It is conceivable, however, that the true quantity responses 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 [19] that export price movements are more alike than domestic price changes, and trade shifts for standardized goods could come about principally through the operation of domestic supply elasticities in countries with declining competitiveness.[20]

The number of observations on the two-digit commodity level is small, and we have therefore divided the commodities into only two groups which we shall call "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 21 observations for M and 47 for E, are:

For "metals":

$$q_M = .09 - \underset{(.6)}{} \underset{(3.1)}{8.96 p_M} \qquad \bar{r}^2 = .30 \quad S.E. = .68 \tag{21}$$

$$q_M = -0.24 + \underset{(1.1)}{} \underset{(2.0)}{.16T} - \underset{(1.4)}{4.63 p_M} \qquad \bar{R}^2 = .40 \quad S.E. = .63 \tag{22}$$

$$\begin{aligned} q_M = {} & \underset{(1.7)}{-0.85} - \underset{(1.1)}{0.2T} - \underset{(0.4)}{7.66 p_M} + \underset{(1.4)}{1.67 S_F p_M} - \underset{(1.1)}{1.24 S_S p_M} \\ & - \underset{(0.6)}{23.95 p'_M} - \underset{(1.0)}{1.59 S_F p'_M} + \underset{(1.7)}{3.61 S_S p'_M} - \underset{(2.0)}{4.07L} \end{aligned} \tag{23}$$

$$\bar{R}^2 = .42 \qquad S.E. = .62$$

[19] Kravis and Lipsey, *Competitiveness,* Chap. 8.

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

For "equipment":

(24) $$q_E = 0.19 - 7.73p_E \qquad \bar{r}^2 = .25$$
$$(2.8) \quad (4.1) \qquad S.E. = .46$$

(25) $$q_E = -0.13 + 0.15T - 7.50p_E \qquad \bar{R}^2 = .41$$
$$(1.2) \quad (3.6) \quad (4.4) \qquad S.E. = .41$$

(26) $$q_E = -.04 + 0.10T - 15.43p_E + 2.47S_Fp_E - 1.09S_Sp_E$$
$$(.5) \quad (2.7) \quad (2.0) \quad (5.7) \quad (3.6)$$
$$+ 20.46p'_E - 3.03S_Fp'_E + 1.24S_Sp'_E + 0.87L$$
$$(1.6) \quad (4.4) \quad (2.5) \quad (1.4)$$
$$\bar{R}^2 = .73 \qquad S.E. = .28$$

Simple relationships [equations (21), (22), (24), and (25)] as well as those involving the share variables [equations (23) and (26)] are shown. In the latter equations, the coefficients of the S_p and $(S_p + S_{p'})$ variables all have the correct signs. However, both equations yield elasticities that are positive for a number of realistic S_F and S_S combinations, particularly when foreign relative prices are rising.

The same variables used in separate equations for the 29 U.K.-U.S. observations (K/S) and for the 29 Germany-U.S. observations (G/S) produce results as follows:

$$q_{K/S} = -0.10 + 0.03T - 14.78p + 1.40S_Fp - 0.58S_Sp$$
$$(1.9) \quad (1.3) \quad (1.8) \quad (1.5) \quad (1.4)$$
$$+ 21.67p' - 3.10S_Fp' + 1.44S_Sp' - 28L$$
$$(2.1) \quad (2.4) \quad (2.8) \quad (.6)$$
$$\bar{R}^2 = .58 \qquad S.E. = .15$$

$$q_{G/S} = -0.41 + 0.17T - 32.43p + 2.48S_Fp - 0.46S_Sp$$
$$(2.0) \quad (2.0) \quad (2.0) \quad (2.1) \quad (1.1)$$
$$+ 32.37p' - 3.45S_Fp' + 0.92S_Sp' - 5.10L$$
$$(1.7) \quad (2.0) \quad (1.3) \quad (1.9)$$
$$\bar{R}^2 = .59 \qquad S.E. = .46$$

Both the U.K.-U.S. and the Germany-U.S. equations have coefficients with signs that conform to the a priori expectations set out above [as does equation (17)].

It seems likely that the high U.S. share at the beginning of our period helped to explain the large responsiveness of relative quantities to declining relative foreign prices. The share and other variables we have introduced do not, however, fully explain the observed differences in the elasticity of substitution before and after 1961 or its asymmetry for declining and rising relative foreign prices.

However, the share variables perform well enough to suggest that the usual procedure of seeking a single measure of the response of quantities to price changes is invalid, and that this responsiveness is itself a variable dependent on other factors.[21]

We have at this stage hardly done more than identify some of these factors. The results reported here represent an early stage in our planned exploration of quantity-price relations in international trade. The market share variable itself is not properly applied to the world market as a whole, since conditions of competition, and therefore the response to price change, may differ from one market to another. A country may have reached a ceiling on its exports to one area while its share is still low in the world market as a whole. We plan to analyze the response to price changes in several divisions of the world market both for these reasons and also to eliminate the domestic markets of competing countries which tend to distort the results reported here because each country's sales on its own domestic market are omitted.

A further extension of this work will be the analysis of price-quantity reactions on a more detailed commodity breakdown, as far as that can be carried out within the limits of the trade statistics. The results so far must be affected by the heterogeneity of the two-digit SITC divisions which combine many products not linked by any competitive relationship.

[21] Mention might also be made of the difference in the measured elasticity that may be produced when observations are based on changes in individual prices rather than on the broad changes in $P_{F/S}$ that result from a devaluation. If there are significant cross elasticities of demand between two exports of one of the countries, the elasticity of substitution between the exports of the two countries will differ for the two types of price change. Cf. Zelder, "Estimates."

COMMENT

ROBERT M. STERN, University of Michigan

The appropriate starting point for my comment may be to ask why one wishes to measure the elasticity of substitution in world trade. Historically speaking, the main reason was that ordinary least squares analysis of import and export demand functions, based mainly on interwar data, frequently yielded price elasticities that were so low as to cast doubt on the efficacy of the international price mechanism. The elasticity of substitution was a conceptual alternative that apparently yielded empirical results more in accord with a priori presumptions concerning relatively high price elasticities. More recently, this concept has been prominent in models designed to explain relative export performance.

In pursuing the measurement of the elasticity of substitution over the years, it has too often been overlooked that its theoretical foundation is rather shaky. Let me elaborate briefly.

THEORETICAL FOUNDATION [1]

In terms of utility analysis, the elasticity of substitution is rigorously defined with respect to movement along a single indifference curve. However, since the value of this elasticity will depend upon the particular indifference curve selected as well as upon relative prices, it is necessary to impose the assumption that there be equal proportional responses of the quantities of each good to changes in the levels of all other variables, chiefly income and the prices of other goods. All of this presumes, furthermore, that the two goods are not identical, since if they were, the indifference curves would be straight lines and the analysis would be trivial.

NOTE: The preparation of this comment benefited materially from discussion with Edward E. Leamer, J. David Richardson, and other members of the Research Seminar in International Economics at the University of Michigan.

[1] This section draws upon the discussion presented in Edward E. Leamer and Robert M. Stern, *Quantitative International Economics*, Boston, Allyn and Bacon, 1970, especially pp. 57–63.

In order to clarify matters further, suppose now that we move from a utility framework to conventional demand analysis, and write the following export demand functions:

$$(1) \qquad q_1 = f(p_1, p_2, y, p_n)$$

and

$$q_2 = g(p_1, p_2, y, p_n),$$

where q_1 and q_2 and p_1 and p_2 refer to the quantities and prices of the respective goods; y, to money income in the importing country; and p_n, to the general price level in this country of goods other than 1 and 2. Assuming constant-elasticity approximations to equation (1), we can then write:

$$(2) \qquad q_1/q_2 = (a/b)[(p_1^{\alpha_1-\beta_1})/(p_2^{\beta_2-\alpha_2})]y^{\alpha_y-\beta_y}(p_n)^{\alpha_n-\beta_n}$$

where the α's and β's refer to the elasticities of the respective variables. Holding money income and other prices constant, it is evident from equation (2) that q_1/q_2 will be functionally related to p_1/p_2 in terms of the elasticity of substitution (e) only if the exponents of the price variables are equal:

$$(3) \qquad e = \alpha_1 - \beta_1 = \beta_2 - \alpha_2, \text{ or } \alpha_1 + \alpha_2 = \beta_1 + \beta_2$$

Equation (3) asserts that the sum of the direct and cross elasticities of demand be the same for each commodity. With respect to money income and other prices, it also follows from equation (2) that the income elasticities and cross-price elasticities must be comparable, that is $\alpha_y = \beta_y$ and $\alpha_n = \beta_n$. Now whether or not the foregoing equalities hold is a question of fact rather than theory. This suggests that the proper test of their validity and thus of the concept of the elasticity of substitution is a regression of the form:

$$(4) \qquad \log (q_1/q_2) = a + b_1 \log p_1 + b_2 \log p_2 + c \log y + d \log p_n.$$

The hypothesis represented by equations (2) and (3) could then be examined by testing whether $-b_1 = b_2$ and whether $c = d = 0$.

MEASUREMENT

In their equations (2)–(6), Kravis and Lipsey (K-L) have imposed the a priori assumption on the data that $-b_1 = b_2$ and that $c = d = 0$.

Their apparent justification for this stemmed from the way in which their data were gathered. Since their success in data gathering could not be assured in advance and if equation (4) above is granted, the K-L regression results presented in their equations (2)–(6) are, strictly speaking, not acceptable. Their most meaningful results are, in contrast, contained in equations (11) and (12) in which the changes in foreign and U.S. prices are entered separately, and in equations (13)–(15) which contain a world income variable. Despite the authors' contention that the separate price coefficients in equation (11) do not differ from one another statistically speaking, it is nevertheless conceivable that the elasticities of -17.11 and 13.08 may be economically different, particularly if the significance tests are not interpreted literally. The authors do not place much stock in their equations (13)–(15) especially since the income variable was highly correlated with their trend variable in equation (3). Again, economic logic would dictate that the income variable is more meaningful than the trend variable, which is usually a catchall and therefore difficult to interpret. It would have been preferable of course if the income variable had been included with the separate price variables in K-L equations (11) and (12).

A related matter of logic concerns the authors' aggregation of the four-digit SITC data to the two-digit level. In carrying out this aggregation, it was in effect assumed that the elasticity-of-substitution relations noted held at the four-digit level. As argued in the preceding discussion, there is no a priori basis for such an assumption.

Leaving aside for a moment the question of the appropriate form of the model, there are some troublesome points that arise when we take K-L on their own ground. These concern mainly (1) the derivation of the export quantity indexes; (2) the disregard of cross effects involving the United Kingdom, Germany, and Japan; and (3) the adjustment lags.

To obtain export quantities, the authors divided current value figures by a price index based upon 1963 weights. The resulting quantity index is unfortunately difficult to interpret since it involves variable weights. Rather, what they should have done was to construct a quantity index that reflected the same weighting pattern as their price index. This might admittedly be a difficult undertaking because of data problems, but it would be worthwhile to determine if the results were materially affected by using a different quantity index.

In focusing only on the substitution relations involving the United States vis-à-vis the United Kingdom, Germany, and Japan, the possibility exists that substitutions among these latter three countries might be attributed erroneously to substitution vis-à-vis the United States. Suppose, for example, that the pattern of specialization at the four-digit SITC level differed substantially and that substitutions occurred among the three countries that were different from those that occurred vis-à-vis the United States. It is conceivable therefore that the K-L measure may overstate the responsiveness of foreign export quantities relative to the United States.

On the matter of adjustment lags, it is noteworthy that the authors obtain quite different results for the two four-year periods from 1953 to 1961 in equation (4) as compared to the results for the period 1961–64 in equations (5) and (6). On the face of it, this is not really surprising since there could be differential time lags involved in the different classes of manufactured goods. Thus, part of what may appear to have been a change in the structure of the relationship is perhaps attributable to the time units chosen as they relate to the nature of the adjustment lags.

Let us turn next to the question of the variability of the elasticity of substitution with respect to market shares and the asymmetry of declining and rising relative prices. It is evident from the space allotted that the authors consider their findings here to be interesting and important. Now it is true that a country's existing market share will influence what it can gain or lose in this respect as its prices decline or rise. It does not necessarily follow, however, that the elasticity of substitution need be variable. This can be seen from the following expression for the elasticity of substitution defined in terms of market share, e_g: [2]

$$e_g = (e + 1)(1 - g), \tag{5}$$

where e is the conventional elasticity of substitution and g is the market share. Thus, e_g will vary with g, but e can nevertheless remain constant.

[2] See *ibid.*, pp. 178–79, n. 9.

IMPLICATIONS FOR FURTHER RESEARCH

One of the obvious extensions of this research is to disaggregate not only by commodity categories but also by importing regions. The authors can do the former since their price indexes were based upon the four-digit SITC classification. Unfortunately, they cannot effectively disaggregate by importing region. This is because their price indexes refer to exports to all regions and there is no reason to believe that the same price is applicable throughout.[3] Further research may also be hampered by the fact that the authors' indexes stop in 1964. It would be desirable if these indexes could be kept current and differentiated by importing region.

If disaggregation is to be pursued, a more comprehensive pooling procedure might be employed. Particularly to be recommended is the procedure used by Ginsburg, in which separate allowance is made for the effects of commodity composition, regional composition, time, and curvilinearities in the relative price influences.[4]

However, before substantial additional resources are expended on further research, it seems fitting to ask why it is that we want to measure the elasticity of substitution in international trade. If the answer is to obtain better estimates of price elasticities of demand, then why not approach such estimation directly rather than in a roundabout way. This same conclusion holds even when we are seeking to explain export-market shares, especially since most implications for policy can be stated more readily in terms of the directly estimated rather than the substitution elasticities.

REPLY BY KRAVIS AND LIPSEY

Stern raises several theoretical points, on which we disagree almost completely, and makes a number of suggestions, some of which we plan to carry out in future work and some of which we would follow if the

[3] See 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, p. 267.

[4] See Alan L. Ginsburg, *American and British Regional Export Determinants,* Amsterdam, North-Holland, 1969.

required data were available. Our main disagreement relates to the meaning of the price variable. Stern treats it as a relation between prices of two different commodities and we consider it to be a comparison of the price in two countries for the same commodity. The divergences of our views regarding both the use of individual-country prices rather than price competitiveness and the importance of income variables stem mainly from our differences in the interpretation of the price measure.

With respect to the use of substitution elasticities, as opposed to demand elasticities, Stern's objection seems to be to the use of relative prices, in place of an individual-country price index, in the denominator of the elasticity measure. This is not really an objection to the substitution elasticity because the same objection can be made to demand elasticities, many of which are calculated using relative, rather than absolute, price as the independent variable. In fact, there is not, as Stern claims, any economic logic which requires the use of the separate price indexes. There is nothing in the underlying theoretical formulation applying to comparisons between commodities, summarized by Stern at the beginning of his comment, that dictates the order in which our equations should be presented. Since we consider relative prices to be the appropriate variable, we start with them. We run the separate country price equations that Stern advocates [(10) and (11)] to see whether we have successfully matched commodities between exporting countries. In any case, the question of which measure provides the better explanation of trade flows is one to be answered empirically, and we found relative prices superior in this respect.

In some products or industries we could go further and say that the single-country price index, which Stern advocates, has little meaning. Competition takes place through successive place-to-place comparisons by buyers, as in international bidding for heavy electrical equipment. The time-to-time index is an artificial construction which we have put together to produce a comprehensive price index, but it does not represent the buyer's view of the market.

Stern asks why the elasticity of substitution should be calculated at all. Its virtues are pointed out by Leamer and Stern themselves, in their book. It avoids the need for including a large number of variables that would be required for explaining the level of exports. These variables, such as income in the importing country, canceled out, as we expected, when we focused on the explanation of export shares instead.

Professor Stern suggests that our export quantity index, which is derived from the value of trade and the price index, is difficult to interpret because it involves changing weights. The problem is a very old one. The only observable event is the change in the value of trade, and we wish to analyze this event by factoring the change in value into price and quantity elements, which are analytical categories, not observable values. Since the price index is a Laspeyres (fixed weight) index, the corresponding quantity index that factors the value change is a Paasche (current weight) quantity index. It is true that the elasticity measure calculated in this way will differ from that derived from Paasche price and Laspeyres quantity indexes, or from Fisher indexes for both price and quantity. The latter form would meet Stern's preference for price and quantity indexes of the same type. His suggestion of fixed weight price and quantity indexes, on the other hand, would not factor the value change. The conditions under which there will be bias, and the factors determining the direction of bias with each type of index, have been discussed elsewhere.[1]

One question Stern asks is whether the difference between our results for the four-year periods before 1961 and those for the one-year periods afterward is a consequence of the length of the period alone, since one might well expect longer-run quantity responses to be greater than the short-run ones. We calculated an elasticity coefficient for the period 1961–64 as a whole and found it to be higher than the one-year coefficient, but still considerably below the four-year coefficients for earlier years.

Another suggestion is that it would be useful to disaggregate by importing regions, but that our data are not suitable for this purpose because we calculate a single index for exports to all countries. There are two issues involved. One is that there may be differences in price behavior in exports to different regions and the other is that there may be regional differences in response to the same price changes. We cannot deal with the former question, although we wish we had the data for it. We can and will test the latter possibility and we think there

[1] See, for example, Robert E. Lipsey, *Price and Quantity Trends in the Foreign Trade of the United States*, New York, NBER, 1963, Chap. 3.

may be significant differences in response to a U.S. price change between say, the EEC countries and Canada.

To say, as Stern does, that there is no reason to believe that the same price movements are applicable to different regions is an exaggeration. One would not expect large differences for most commodities. However, there are at present no data with which to answer this question. Given the limitations of price data, it is completely unwarranted to assume that differences in unit values represent regional price differences, as the comprehensive pooling procedure used by Ginsburg and approved by Stern would require.

Several of the other points Stern raises we have no disagreement with. Some of the suggested analyses are part of our future program; others are beyond the limits of our data. We do plan to disaggregate by both commodity and region and we will test country and commodity cross elasticities, although we do not expect them to be significant because we believe that our commodity matching was successful in eliminating most of them. We wish the data covered a longer period but we will leave that job to others. Our plans do include, however, an attempt to interpolate and extrapolate our indexes using domestic price data for each country, reweighted to form indexes with a single set of international trade weights.