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The Effect of Exchange Rate Changes on the Balance of Trade in Ten Industrial Countries*

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Abstract

This paper reports on an empirical study of the effects of exchange rate changes on the balance of trade in ten industrial countries: the United States, Germany, Japan, France, Italy, the United Kingdom, Canada, Belgium, the Netherlands and Austria, in the period 1971-1977. Import and export equations are estimated from monthly data with effective exchange rate indices as explanatory variables. Significant estimates of the exchange rate elasticities of either imports or exports or both are obtained for nine of the ten countries in the sample, all except Canada. The coefficient estimates suggest that currency depreciation improves the trade balance in all nine countries for which some significant estimates are obtained except the United Kingdom. In most of these countries, or seven, it is apparent that the trade balance begins to improve within a month.

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I. Introduction

This paper reports on an empirical study of the effects of exchange rate changes on the balance of trade in ten industrial countries: the United States, Germany, Japan, France, Italy, the United Kingdom, Canada, Belgium, the Netherlands and Austria, in the period from 1971 to 1977.

The study differs from previous empirical studies in this area in two main respects.1/ Firstly, while almost all previous studies--for example, those by Houthakker and Magee (1969), Khan (1974) and Goldstein and Khan (1976)--have presented regression estimates of structural import and export demand equations with relative import and export prices as explanatory variables, the import and export equations presented in this paper were estimated by multiple regression methods in reduced form with exchange rates as explanatory variables. This approach has the advantage that it makes it possible to evaluate the effects of exchange rate changes on imports and exports directly and also to derive estimates of the price elasticities of the demand for and supply of imports and exports, provided that the income elasticities of the demand for imports and exports may be assumed to be known from previous empirical studies. Because of the difficulty involved in estimating simultaneously structural demand and supply functions for imports and exports, very few estimates of supply elasticities in world trade have been published.2/ Instead, investigators in the past have generally had to rely on the simple Marshall-Lerner condition to determine whether depreciation improves the trade balance by adding the estimated price elasticities of the demand for imports and exports in order to see whether the sum is greater or smaller than one, assuming that the price elasticities of the supply of imports and exports are infinitely large. This is an unnecessarily restrictive assumption in empirical work, now that data for floating exchange rates have become available in recent years. With these data it is possible to estimate reduced-form equations for imports and exports and use the estimated reduced-form coefficients to derive the structural estimates of the price elasticities of the demand for and supply of imports and exports, provided that the income elasticities of the demand for imports and exports are known. This procedure was followed in the empirical work reported in this paper.

1/ The following are among the most important empirical studies of price elasticities in world trade: Polak (1953), Harberger (1957), Ball and Marwah (1962), Rhomberg and Boissoneault (1964), Junz and Rhomberg (1965, 1973), Kreinin (1967, 1973), Heien (1968), Turnovsky (1968), Houthakker and Magee (1969), Armington (1970), Branson (1972), Kwack (1972), Hickman and Lau (1973), Taplin (1973), Khan (1974), Khan (1975), Khan and Ross (1975), Goldstein and Khan (1976, 1978) and Brillembourg (1977). The empirical literature on international trade has been surveyed by Cheng (1959), Prais (1962), Harley (1967), Magee (1968), Leamer and Stern (1970), Magee (1975) and Stern, Francis and Schumacher (1976). These surveys contain extensive bibliographies.

2/ See, however, a recent paper by Goldstein and Khan (1978) where simultaneous estimates of demand and supply equations for the exports of eight industrial countries are presented. See also Magee (1970) and Rhomberg and Boissoneault (1964).

Secondly, the present study differs from previous empirical studies in this area in that the period under study here, from January 1971 to September 1977, coincides with the recent experience with floating exchange rates in the industrial countries. All the countries in the sample except Austria have had floating exchange rates in this period. Although the sample period is thus much more recent and shorter than in previous studies, observations for the regression analysis the results of which are reported in this paper were plentiful, because the data under study are monthly time series. The data used in previous studies have, by contrast, been either annual (see, e.g., Houthakker and Magee, 1969, and Khan, 1974), semiannual (see Khan and Ross, 1975) or quarterly series (see, e.g., Goldstein and Khan, 1976, 1978). With annual (or quarterly) data it is, of course, only possible to find whether a devaluation in, say, January improves the balance of trade for the year (or quarter) as a whole. With monthly data, on the other hand, it is possible to find whether a devaluation in January improves the trade balance in January, later in the year, next year perhaps or even not at all, as might be the case if the volume of imports and exports does not respond sufficiently quickly or strongly to exchange rate changes to overcome the adverse effect of the resulting changes in the terms of trade on the trade balance. For this reason monthly data are particularly useful in an empirical study of price elasticities in world trade.

The structure of the paper is as follows: In Section II the estimating equations for imports and exports are derived in reduced form from a familiar model of the balance of trade. It is shown that the simple Marshall-Lerner condition is unduly restrictive because it assumes infinite supply elasticities. A simple expression--of which the simple Marshall-Lerner condition is a special case--is presented for the necessary and sufficient condition for depreciation to improve the trade balance in domestic and foreign currency. This condition is used in Section III to determine whether the estimated price elasticities of demand and supply in international trade are such that depreciation improves the trade balance.

The empirical results of the estimation of the import and export equations for the ten industrial countries in the sample are presented in Section III. Significant estimates of the exchange rate elasticities of either imports or exports or both are obtained for nine of these ten countries, all except Canada. The price elasticities derived from the coefficient estimates suggest that depreciation improves the trade balance in all countries for which some significant estimates are obtained except the United Kingdom, eight countries in all. In most of these countries, or seven, it is apparent that the trade balance begins to improve within a month.

II. A Simple Model of the Balance of Trade

The model from which the reduced-form equations for exports and imports to be estimated are derived is described in this section. The model is similar to that presented by Egon Sohmen in his book, Flexible Exchange Rates.1/

1/ See Sohmen (1969). The original sources are Marshall (1923), Lerner (1944), Robinson (1937) and Metzler (1948).

The only difference between the present model and Sohmen's model is that the price level at home and abroad is allowed to vary in the present model, so that a distinction must be made between nominal and real exchange rates, while in Sohmen's model domestic and foreign prices are implicitly assumed to be fixed. The notation, presented in Table 1, is mostly the same as Sohmen's.

The supply and demand functions for exports and imports are approximated by constant-elasticity functions:

$$(1) \qquad \log(X^s) = \log(X_0) + \sigma_X \log(p/P)$$

$$(2) \qquad \log(X^d) = \log(X_0) - \delta_X \log(p^*/P^*) + \eta_X \log(Y^*)$$

$$(3) \qquad \log(M^s) = \log(M_0) + \sigma_M \log(q^*/P^*)$$

$$(4) \qquad \log(M^d) = \log(M_0) - \delta_M \log(q/P) + \eta_M \log(Y)$$

Table 1. Notation

X	=	volume of exports (s = supply, d = demand)
M	=	volume of imports (s = supply, d = demand)
p	=	price of exports in domestic currency
p^*	=	price of exports in foreign currency
q	=	price of imports in domestic currency
q^*	=	price of imports in foreign currency
P	=	domestic price level
P^*	=	foreign price level
e	=	exchange rate (defined as the number of units of domestic currency per unit of foreign currency)
Y	=	volume of domestic output
Y^*	=	volume of foreign output

σ_X = price elasticity of export supply

δ_X = price elasticity of export demand (absolute value)

η_X = income elasticity of export demand

σ_X = price elasticity of import supply

δ_M = price elasticity of import demand (absolute value)

η_M = income elasticity of import demand

In the absence of transport costs, tariffs and other barriers to trade, exports and imports are assumed to cost the same at home and abroad, so that the following equilibrium conditions must be met:

$$(5) \qquad p = ep^*$$

$$(6) \qquad q = eq^*$$

Units are chosen so as to make all prices, output and the exchange rate initially equal to one. With this convention the constants X_0 and M_0 in the supply and demand functions equal the volumes as well as the values of exports and imports in the initial equilibrium position.

Using equations (5) and (6) to eliminate p* and q* from the structural equations (1) through (4), and then using the market equilibrium conditions:

$$(7) \qquad X^s = X^d$$

$$(8) \qquad M^s = M^d$$

to eliminate p and q, the following two reduced-form equations for exports and imports are obtained:

$$(9) \qquad \log(X) = \log(X_0) + \left[\frac{\eta_X\sigma_X}{\sigma_X + \delta_X}\right] \log(Y^*) + \left[\frac{\sigma_X\delta_X}{\sigma_X + \delta_X}\right] \log(eP^*/P)$$

$$(10) \qquad \log(M) = \log(M_0) + \left[\frac{\eta_M\sigma_M}{\sigma_M + \delta_M}\right] \log(Y) - \left[\frac{\sigma_M\delta_M}{\sigma_M + \delta_M}\right] \log(eP^*/P)$$

Exports are thus expressed as a function of income abroad and the exchange rate, all in real terms, and real imports are similarly expressed as a function of real domestic income and the real exchange rate. Regression estimates of these two equations are presented in Section III.1/

It is a routine exercise in algebra to derive from the model the necessary and sufficient condition for depreciation (an increase in the exchange rate, nominal or real as the case may be, cf. Section III) to improve the trade balance in domestic currency, at current or constant prices. If units are chosen appropriately and the trade balance is initially assumed to be in equilibrium, this condition is as follows:

$$\frac{\delta_X(\sigma_X + 1)}{\sigma_X + \delta_X} + \frac{\sigma_M(\delta_M - 1)}{\sigma_M + \delta_M} > 0 \tag{11}$$

It follows from (11) that a sufficient, but not necessary, condition for depreciation to improve the trade balance in domestic currency is that the price elasticity of import demand (δ_M) be greater than or equal to one. Likewise, a necessary and sufficient condition for depreciation to improve the trade balance in foreign currency is that

$$\frac{\sigma_X(\delta_X - 1)}{\sigma_X + \delta_X} + \frac{\delta_M(\sigma_M + 1)}{\sigma_M + \delta_M} > 0 \tag{12}$$

It follows from (12) that a sufficient, but not necessary, condition for depreciation to improve the trade balance in foreign currency is that the price elasticity of export demand (δ_X) be greater than or equal to one.

1/ If export supply had been assumed to depend on domestic output as well as relative prices in equation (1) and import supply had similarly been assumed to depend on foreign output in equation (3), both domestic and foreign output would appear as independent variables in each of the reduced-form equations (9) and (10) for exports and imports. In order to avoid multicollinearity problems in the estimation of these equations, these assumptions were not made. If, on the other hand, export supply had been assumed to depend on foreign output and import supply on domestic output, the specification of the reduced-form equations would still be the same as in equations (9) and (10); only the algebraic expressions for the output coefficients in these equations would be different.

Both these conditions, (11) and (12), are equivalent to

$$(13) \qquad \delta_X + \delta_M + \left[\frac{1 + \sigma_X + \sigma_M}{\sigma_X \sigma_M}\right] \delta_X \delta_M - 1 > 0$$

When the supply elasticities are assumed to be infinite, this condition (13) boils down to the simple Marshall-Lerner condition:

$$(14) \qquad \delta_X + \delta_M - 1 > 0$$

The empirical estimates of the exchange rate coefficients in equations (9) and (10) may be interpreted as estimates of the two demand elasticities, δ_X and δ_M, respectively, provided that it may be assumed that the price elasticities of the supply of exports and imports are infinitely large. But it is unnecessarily restrictive to assume infinite supply elasticities as is typically done in the application of empirical studies of price elasticities in world trade.1/ In fact, the lower the supply elasticities, the greater is the value of the expression in brackets in (13) and the greater is the likelihood that the inequality in (13) is satisfied. A numerical example will illustrate the point. If the demand elasticities are both equal to, say, 0.4 so that the simple Marshall-Lerner condition (14) is not met, but the supply elasticities are both equal to one, the inequality in (13) will still be satisfied. Depreciation will improve the trade balance under these circumstances.

If the trade balance is not in equilibrium to begin with, the analysis becomes slightly more complicated.2/ It can be shown that the bigger the initial deficit, the <u>less</u> likely it is that depreciation will improve the trade balance in domestic currency if the price elasticity of import demand is less than one. In the extreme, an infinite initial deficit requires a price elasticity of import demand greater than one, if depreciation is to improve the trade balance in domestic currency. It can also be shown that the bigger the initial deficit, the <u>more</u> likely it is that depreciation will improve the trade balance in foreign currency if the price elasticity of export demand is less than one. In the extreme, an infinite initial deficit ensures that depreciation improves the trade balance in foreign currency regardless of the value of the price elasticity of the demand for exports.

1/ This was pointed out by Metzler (1948) and Haberler (1949).

2/ Robinson (1947, pp. 142-143) and Hirschman (1949) were first to call attention to this.

III. Empirical Results

The empirical work reported in this section is intended to answer the following question, at least for the ten industrial countries under study: Does depreciation of a country's currency improve its balance of trade and, if so, within what period of time?

Data and method of estimation

To answer this question, the reduced-form equations (9) and (10) derived in Section II were estimated for each of the ten industrial countries in the sample. All the time series used in the estimation are monthly series as published in the IMF's International Financial Statistics (IFS). They are as follows:

(1) The volume of imports (M) is represented by the import volume index (line 73, 1975 = 100) in IFS, seasonally adjusted.

(2) The volume of exports (X) is represented by the export volume index (line 72, 1975 = 100) in IFS, seasonally adjusted.

(3) The volume of domestic output (Y) is represented by the seasonally adjusted industrial production index (line 66c, 1975 = 100) in IFS. This is the only monthly series for output or income available for all the countries in the sample.

(4) The volume of foreign output (Y*) is approximated by real world exports, defined as the seasonally adjusted ratio of nominal world exports in millions of U.S. dollars (line 00170d in IFS) to world export prices expressed in U.S. dollars (line 00174d in IFS, 1975 = 100). No published data, monthly or otherwise, are available for world output.1/

(5) The nominal exchange rate (e) is represented by the reciprocal of the effective exchange rate index (line amx in IFS, May 1970 = 100) as

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1/ Ten different indices for world output were also calculated, one composite index for each country, by taking weighted averages of the industrial production indices of the other nine countries in the sample and using weights derived from the Multiple Exchange Rate Model developed at the IMF, cf. the next paragraph in the text. These indices turned out to be highly correlated with the proxy for world output described in the text; the coefficients of correlation between each of these ten indices and the world export index were clustered between 0.95 and 0.97. Experiments with these indices showed that it does not make much difference for the empirical results reported in this section whether these ten different indices are used in the estimation or just the world export index described in the text; yet the world export index gave better results on the whole. This is noteworthy in the light of the fact that Jacques J. Polak has argued that world exports are in fact preferable to world output as an explanatory variable in export equations. See Polak (1953, pp. 47-51). See also Leamer and Stern (1970, p.16).

derived from the Multiple Exchange Rate Model (MERM) developed at the IMF.1/ This measure of the nominal exchange rate indicates the number of units of domestic currency per unit of foreign currency; when the value of the domestic currency falls in terms of foreign currencies, the nominal effective exchange rate (e) rises. The effective exchange rate index for each country is meant to measure the average change of the country's exchange rate against the currencies of all other countries. In the calculation of the index, a weight representing the relative importance of each foreign country to the home country is applied to the value of the exchange rate between the foreign currency in question and the home currency relative to a chosen base period. The effective exchange rate is thus, by definition, a weighted average of index numbers expressing exchange rates relative to a base period level. It should be noted that in the derivation of the MERM weights, certain assumptions are made about the price elasticities of the demand for and supply of exports and imports.2/ By and large, these assumptions are consistent with the estimates of price elasticities presented in this section. It is possible, however, in principle at least, that these estimates could be improved by recalculating the effective exchange rate indices on the basis of the estimates of the price elasticities obtained in the first round, then re-estimating the price elasticities, and so on until this iterative process converges.3/

(6) The domestic price level (P) is represented by the consumer price index (line 64, 1975 = 100) in IFS.

(7) The foreign price level (P*) is approximated by the index of world export prices expressed in U.S. dollars (line 00174d, 1975 = 100) in IFS.4/

1/ The MERM is described in detail by Artus and Rhomberg (1973). For a lucid discussion of the derivation of effective exchange rate indices from the MERM and a comparison of alternative indices, see also Rhomberg (1974).

2/ See Artus and Rhomberg (1973), Tables 1, 2 and 3 on pp. 603-604.

3/ Dollar exchange rates (line ahx in IFS, May 1970 = 100) were also tried in the estimation of the reduced-form equations (9) and (10) on page 4 for all the countries in the sample except, of course, the United States. The results obtained were not nearly as good as those obtained with the effective exchange rate indices, especially in the export equations.

4/ Ten different indices for world prices were also calculated, one for each country, by taking weighted averages of the consumer price indices of the other nine countries and using the MERM weights as before. The correlation coefficients between each of these ten indices and the world export price index described in the text were clustered between 0.83 and 0.87. Experiments with these indices indicated that it did not matter much for the empirical results reported in this section whether these ten different indices were used in the estimation or just the world export price index described in the text; yet, on the whole, the world export price index produced better results.

Both the sample period and the sample itself are constrained by the data. In all the countries in the sample the effective exchange rate index does not go further back than to January 1971, and at the time of writing, the world export series used did not go beyond September 1977. Hence, the sample period begins in January 1971 and ends in September 1977.

Of the 15 countries classified by the IMF as industrial, three (Denmark, Norway and Sweden) do not have monthly indices for export and import volume in the sample period. Luxembourg has neither such indices nor an effective exchange rate index. Finally, Switzerland does not have a monthly industrial production index. This limits the sample to the ten countries listed in the introduction.

For each of the ten countries in the sample the following reduced-form equations for exports and imports were estimated by the two-stage least-squares method over the sample period January 1971-September 1977:

$$\log(M_t) = \alpha_0 + \alpha_1\log(Y_t) + \alpha_2\log(e_t) + \alpha_3\log(P^*_t/P_t) + u_{1t} \tag{15}$$

$$\log(X_t) = \beta_0 + \beta_1\log(Y^*_t) + \beta_2\log(e_t) + \beta_3\log(P^*_t/P_t) + u_{2t} \tag{16}$$

These two equations are identical to equations (9) and (10) developed in Section II, except the nominal exchange rate and relative prices are now allowed to influence imports (and exports) separately; after all, the regressions are free to make the two elasticities α_2 and α_3 (and β_2 and β_3) equal. There are two main reasons why the effect of changes in the real exchange rate on imports and exports is split into a nominal exchange rate component and a relative price component. Firstly, importers and exporters might suffer from money illusion and for that reason respond differently to nominal exchange rate changes than to changes in relative prices. Secondly, regardless of money illusion importers and exporters might perceive (nominal) exchange rate changes and relative price changes differently; they might, for example, expect relative price changes to be transitory, but exchange rate changes permanent.1/ These points will be discussed further below in the light of the empirical results.

The two-stage least-squares method was used in the estimation rather than the ordinary least-squares method because floating exchange rates (as well as relative prices) must be treated as endogenous variables which are influenced, *inter alia*, by imports and exports. The error terms u_{1t} and u_{2t} are assumed to be normally and independently distributed with zero means and constant variances. Where necessary, however, the Cochrane-Orcutt method was used to correct for serial correlation.

1/ I am indebted to Morris Goldstein for suggesting this interpretation.

Consistent estimates may be obtained by including among the instrumental variables current and lagged values of the predetermined variables in the model and lagged values of the endogenous variables in each equation, and by choosing the lags in accordance with the degree of the autocorrelation scheme adopted.1/ Accordingly, the following instrumental variables were used in the estimation of equations (15) and (16): Y_t, Y_{t-1}, Y^*_t, Y^*_{t-1}, e_{t-1}, P^*_{t-1}/P_{t-1} and M_{t-1} (in the import equations) or X_{t-1} (in the export equations).

Import equations

The estimated import equations are presented in Table 2. In view of the fact that the data are monthly time series, the R^2's shown in column 5 in the table are reasonably high, except perhaps in the case of Italy. The F-statistics shown in column 7 indicate that all the regressions are highly significant as a whole.2/ Where necessary, positive serial correlation has been eliminated by a first-order autoregressive Cochrane-Orcutt scheme, as evidenced by the Durbin-Watson statistics shown in column 8.3/ In two countries, however, Germany and Italy, the Durbin-Watson test for serial correlation is marginally inconclusive, and in France the Durbin-Watson statistic is at the far end of the upper inconclusive range.

It is clear from the second column in Table 2 that the estimates of the income elasticities in the import equations for all ten countries are highly significant.4/ Five of these coefficients (United States, Japan, France, Canada and Austria) are significantly greater than one at the 5 per cent level. The rest are not significantly different from one. It is noteworthy that in all the countries for which significant estimates of the exchange rate elasticity of imports were obtained, cf. the next paragraph, i.e., all except Japan, France and Canada, the estimates of the income elasticity of imports (α_1) are lower than the estimates of the income elasticity of the demand for imports (η_M) reported, for example, by Houthakker and Magee (1969) and Goldstein and Khan (1976).5/ This is an

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1/ This result is due to Fair (1970).

2/ The critical F-value with 4 degrees of freedom in the numerator and 80 in the denominator is 3.56 at the 1 per cent significance level.

3/ Given the sample size and the number of coefficients estimated, a DW-statistic between 1.65 and 2.35 allows us to reject with 95 per cent confidence the hypothesis that the residuals are serially correlated. The ranges in which the DW-test is inconclusive are 1.49 - 1.64 and 2.36 - 2.51.

4/ A distinction is not made between cyclical and secular effects of income on imports and exports in this paper. For separate estimates of cyclical and secular income elasticities of the demand for imports in 14 industrial countries, including the ten countries under study here, see Khan and Ross (1975).

5/ See Tables 6 and 7 on pp. 23-24.

T[redacted] 2. Import Equations

$$\log(M_t) = \alpha_0 + \alpha_1\log(Y_t) + \alpha_2\log(e_t) + \alpha_3\log(P^*_t/P_t) + u_{1t}$$

	α_0	α_1	α_2	α_3	$\bar{R}^2$	SE	F	DW	ρ	N	r
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
United States	-7.01 (4.79)	1.59 (9.91)	-0.97 (3.89)	0.06 (0.77)	0.69	0.066	38.04	1.96	0.19 (1.77)	79	0.66
Germany	-3.19 (1.88)	0.87 (2.66)	-0.78 (1.95)	-0.03 (0.16)	0.74	0.060	21.70	2.38	0.45 (4.38)	79	-0.93
Japan	-1.68 (3.22)	1.34 (9.12)	-0.02 (0.08)	0.61 (7.37)	0.93	0.036	162.76	1.88	0.33 (3.11)	79	-0.38
France	-6.85 (2.43)	1.82 (6.72)	-0.65 (1.51)	0.46 (3.72)	0.83	0.058	26.56	2.52	0.56 (5.79)	79	-0.25
Italy	-1.95 (1.78)	1.22 (6.97)	-0.21 (2.76)	-0.24 (2.38)	0.43	0.084	20.95	1.63		80	-0.01
United Kingdom	0.94 (0.93)	1.23 (5.70)	0.45 (10.78)	0.20 (3.01)	0.68	0.061	57.32	1.85		80	-0.15
Canada	-2.94 (2.74)	1.52 (13.56)	-0.11 (0.61)	0.28 (5.50)	0.93	0.039	351.23	2.09		80	0.38
Belgium	-8.16 (4.19)	1.11 (8.10)	-1.63 (3.92)	0.08 (0.81)	0.86	0.046	53.72	2.16	0.47 (4.69)	79	-0.67
Netherlands	-5.02 (5.64)	1.14 (7.09)	-0.92 (4.57)	-0.38 (5.03)	0.73	0.051	71.91	2.25		80	-0.85
Austria	-8.36 (10.75)	1.60 (10.08)	-1.16 (7.14)	-0.56 (5.96)	0.87	0.056	182.60	1.85		80	-0.91

Note: t-statistics appear in parentheses below the coefficients. The sample period is January 1971—September 1977. The summary statistics are as follows:

$\bar{R}^2$ = coefficient of determination, adjusted for degrees of freedom
SE = standard error of regression
F = F-statistic
DW = Durbin-Watson statistic
ρ = estimated first-order serial correlation coefficient
N = number of observations
r = correlation coefficient between e_t and P^*_t/P_t.

indication that the supply of imports is not infinitely elastic with respect to price changes, cf. the algebraic expression for the income elasticity of imports in equation (10) on page 4.

Column 3 in Table 2 shows the estimated coefficients of the effective exchange rate indices in the import equations. These coefficients are significantly negative as expected in six of the ten countries (United States, Germany, Italy, Belgium, Netherlands and Austria).1/ In five of these six countries, the exchange rate coefficients are not significantly different from one; only in Italy is the coefficient significantly smaller than one. Of the remaining four countries, the exchange rate coefficients are insignificant in three (Japan, France and Canada) and significant with wrong sign (positive) in one (United Kingdom). With a t-statistic of 1.51, the French exchange rate coefficient is nonetheless significant at the 10 per cent level.2/

The estimates of the relative price elasticities in the import equations are shown in column 4 in Table 2. These estimates are significantly negative as expected in three of the ten countries in the sample (Italy, Netherlands and Austria), very small and insignificant in three (United States, Germany and Belgium), and significant with wrong sign (positive) in the remaining four countries (Japan, France, United Kingdom and Canada).3/ Of the three significantly negative relative price coefficients, the Italian one is not significantly different from the exchange rate coefficient. The other two are significantly smaller than the corresponding exchange rate coefficients; the relevant t-values computed are 2.13 for the Netherlands and 2.47 for Austria.

There could be several reasons for the failure of the estimates of the relative price elasticities to have a significantly negative sign in a majority of the regressions. Firstly, the world export price index used to represent the level of world prices P* facing all the countries may not be a good measure of relevant price developments in world markets for any single country. Trade-weighted or MERM-weighted averages of consumer price indices, one composite index for each country, might perhaps have been expected to give better results, but experiements with such indices bore even less fruit.4/

1/ With 80 degrees of freedom, the critical t-value is 1.67 at the 5 per cent significance level in a one-tailed test and 1.30 at the 10 per cent level.

2/ These and other results reported in this paper will be compared with the results of other empirical studies under separate heading at the end of this section after the price elasticities implicit in the results reported here have been presented.

3/ Attempts to estimate the effects of P and P* on imports separately as some writers have done (see, e.g., Ahluwalia and Hernández-Catá, 1975) bore even less fruit.

4/ See footnote 4 on page 8.

Secondly, insofar as increased inflation at home relative to that abroad results in depreciation of the home currency and vice versa, there is reason to expect negative correlation between the nominal effective exchange rate e and relative prices P*/P in the countries under study. Such correlation might cause multicollinearity and thus result in inefficient or insignificant estimates. Significant negative correlation between e and P*/P is in fact observed in six countries (Germany, Japan, France, Belgium, Netherlands and Austria); the correlation coefficients shown in column 11 of Table 2 range from -0.25 for France to -0.93 for Germany.1/ Two of the correlation coefficients are insignificant (Italy and United Kingdom), and two are significant with wrong (i.e., positive) sign (United States and Canada). Of the six significantly negative correlation coefficients, three are higher (in absolute value) than -0.70. In two of these three cases, highly significant estimates were obtained for all coefficients. Thus, multicollinearity does not appear to cause serious difficulties in the estimation.

Thirdly, the poor overall performance of relative prices as explanatory variables in the import equations might result from money illusion in the following sense.2/ If domestic prices rise faster than foreign prices (i.e., P*/P decreases), but the nominal exchange rate e remains unchanged so that the real exchange rate eP*/P falls and the home currency appreciates in real terms, importers suffering from money illusion may nevertheless behave as if the real exchange rate remained unchanged. In this case imports do not increase as they should in response to an increase in P/P*. If, to take another example, an increase in relative prices at home and abroad P/P* (i.e., a decrease in P*/P) results in nominal depreciation of the home currency so that the nominal exchange rate e rises proportionately and the real exchange rate eP*/P remains unchanged, importers may mistakenly perceive this as depreciation of the currency in real terms. As a result, imports do not remain unchanged in this case as they should, but decline in response to an increase in P/P*. To see this clearly, the import equation (15) on page 9 may be rewritten as

$$(17) \quad \log(M_t) = \alpha_0 + \alpha_1\log(Y_t) + \alpha_2\log(e_t) + (1-\mu)\alpha_2\log(P_t^*/P_t) + u_{1t}$$

or

$$(18) \quad \log(M_t) = \alpha_0 + \alpha_1\log(Y_t) + \alpha_2\log(e_tP_t^*/P_t) - \mu\alpha_2\log(P_t^*/P_t) + u_{1t}$$

In these equations, the coefficient α_3 from equation (15) is constrained to equal α_2, cf. equation (10) on page 4.

The parameter μ reflects the extent of money illusion in the sense that an x per cent increase in relative prices P/P* with the real exchange rate

1/ Given the sample size, a correlation coefficient is significantly different from zero at the 5 per cent level if it is greater than or equal to approximately 0.25 in absolute value.

2/ For empirical evidence of money illusion in the aggregate consumption function for the United States, see Branson and Klevorick (1969).

fixed is perceived as a real depreciation of μx per cent. Thus, when $\mu = 0$, there is no money illusion. In this case, the estimated coefficients of $\log(e_t)$ and $\log(P_t^*/P_t)$ should be the same, as they are in the case of Italy, cf. Table 2. When $\mu > 0$, on the other hand, money illusion is present. The money illusion is partial when $0 < \mu < 1$ in the sense that only part of the increase in relative prices P/P* is perceived as real depreciation. In this case, the estimated coefficient of $\log(P_t^*/P_t)$ in equation (15) or (17) should be smaller (in absolute value) than that of $\log(e_t)$, cf. the estimates for the Netherlands and Austria in Table 2. When $\mu = 1$, the money illusion is complete, for then the entire increase in relative prices P/P* is perceived as depreciation in real terms. In this case, only nominal exchange rate changes influence imports; changes in relative prices have no effect. This could be the explanation of the small and insignificant estimates of the relative price elasticities in the import equations for the United States, Germany and Belgium shown in Table 2, for in all three countries the estimated exchange rate elasticity is significantly negative. Finally, it is conceivable, although implausible, that μ might exceed unity in which case an x per cent increase in relative prices P/P* would be perceived as real depreciation of more than x per cent. In this case, the estimated coefficient of $\log(P_t^*/P_t)$ in equation (17) should be positive, not negative as in the case of partial or no money illusion.

Finally, the failure of relative prices as explanatory variables in the import equations could be interpreted as evidence that importers perceive exchange rate changes and relative price changes differently. While importers might expect exchange rate changes to be permanent and react to them accordingly, they might regard relative price changes as transitory and thus not respond to them at all. Admittedly, however, this argument is less plausible in a period of floating exchange rates than it could have been had exchange rates been fixed during the period under study. Moreover, in the absence of empirical evidence to the contrary it is not clear why importers (or exporters) should expect exchange rate changes to be more permanent than changes in relative prices, nor is it clear, of course, why anyone should suffer from money illusion; an economic theory of the rationale for money illusion remains to be formulated.

Export equations

A similar picture emerges from the estimated export equations presented in Table 3. The estimates of the income elasticities shown in column 2 are highly significant in all ten countries. Two of these coefficients are significantly greater than one (Germany and Japan) and two are significantly smaller than one (U.S. and Italy), but the rest are not significantly different from one. With only one exception (Germany) these estimates of the income elasticities of exports (β_1) are smaller than the estimates of the income elasticities of the demand for exports (η_X) reported by Houthakker and Magee (1969) and Goldstein and Khan (1978).1/ This result supports the hypothesis

1/ See Tables 6 and 7 on pp. 23-24.

Table 3. Export Equations

$$\log(X_t) = \beta_0 + \beta_1 \log(Y_t^*) + \beta_2 \log(e_t) + \beta_3 \log(P_t^*/P_t) + u_{2t}$$

	β_0	β_1	β_2	β_3	$\bar{R}^2$	SE	F	DW	ρ	N
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
United States	7.10 (10.37)	0.80 (8.60)	0.49 (3.21)	0.25 (3.23)	0.89	0.053	224.01	1.82		80
Germany	6.39 (9.25)	1.22 (14.97)	0.26 (1.90)	0.09 (1.54)	0.94	0.035	423.04	1.93		80
Japan	9.89 (11.52)	1.91 (17.27)	0.96 (5.48)	-0.48 (3.66)	0.86	0.070	165.35	1.19		80
France	4.74 (11.14)	0.98 (21.04)	-0.06 (0.61)	0.10 (2.20)	0.94	0.032	434.93	1.88		80
Italy	6.53 (15.20)	0.42 (2.40)	0.41 (3.64)	-0.04 (0.44)	0.79	0.062	59.50	1.99	0.22 (2.00)	79
United Kingdom	5.89 (9.71)	0.66 (3.14)	0.23 (1.49)	0.10 (0.98)	0.71	0.076	65.08	1.70		80
Canada	5.79 (4.63)	0.99 (11.23)	0.16 (0.61)	-0.42 (5.83)	0.76	0.044	52.48	2.05	0.25 (2.28)	79
Belgium	4.04 (2.41)	1.12 (10.47)	-0.22 (0.62)	-0.22 (2.78)	0.86	0.047	101.57	2.00	0.24 (2.14)	79
Netherlands	7.61 (6.37)	1.16 (11.32)	0.54 (2.18)	0.04 (0.49)	0.88	0.042	126.83	1.84	0.21 (1.87)	79
Austria	5.10 (5.66)	1.18 (10.30)	0.00 (0.01)	-0.02 (0.26)	0.88	0.052	196.40	2.06		80

Note: t-statistics appear in parentheses below the coefficients. The sample period is January 1971-September 1977. The summary statistics are as follows:

$\bar{R}^2$ = coefficient of determination, adjusted for degrees of freedom
SE = standard error of regression
F = F-statistic
DW = Durbin-Watson statistic
ρ = estimated first-order serial correlation coefficient
N = number of observations

that the supply of exports in these countries is not infinitely elastic with respect to price changes, cf. the algebraic expression for the income elasticity of exports in equation (10) on page 4.

It is also interesting to compare for each country separately the estimates of the income elasticities of exports and imports. In the United States, France, Italy and the United Kingdom the income elasticity of imports is two to three times as high as the income elasticity of exports. The implication of this is that world output must grow two to three times as fast as domestic output in these countries if the balance of trade is not to deteriorate and the real exchange rate is to remain unchanged. It is therefore not surprising that these countries, especially Italy and the United Kingdom, have had large deficits in the balance of trade for the most part of the period under study. In Germany and Japan, on the other hand, the income elasticity of exports exceeds the income elasticity of imports by almost one half. These countries can afford rates of growth much higher than in the rest of the world without endangering their trade balance position. Not surprisingly, they have had substantial trade surpluses throughout this decade. The cases of the remaining four countries are less clear. The income elasticity of imports is higher than that of exports in both Canada and Austria; Austria has had substantial trade deficits in this decade, but Canada has had small surpluses. Belgium and the Netherlands have also had small surpluses in the trade balance; the income elasticities of exports and imports are almost indentical in both countries. The relationship between the trade balance and the difference between the income elasticities of exports and imports across the sample is more pronounced in these results than in the results reported by Houthakker and Magee (1969) and Goldstein and Khan (1976, 1978).1/ The rank correlation coefficient between the trade balance as a proportion of exports and the difference between the income elasticities of exports and imports is 0.62.

The estimated coefficients of the exchange rate indices shown in column 3 are significantly positive as expected in five countries out of ten (United States, Germany, Japan, Italy and the Netherlands). In four of these five countries, the exchange rate coefficients are significantly smaller than one; only in Japan is the coefficient not significantly different from one. In the other five countries, the exchange rate coefficients are insignificant. With a t-value of 1.49, the exchange rate coefficient for the United Kingdom is still significant at the 10 per cent level, however, but quite small.

The estimates of the relative price elasticities in the export equations are shown in the fourth column of Table 3. They are significantly positive as expected, but small, in two countries (United States and France), very small and insignificant in five (Germany, Italy, United Kingdom, the Netherlands and Austria), and significant with wrong signs (negative) in the remaining three countries (Japan, Canada and Belgium). Again, as more of these coefficient estimates have significantly wrong signs than right, it

1/ See Tables 6 and 7 on pp. 23-24.

is difficult to draw general conclusions from these results. For possible explanations of these results, the reader is referred to the discussion of the same problem in the section above on the import equations, for exactly the same arguments apply to the export equations.

The F-statistics indicate as before that all the export equations are highly significant as a whole, and the $\bar{R}^2$'s are quite high. Serial correlation has been eliminated where necessary as before except in the case of Japan where an attempt to correct for first-order autocorrelation resulted in potentially unstable regression calculations.1/ Thus, with a Durbin-Watson statistic of 1.19, the Japanese export equation has serially correlated residuals. As a result, the standard errors of the coefficient estimates in this particular equation may be underestimated. The t-values shown may, in other words, be too high.

Distributed lags

Presumably the effects of changes in exchange rates or relative prices on imports and exports are not all felt within one month, but take longer to materialize fully. For this reason the import and export equations (15) and (16) were re-estimated, allowing the effects of exchange rates and relative prices to spread over twelve months and approximating the lag distributions with third-degree polynomials constrained to end at zero. Preliminary experimentation showed that it does not matter much for the results whether the lag distributions are constrained to end at zero or not or whether income is also allowed to influence imports and exports with a distributed lag or without lag. For simplicity, it was chosen to ignore lagged income effects.

Import equations with distributed lags. The re-estimated import equations are presented in Table 4. The results are very similar to those obtained before. The estimates of the income elasticity of imports are again highly significant in all ten countries.

Significantly negative response of imports to exchange rate changes is observed in the same six countries as before, except in France, where the response was previously marginally insignificant without lag, but is now significant at the 5 per cent level, and Italy, where the response was significant before without lag, but is now marginally insignificant with a twelve-month distributed lag. Of the seven sums of distributed-lag exchange rate coefficients (six significant and one marginally insignificant), four are bigger in absolute value as expected than the corresponding coefficients in the equations estimated without lags (United States, Belgium, the Netherlands and Austria), one is the same (Italy), and two are slightly smaller (Germany and France). In the remaining three countries (Japan, United Kingdom and Canada), imports fail to respond significantly to exchange rate changes within twelve months. However, the estimated sum of the exchange rate coefficients for Japan is -1.06 and significant at the 10 per cent level with a t-value of 1.65 when the effects of exchange rate changes on imports are

1/ Goldstein and Khan (1978) and others have had similar difficulties in estimating export equations for Japan.

Table 4. Import Equations with Twelve-Month Distributed Lags

$$\log(M_t) = \alpha_0 + \alpha_1 \log(Y_t) + \sum_{i=0}^{11} \alpha_{2i}\log(e_{t-i}) + \sum_{i=0}^{11} \alpha_{3i}\log(P^*_{t-i}/P_{t-i}) + u_{1t}$$

	α_0	α_1	$\sum_{i=0}^{11} \alpha_{2i}$	$\sum_{i=0}^{11} \alpha_{3i}$	$\bar{R}^2$	SE	F	DW	ρ	N
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
United States	-11.44 (8.74)	1.44 (11.13)	-2.13 (6.76)	0.40 (4.48)	0.80	0.050	38.18	2.04		68
Germany	-5.86 (5.95)	1.61 (7.10)	-0.63 (2.27)	0.01 (0.07)	0.82	0.044	69.62	2.17	-0.25 (2.14)	67
Japan	-1.01 (0.76)	1.61 (7.81)	0.39 (0.91)	0.63 (3.90)	0.88	0.035	32.64	1.85	0.33 (2.84)	67
France	-8.15 (4.18)	2.18 (8.01)	-0.58 (1.91)	0.48 (6.49)	0.77	0.054	32.97	1.49		68
Italy	-0.60 (0.38)	0.93 (3.94)	-0.21 (1.63)	-0.39 (3.36)	0.41	0.083	7.60	1.74		68
United Kingdom	3.17 (2.28)	0.66 (2.25)	0.36 (6.29)	0.12 (1.59)	0.49	0.056	10.34	2.06		68
Canada	-1.56 (0.63)	1.44 (14.04)	0.10 (0.20)	0.23 (5.83)	0.87	0.033	131.71	2.17	-0.38 (3.27)	67
Belgium	-12.26 (5.11)	1.17 (8.88)	-2.45 (4.79)	-0.05 (0.52)	0.81	0.041	21.64	2.06	0.35 (3.01)	67
Netherlands	-5.83 (5.21)	0.83 (4.28)	-1.40 (5.31)	-0.45 (5.81)	0.68	0.048	32.15	1.96	-0.22 (1.86)	67
Austria	-9.24 (9.28)	1.48 (7.22)	-1.45 (5.54)	-0.70 (5.08)	0.85	0.051	54.34	2.19		68

<u>Note</u>: t-statistics appear in parentheses below the coefficients. The sample period is January 1971-September 1977. The summary statistics are as follows:

$\bar{R}^2$ = coefficient of determination, adjusted for degrees of freedom
SE = standard error of regression
F = F-statistic
DW = Durbin-Watson statistic
ρ = estimated first-order serial correlation coefficient
N = number of observations

allowed to spread with a distributed lag over 24 months. Similarly, when the effects of exchange rate changes on imports are allowed to be distributed over 36 months, the sum of the exchange rate coefficients for the United Kingdom becomes -1.28 and significant at the 5 per cent level with a t-statistic of 2.01. Thus, Canada is left as the only country in the sample for which no evidence of an inverse relationship between imports and the exchange rate has been found.

A significantly negative relative price elasticity of imports is obtained for the same three countries as before (Italy, the Netherlands and Austria), and as expected all three of these estimates are bigger in absolute value with a distributed lag than without lag as before. The only significant change in the estimated relative price elasticities of the other seven countries is that the U.S. sum of coefficients is now significant with wrong sign (positive), while the sum of coefficients for the United Kingdom is no longer significant with wrong sign.

According to the summary statistics, all the import regressions presented in Table 4 are highly significant as a whole, and serial correlation is absent everywhere. In all ten equations, the standard error of regression is lower than in the corresponding equations presented in Table 2.

<u>Export equations with distributed lags</u>. The re-estimated export equations are presented in Table 5. The results are again very similar as before. The estimates of the foreign income elasticity of exports are highly significant in eight cases out of ten. The income coefficients for Italy and the United Kingdom are now insignificant at the 5 per cent level; the former is, however, significant at the 10 per cent level.

Significantly positive response of exports to exchange rate changes is observed in the same five countries as before with two exceptions. The German and Dutch exchange rate coefficients were significant before, but the corresponding sums of coefficients are now insignificant at the 5 per cent level. They remain significant, however, at the 10 per cent level. On the other hand, the coefficients for France and the United Kingdom were insignificant before (the latter only marginally), but the corresponding sums of coefficients are now significant. Of the five significant and two marginally insignificant sums of coefficients, three (United States, France and the United Kingdom) are bigger as expected than the corresponding coefficients in the equations without lags, three are about the same (Germany, Italy and the Netherlands), and one is smaller (Japan).

The sum of the relative price coefficients in the French export equation is, like before, significantly positive, but small. And while the relative price coefficient in the Japanese export equation was significant with wrong sign (negative) before, the corresponding sum of coefficients is now significantly positive. The significance of these two estimated sums of coefficients, the French and the Japanese, is marginal, however. In the U.S. export equation, the sum of the relative price coefficients is insignificant, while the corresponding coefficient was significant with wrong sign before. Insignificant sums of coefficients are also obtained in the same

Table 5. Export Equations with Twelve-Month Distributed Lags

$$\log(X_t) = \beta_0 + \beta_1 \log(Y^*_t) + \sum_{i=0}^{11} \beta_{2i} \log(e_{t-i}) + \sum_{i=0}^{11} \beta_{3i} \log(P^*_{t-i}/P_{t-i}) + u_{2t}$$

	β_0	β_1	$\sum_{i=0}^{11} \beta_{2i}$	$\sum_{i=0}^{11} \beta_{3i}$	$\bar{R}^2$	SE	F	DW	ρ	N
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
United States	11.34 (12.73)	0.84 (12.45)	1.45 (7.31)	0.02 (0.22)	0.94	0.029	148.31	2.14		68
Germany	6.25 (7.16)	1.23 (15.53)	0.23 (1.33)	0.08 (1.14)	0.93	0.031	185.68	2.03	-0.28 (2.31)	67
Japan	8.56 (5.06	1.60 (12.03)	0.70 (2.00)	0.33 (1.75)	0.89	0.056	82.16	1.36		68
France	6.60 (9.05)	1.00 (16.21)	0.34 (2.18)	0.07 (1.71)	0.92	0.028	108.50	2.22		68
Italy	6.66 (13.32)	0.30 (1.48)	0.45 (3.45)	-0.10 (1.11)	0.74	0.060	28.75	1.71		68
United Kingdom	7.10 (7.79)	0.33 (0.99)	0.53 (2.26)	0.19 (1.61)	0.62	0.077	16.57	1.85		68
Canada	5.91 (1.60)	0.89 (11.47)	0.20 (0.25)	-0.40 (6.39)	0.74	0.039	28.01	1.99		68
Belgium	2.09 (1.14)	1.06 (12.95)	-0.63 (1.63)	-0.30 (4.84)	0.86	0.037	58.28	1.86		68
Netherlands	7.32 (4.80)	1.10 (9.60)	0.48 (1.52)	0.05 (0.68)	0.83	0.039	49.32	1.86		68
Austria	4.62 (3.00)	1.23 (7.59)	-0.10 (0.33)	-0.13 (0.89)	0.80	0.053	40.41	2.16		68

Note: t-statistics appear in parentheses below the coefficients. The sample period is January 1971-September 1977. The summary statistics are as follows:

$\bar{R}^2$ = coefficient of determination, adjusted for degrees of freedom
SE = standard error of regression
F = F-statistic
DW = Durbin-Watson statistic
ρ = estimated first-order serial correlation coefficient
N = number of observations

five export equations as had insignificant relative price coefficients before (Germany, Italy, United Kingdom, the Netherlands and Austria). Of these five, only the sum of coefficients for the United Kingdom is significantly positive at the 10 per cent level. Like before, the export equations for Canada and Belgium have significant sums of relative price coefficients, but with wrong (i.e., negative) signs.

Judging by the summary statistics, all the export regressions presented in Table 5 are highly significant as a whole. The standard error of regression is lower than before in all but two of the equations. Serial correlation is nowhere present except in the case of Japan where the Durbin-Watson statistic is just outside the inconclusive range.

The import and export equations were also estimated with longer lag distributions (24 and 36 months) and shorter ones (6 months). On the whole, the results were not very different from the ones reported above. Yet the twelve-month lag distributions yielded the best overall results; the longer lag distributions produced fewer significant estimates of exchange rate elasticities. These results are by and large consistent with the results of other empirical studies. Implicit in Houthakker and Magee's (1969) aggregate import demand equation based on quarterly data for the United States is an average lag of one quarter. Khan (1974) found no evidence of lagged effects in his study of import demand based on annual data for 15 developing countries. Ahluwalia and Hernández-Catá (1975) report lags of four to five quarters in their study of import demand in the United States. Goldstein and Khan (1976, 1978) report lags of one to three quarters in their study of import demand in twelve industrial countries and one to five quarters in their study of export demand and supply in a similar group of countries. According to these empirical studies most of the effects of changes in prices (and incomes) on imports and exports are felt within a year.

Conclusions

In sum, several general conclusions can be drawn from these results. In the first place, the volume of imports appears to be closely related to industrial production in the ten countries under study. The estimates of the income elasticity of imports are in most cases greater than one or close to one. In Table 2 they range from 0.87 for Germany to 1.82 for France. The average for the sample is 1.34.

Secondly, real world exports as measured in IFS perform quite well as a proxy for real world income in the export equations. Thus measured the estimates of the income elasticity of exports are close to one in most cases. In Table 3 they range from 0.42 for Italy to 1.91 for Japan. The average for the sample is 1.04.

Thirdly, effective exchange rates as measured by the IMF's Multiple Exchange Rate Model contribute significantly toward explaining the movements of imports or exports or both in nine of the ten industrial countries in the sample, all except Canada. Where statistically significant the estimates of the exchange rate elasticities of imports are either less than or not significantly different from one (in absolute value). In Table 2 they range from

-0.21 for Italy to -1.63 for Belgium with an average of -0.95. The estimates of the elasticities of imports with respect to exchange rate changes over a twelve-month period are higher in most cases. The average of the significant estimates in Table 4 is -1.44; they range from -0.58 for France to -2.45 for Belgium. Where statistically significant the estimates of the exchange rate elasticities of exports are significantly less than one in all countries except Japan. In Table 3 they range from 0.26 for Germany to 0.96 for Japan with an average of 0.53, while in Table 5 the significant estimates of the twelve-month exchange rate elasticities range from 0.34 for France to 1.45 for the United States with an average of 0.69.

Finally, relative prices as measured by the ratio of the world export price index in IFS and domestic consumer price indices perform poorly as explanatory variables in most of the import and export equations. Four possible explanations for this result were suggested above, one statistical (inadequacy of the world export price index as a proxy for the level of world prices), one econometric (multicollinearity) and two economic (money illusion and expectations). This point needs further investigation.

Derivation of price elasticities

It still remains to be seen whether the estimates reported above imply that depreciation in the sample countries improves their balance of trade. To find out, structural estimates of the price elasticities of the demand and supply of imports and exports may be derived from the reduced-form estimates presented in Tables 2 and 3 by making use of the estimates of the income elasticities of import demand and export demand obtained by Goldstein and Khan (1976, 1978).1/ The structural estimates so obtained may then be inserted into equation (13) on page 6 to ascertain whether depreciation improves the balance of trade or not.

Comparison of equations (9) and (10) on page 4 and (15) and (16) on page 9 shows the relationship between the reduced-form and structural parameters in the import and export equations:

$$\alpha_1 = \frac{\eta_M \sigma_M}{\sigma_M + \delta_M} \qquad \alpha_2 = \frac{-\sigma_M \delta_M}{\sigma_M + \delta_M}$$

$$\beta_1 = \frac{\eta_X \sigma_X}{\sigma_X + \delta_X} \qquad \beta_2 = \frac{\sigma_X \delta_X}{\sigma_X + \delta_X}$$

1/ Their results, including their estimates of the income elasticities, are summarized in Table 6. For comparison the results of Houthakker and Magee (1969) are also summarized in Table 7.

Table 6. Goldstein and Khan's Empirical Results

(Quarterly data)

	Demand for Imports 1/				Demand for Exports 2/		
	Income elasticity η_M	Price elasticity δ_M	$\bar{R}^2$	DW	Income elasticity η_X	Price elasticity δ_X	R^2
United States	1.84 (17.69)	0.45 (1.97)	0.99	2.51	1.01 (29.43)	2.32 (5.08)	0.94
Germany	1.52 (12.91)	0.70 (5.05)	0.99	2.15	1.80 (46.30)	0.83 (4.31)	0.92
Japan	1.30 (23.25)	0.00 (0.86)	0.99	1.61	4.23 (13.26)	-2.47 (2.17)	0.94
France	1.28 (9.96)	1.09 (4.05)	0.99	2.43	1.69 (51.57)	1.33 (5.91)	0.98
Italy	1.84 (16.02)	0.16 (0.87)	0.99	2.21	1.96 (17.81)	3.29 (8.54)	0.96
United Kingdom	1.78 (27.51)	-0.18 (1.90)	0.98	2.01	0.92 (27.04)	1.32 (6.70)	0.95
Canada 3/	--	--	--	--	--	--	--
Belgium	1.75 (14.49)	0.62 (3.42)	0.92	2.02	1.68 (20.91)	1.57 (2.63)	0.97
Netherlands	2.04 (18.34)	-0.33 (2.21)	0.99	2.07	1.90 (62.23)	2.73 (4.89)	0.95
Austria 3/	--	--	--	--	--	--	--

1/ Source: Goldstein and Khan (1976), Table 1 on p. 209. The estimates were obtained with the OLS method, corrected for serial correlation. Sample period = 1955:3 - 1973:4.

2/ Source: Goldstein and Khan (1978), Table 3 on p. 279. The estimates were obtained with the FIML method; no DW-statistics are reported. Sample period = 1955:1 - 1970:4.

3/ Canada and Austria are not included in Goldstein and Khan's sample.

Note: t-statistics are shown in parentheses below the coefficients.

Table 7. Houthakker and Magee's Empirical Results

(Annual data, 1951-66)

	Demand for Imports				Demand for Exports			
	Income elasticity η_M	Price elasticity δ_M	$\bar{R}^2$	DW	Income elasticity η_X	Price elasticity δ_X	$\bar{R}^2$	DW
United States	1.68	1.03	0.98	2.00 1/	0.99	1.51	0.93	1.82
	(10.66)	(2.43)			(10.46)	(3.24)		
Germany	1.85	0.24	-- 2/	-- 2/	0.91	1.25	0.99	2.39 1/
	(30.19)	(0.91)			(3.25)	(3.48)		
Japan	1.23	0.72	0.98	2.40	3.55	0.80	0.98	1.04
	(13.06)	(2.40)			(14.82)	(1.78)		
France	1.66	-0.17	0.96	1.42	1.53	2.27	0.99	2.35
	(9.31)	(0.26)			(31.21)	(5.63)		
Italy	2.19	0.31	0.98	1.21	2.68	1.12	0.99	1.81 1/
	(6.48)	(0.18)			(22.63)	(3.61)		
United Kingdom	1.45	0.21	0.99	2.14 1/	1.00	1.24	0.98	2.13 1/
	(10.29)	(0.99)			(8.25)	(2.37)		
Canada	1.20	1.46	0.96	1.25	1.41	0.59	0.97	1.76
	(16.31)	(2.67)			(22.31)	(2.85)		
Belgium 3/	1.94	1.02	0.99	1.27	1.87	0.42	-- 2/	-- 2/
	(13.10)	(2.33)			(28.21)	(1.31)		
Netherlands	1.89	0.23	0.99	2.04	1.88	0.82	0.99	0.97
	(11.37)	(0.44)			(43.88)	(1.63)		
Austria 4/	--	--	--	--	1.59	1.30	0.97	0.42
					(12.55)	(3.01)		

Source: Houthakker and Magee (1969), Table 1 on p. 113, Table 3 on p. 115 and Table 8 on p. 125. The estimates were obtained with the OLS method.

1/ The regression has been corrected for serial correlation.
2/ The summary statistics are not available because the two coefficients come from two different equations.
3/ Includes Luxembourg.
4/ Houthakker and Magee do not report estimates of an import equation for Austria.

Note: t-statistics are shown in parentheses below the coefficients.

These relationships may be used to derive the following expressions for the price elasticities of the demand and supply of imports and exports:

$$\delta_M = \frac{-\eta_M\alpha_2}{\alpha_1} \qquad \sigma_M = \frac{-\eta_M\alpha_2}{\eta_M - \alpha_1}$$

$$\delta_X = \frac{\eta_X\beta_2}{\beta_1} \qquad \sigma_X = \frac{\eta_X\beta_2}{\eta_X - \beta_1}$$

Substitution of Goldstein and Khan's estimates of the income elasticities shown in Table 6 and the estimates of the reduced-form coefficients shown in Tables 2 and 3 into these expressions yields the estimates of the price elasticities presented in Table 8.1/

On the basis of the estimates presented in Table 8, it can now be determined whether depreciation improves the balance of trade in the countries under study. It is clear from the table that the sufficient conditions for that to occur within a month (i.e., $\delta_M \geq 1$ or $\delta_X \geq 1$, cf. equation (13) on page 6) are satisfied in seven of the ten countries in the sample : the United States ($\delta_M = 1.12$, $\delta_X = 0.62$), Germany ($\delta_M = 1.36$), Japan ($\delta_X = 2.13$), Italy ($\delta_X = 1.91$), Belgium ($\delta_M = 2.57$), the Netherlands ($\delta_M = 1.65$) and Austria ($\delta_M = 1.21$).

In the case of France, the estimates of the twelve-month exchange rate elasticities reported in Tables 4 and 5 are significant at the 5 per cent level while the estimate of the contemporaneous elasticity shown in Table 2 is significant only at the 10 per cent level. When the twelve-month reduced-form coefficients are used to calculate the structural parameters as above, the following estimates are obtained: $\delta_M = 0.34$, $\sigma_M = -0.82$, $\delta_X = 0.57$ and $\sigma_X = 0.83$. In this case, the Marshall-Lerner condition is not met for the first time. Unfortunately, however, the negative sign of the import supply elasticity σ_M 2/ makes it pointless to check through equation (13) on page 6 whether the supply elasticities are sufficiently low to ensure that depreciation improves the trade balance. It is nonetheless noteworthy that if the import supply elasticity were actually positive, and even if it were infinitely large, the export supply elasticity σ_X is by itself sufficiently small to ensure, according to equation (13), that depreciation does

1/ As Austria is not in Goldstein and Khan's sample, it is arbitrarily assumed that the income elasticity of import demand in Austria is equal to the average of the income elasticities of import demand estimated by Goldstein and Khan, or 1.67. It is interesting to note that the average income elasticity of import demand reported by Houthakker and Magee (1969) is also 1.67.

2/ This estimate is negative because Goldstein and Khan's estimate of η_M (= 1.28) shown in Table 6 is lower than the estimate of α_1 (= 2.18) shown in Table 2, cf. the expression for σ_M above. The same applies to the negative estimate of France's import supply elasticity shown in Table 8.

Table 8. Implicit Estimates of Price Elasticities in World Trade

	Imports		Exports	
	Price elasticity of demand δ_M	Price elasticity of supply σ_M	Price elasticity of demand δ_X	Price elasticity of supply σ_X
United States	1.12	7.14	0.62	2.36
Germany	1.36	1.82	0.38	0.81
Japan	...	...	2.13	1.75
France	0.46	-1.54	...	...
Italy	0.32	0.62	1.91	0.52
United Kingdom	...	...	0.32	0.81
Canada	...	...	...	...
Belgium	2.57	4.46	...	...
Netherlands	1.65	2.09	0.88	1.39
Austria	1.21	27.67	...	...

Sources: Tables 2, 3 and 6.

Note: All the reduced-form estimates of exchange rate elasticities underlying the structural estimates presented in the table are significant at the 5 per cent level except the ones for France and the United Kingdom which are significant only at the 10 per cent level,cf. Tables 2 and 3. Three dots (...) denote insignificant estimates except in one case (U.K. imports) where the relevant reduced-form estimate is significant with wrong sign,cf. Table 2.

improve the balance of trade in France within a year, even if the Marshall-Lerner condition is not met.

About the remaining two countries little can be said. Whenever a significant estimate of the exchange rate elasticity of exports or imports was obtained for the United Kingdom, such as in the twelve-month export equation (cf. Table 5) or the 36-month import equation (mentioned on page 19, but not reported), the estimate of the income elasticity turned out to be insignificant, making it impossible to derive estimates of the structural parameters. No significant estimates of the effect of exchange rate changes on imports or exports were obtained for Canada.

Comparison with other estimates

Before comparing the estimates of the price elasticities of the demand and supply of imports and exports presented above with those reported in other empirical studies, especially with those reported in the studies by Houthakker and Magee (1969) and Goldstein and Khan (1976, 1978), it is useful to describe those studies briefly.

Houthakker and Magee estimated simple demand functions for exports and imports from annual data for fifteen industrial countries, including all the countries in the present sample, in the period 1951-66. They also estimated export demand functions for ten other countries, mostly developing countries. In the estimation they applied the ordinary least-squares method to the same logarithmic functional forms as in equations (2) and (4) on page 3. A summary of their results for the countries in the present sample is presented in Table 7 on page 24. Of the fifteen industrial countries in their sample, Houthakker and Magee obtained significant estimates of price elasticities in only six import demand equations, but twelve export demand equations; the rest of their price elasticity estimates were insignificant (except one which was significant with wrong sign). Similarly, of the ten developing countries for which they estimated export demand functions, Houthakker and Magee obtained significant estimates of price elasticities in only three cases; of the other seven estimates, six were insignificant and one was significant with wrong sign. Thus, even though their study is probably the most frequently cited empirical study of income and price elasticities in world trade, Houthakker and Magee's attempts to estimate the price elasticity of the demand for imports and exports met on the whole with only moderate success.

Goldstein and Khan (1976) estimated logarithmic demand functions for imports with the ordinary least-squares method from quarterly data for twelve industrial countries, including all the countries in the present sample except Canada and Austria, in the period 1955-73. A summary of their results for the countries in the present sample is presented in Table 6 on page 23. Of the twelve industrial countries in their sample, Goldstein and Khan obtained significant estimates of price elasticities in eight cases; of the rest, two estimates were insignificant and two were significant with wrong signs. In a more recent paper, Goldstein and Khan (1978) report full-information maximum likelihood estimates of logarithmic demand and supply functions for exports based on quarterly data for eight industrial countries, all the countries in the present sample except Canada and Austria, in the period 1955-70. Of these eight countries, Goldstein and Khan obtained significant estimates of the price elasticity of export demand and export supply in seven cases, all except Japan in which case the price elasticities turned out to be significant with wrong sign and insignificant, respectively.1/ In comparison with Houthakker and Magee, Goldstein and Khan obtained a relatively larger number of significant estimates of price elasticities with better data and more sophisticated econometric techniques. Besides, unlike Houthakker and Magee they estimated supply functions for exports.

In Table 9 a comparison is made between the estimates of the price elasticity of import demand presented in Table 8 above and the estimates reported by Goldstein and Khan, 1976 (henceforth, GK), Khan and Ross, 1975 (KR), Houthakker and Magee, 1969 (HM), and Stern, Francis and Schumacher, 1976 (SFS). The table shows that while only a half or less of the estimates reported by GK, KR and HM are significant, 70 per cent of the estimates presented in this study are significant. The average estimate of the price elasticity of import demand obtained in this study is 1.24, which is similar to that obtained by KR (1.18), but higher than those reported by HM (1.06), SFS (1.02) and, especially, GK (0.72). Despite these similarities there are considerable differences between the estimates for individual countries. The estimate obtained here for the United States is, for example, similar to those reported by KR and HM, much bigger than the one obtained by GK, but much smaller than the "best" estimate of the price elasticity of import demand in the United States reported by SFS.2/ The estimates obtained here for Germany and Belgium are much higher than those reported by the others, but the ones for France and Italy are much smaller. The line in the table representing the United Kingdom shows that GK, KR and HM have all had difficulty in estimating the price elasticity of the demand for imports in that country; like this writer, GK and KR actually obtained significant estimates with wrong signs.3/ While GK and KR also obtained significant estimates with wrong signs for the Netherlands, a significantly negative price elasticity was obtained by this writer. This estimate is, however, much bigger (in absolute value) than the "best" estimate for the Netherlands reported by SFS. Finally, the price elasticity estimate obtained here for Austria is much bigger than the one reported by KR, but similar to the "best" estimate reported by SFS.

In Table 10 the estimates of the price elasticity of the demand for exports presented in Table 8 are compared with the estimates reported by GK, Hickman and Lau, 1973 (henceforth, HL), HM and SFS. The table shows that while the estimates reported by GK, HL and HM are significant with only one or two exceptions, 60 per cent of the estimates presented in this study are

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1/ Goldstein and Khan also estimated a disequilibrium version of their model by including lagged dependent variables in the estimating equations. In this version of the model, they obtained significant estimates of the price elasticity of export demand and export supply in five cases each.

2/ See footnote 5 to Table 9.

3/ Deppler (1974) and Marston (1971) also encountered similar difficulties in empirical work on imports into the United Kingdom.

Table 9. Comparison with Other Estimates:
Price Elasticity of Demand for Imports

	Present Study 1/	Goldstein-Khan 2/	Khan-Ross 3/	Houthakker-Magee 4/	Stern et al. 5/
United States	1.12	0.45	1.00	1.03	1.66
Germany	1.36	0.70	0.53	...	0.88
Japan	...	...	...	0.72	0.78
France	0.46	1.09	...	...	1.08
Italy	0.32	...	1.67	...	1.03
United Kingdom	... 6/	... 6/	... 6/	...	0.65
Canada	...	--	2.13	1.46	1.30
Belgium	2.57	0.62	...	1.02	0.83
Netherlands	1.65	... 6/	... 6/	...	0.68
Austria	1.21	--	0.59	--	1.32
Average	1.24	0.72	1.18	1.06	1.02

1/ Source: Table 8. Monthly data; sample period = 1971-77; estimation method = 2SLS. Note: Structural estimates of price elasticities are derived from estimates of reduced-form equations.

2/ Source: Table 6. Quarterly data; sample period = 1955-73; estimation method = OLS.

3/ Source: Khan and Ross (1975), Table 1 on p. 360. Semiannual data; sample period = 1960-72; estimation method = OLS.

4/ Source: Table 7. Annual data; sample period = 1951-66; estimation method = OLS.

5/ Source: Stern, Francis and Schumacher (1976), Table 2.2 on p. 20. Note: The authors consider these the "best" estimates of long-run price elasticities; they are based on the approximate median when several estimates are available.

6/ Estimate is significant, but with wrong sign.

Note: Three dots (...) indicate that the estimates are insignificant (or, in five cases, significant with wrong sign, cf. n.6). Two bars (--) indicate that the country in question was not included in the sample. The table shows absolute values.

Table 10. Comparison with Other Estimates:
Price Elasticity of Demand for Exports

	Present Study 1/	Goldstein-Khan 2/	Hickman-Lau 3/	Houthakker-Magee 4/	Stern et al. 5/
United States	0.62	2.32	1.07	1.51	1.41
Germany	0.38	0.83	0.76	1.25	1.11
Japan	2.13	... 6/	0.46	0.80	1.25
France	...	1.33	0.96	2.27	1.31
Italy	1.91	3.29	0.71	1.12	0.93
United Kingdom	0.32	1.32	1.05	1.24	0.48
Canada	...	--	0.56	0.59	0.79
Belgium	...	1.57	0.67	...	1.02
Netherlands	0.88	2.73	0.72	0.82	0.95
Austria	...	--	0.76	1.30	0.93
Average	1.04	1.91	0.77	1.21	1.02

1/ See footnote 1 to Table 9.
2/ Source: Table 6. Quarterly data; sample period = 1955-70; estimation method = FIML.
3/ Source: Hickman and Lau (1973), Table 5 on p. 375. Annual data; sample period = 1961-69; estimation method = OLS. Note: Estimates of export price elasticities are derived from cross-section estimates of elasticities of substitution.
4/ See footnote 4 to Table 9.
5/ See footnote 5 to Table 9.
6/ Estimate is significant, but with wrong sign.
Note: Three dots (...) indicate that the estimates are insignificant (or, in one case, significant with wrong sign, cf. n.6). Two bars (--) indicate that the country in question was not included in the sample. The table shows absolute values.

significant. The average estimate of the price elasticity of export demand obtained in this study is 1.04, which is almost identical to the average of the "best" estimates reported by SFS (1.02), bigger than the average estimate of HL (0.77), smaller than the average estimate of HM (1.21) and much smaller than that of GK (1.91). In particular, the estimates obtained here for the United States, Germany and the United Kingdom are smaller than those reported by the others; yet the estimate for the United Kingdom is of the same order of magnitude as the "best" estimate reported by SFS. The estimates for Japan and Italy, on the other hand, are bigger than those reported by the others, except GK estimate Italy's price elasticity of export demand higher than anyone else. The estimate of the price elasticity of export demand in the Netherlands obtained by GK is also much higher than the estimates of the others which are similar.

In Table 11, finally, a comparison is made between the estimates of the price elasticity of the supply of exports from Table 8 and the estimates reported by Goldstein and Khan (1978); no other comparable estimates of supply elasticities in world trade have been published. From the equilibrium version of their model GK obtained significant estimates for seven countries out of eight, and from the disequilibrium version, for five countries out of eight. By comparison, 60 per cent of the estimates reported in this study are significant. The average estimate of the price elasticity of export supply reported here is 1.27, which is much smaller than the averages of the two sets of estimates reported by GK, 2.76 and 2.05, respectively. The estimates reported here for the United States, Germany, Italy and the Netherlands are all much lower than those obtained by GK. The estimate for the United Kingdom is also lower than that obtained by GK from their equilibrium model, but similar to their estimate from the disequilibrium model.

It might be expected *a priori* that the price elasticity of export supply should be lower and the price elasticity of import supply higher in small, open economies like those of Belgium, the Netherlands and Austria than in bigger, less open economies like those of the United States, Germany and Japan. While no such clear pattern is present in the estimates reported in this paper, it is interesting to note the following results of rank correlation tests. The rank correlation coefficient between the degree of "openness," as measured by the ratio of exports to gross national product, cf. Table 11, and the magnitude of the estimates of the price elasticity of export supply reported in this paper is -0.43. This is an indication that the price elasticity of export supply tends to be lower in open economies than in closed ones as expected. For comparison, a rank correlation test between "openness" and the estimates of the price elasticity of export supply reported by Goldstein and Khan (1978) yields a coefficient of only -0.18 if the estimates from their equilibrium model are used in the calculation and -0.10 if the estimates from their disequilibrium model are used. A rank correlation test between the size of the countries under study, as measured by real gross national product in U.S. dollars, and the magnitude of the estimates of the price elasticity of export supply reported in this paper is 0.66. This indicates that the price elasticity of export supply tends to be higher in

Table 11. Comparison with Other Estimates: Price Elasticity of Supply of Exports

	Present Study 1/	Goldstein-Khan 2/	Goldstein-Khan 3/	Ratio of Exports to GNP in 1974 (In per cent) 4/
United States	2.36	6.58	4.00	7.9
Germany	0.81	4.57	...	28.0
Japan	1.75	...	...	14.7
France	...	1.89	1.38	20.6
Italy	0.52	1.12	...	22.5
United Kingdom	0.81	1.45	0.85	27.5
Canada	...	--	--	25.5
Belgium	...	1.23	1.65	52.7
Netherlands	1.39	2.50	2.39	56.2
Austria	...	--	--	36.4
Average	1.27	2.76	2.05	

1/ See footnote 1 to Table 9.
2/ Source: Goldstein and Khan (1978), Table 3 on p. 279. Quarterly data; sample period 1955-70; estimation method = FIML. Note: Estimates are taken from equilibrium model.
3/ Source: Goldstein and Khan (1978), Table 4 on pp. 280-281. Quarterly data; sample period 1955-70; estimation method = FIML. Note: Estimates are taken from disequilibrium model.
4/ Source: IMF, International Financial Statistics.
Note: Three dots (...) indicate that the estimates are insignificant. Two bars (--) indicate that the country in question was not included in the sample.

big countries than in small ones as expected. For comparison, a rank correlation test between "openness" and Goldstein and Khan's estimates of the price elasticity of export supply produces rank correlation coefficients of 0.71 and 0.20 for the equilibrium and disequilibrium models, respectively. Finally, the rank correlation coefficient between "openness" and the estimates of the price elasticity of import supply presented in Table 8 is only 0.08, while between size and the price elasticity of import supply the rank correlation coefficient is -0.37. The latter coefficient indicates that there is some tendency for the price elasticity of import supply to be lower, as expected, in big countries than in small countries.

IV. Concluding Remarks

In conclusion, the empirical results reported in this paper do not lend support to pessimistic views about the magnitudes of price elasticities in international trade. On the contrary, they seem to indicate that, in the industrial countries at least, the price elasticities of the demand for imports and exports are generally large enough for depreciation to improve the balance of trade quite quickly, in most cases within a month. Furthermore, they seem to indicate that the price elasticities of the supply of imports and exports may in many cases be smaller than is commonly believed, too small at any rate to warrant the assumption commonly made in empirical work that they are infinitely large.

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